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MILITARY OPERATIONS RESEARCH SOCIETY

MORS Workshop
Agent-Based Models and Other Analytic Tools in Support of Stability Operations

25-27 October 2005
Science Applications International Corporation (SAIC)
McLean, Virginia

Chairs:
Col Gregory Reuss and COL George Stone
Technical Co-Chairs:
LTC Scott Schutzmeister and Steve Stephens

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This Military Operations Research Society report summarizes the proceedings of a workshop conducted over three days by experts, users and participants interested in quantifying the relationship between testing and simulation. It is not intended to be a comprehensive treatise on the subject. It reflects the major concerns, insights, thoughts and directions of the participants at the time of the workshop.

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The purpose of the Military Operations Research Society (MORS) is to enhance the quality and effectiveness of classified and unclassified military operations research. To accomplish this purpose, the Society provides media for professional exchange and peer criticism among students, theoreticians, practitioners and users of military operations research. These media consist primarily of the traditional annual MORS Symposia (classified), their published abstracts or proceedings, special mini-symposia, workshops, colloquia and special purpose monographs and other publications. MORS publishes two quarterly periodicals, *PHALANX* and *Military Operations Research*. *PHALANX* is the MORS bulletin and *Military Operations Research* is a refereed journal. The forum provided by these media is intended to display the state of the art, to encourage consistent professional quality, to stimulate communication and interaction between practitioners and users, and to foster the interest and development of students of operations research. The Military Operations Research Society neither makes nor advocates official policy, nor does it attempt to influence the formulation of policy. Matters discussed or statements made during the course of its meetings or printed in its publications represent the positions of the individual participants and authors and not of the Society.

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- The Director of Force Structure, Resources and Assessment, The Joint Staff
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Military Operations Research Society Workshop

Agent-Based Models and Other Analytic Tools in Support of Stability Operations

Executive Summary

The Military Operations Research Society (MORS) conducted a workshop titled *Agent Based Models and Other Analytic Tools in Support of Stability Operations* at the Science Applications International Corporation (SAIC) Conference Center in McLean, VA from 25 to 27 October 2005.

Stability operations are military, civilian, and multi-national. Analytical approaches to stability operations are also military, civilian, and multi-national. There is no shortage of good research and analysis in stability operations. Nevertheless, a critical failing is that many agencies are conducting military, civilian, and multi-national analyses independently without cross-domain sharing of ideas and methods. This confirms the need for analysts from the military, civilian, and multi-national analytical communities to collaborate and address the most significant shortcoming. ***This shortcoming is the inability to assess the interdependency of military, civilian, and multi-national efforts during the conduct of stability operations.***

Agent-based models (ABMs) are not unique; there are many models and simulations that have degrees of "ABMness." Many have been proven useful when analyzing stability operations and, among these models, a beneficial characteristic is the promising ability to represent behavioral and social concepts that are important to success in stability operations. ABMs are appropriately being used as filters (to conduct and screen many runs) in conjunction with more traditional simulations. We determined that nothing is to be gained by trying to divide models into two groups with agent-based models in one group and all other models in the other group. The fundamental basics for good analysis have not changed. Problem definition is first. The analyst then defines appropriate measures of effectiveness (MOEs), and then selects or develops the best tool for the job. We do not recommend that MORS treat agent-based models as a special topic in future workshops or other venues, because the term 'agent-based model' does not have unique meaning.

Much is being done in the stability operations arena towards setting goals and objectives, then developing metrics. Quality analysis starts with goals and objectives. Only after goals and objectives have been established does an analyst start developing metrics. For stability operations, however, the subsequent metrics will be unique to each operation, difficult to define, and difficult to collect data for. A very promising approach towards setting goals and objectives in stability operations is from the State Department's Office of the Coordinator for Reconstruction and Stabilization (S/CRS). They have outlined a dynamic planning framework for conflict transformation during stability operations that

involves a Post-Conflict Reconstruction Essential Task Matrix as a reference tool for comprehensive planning for stability operations.

We recommend that MORS Sponsors, within their organizations, examine, consider the use of, and provide analytical feedback to the S/CRS on the "Post Conflict Reconstruction Essential Task List."

The goals of the workshop were to identify techniques and methodologies that show promise for conducting analyses in support of stability operations and to determine the capabilities that agent-based models provide for military analyses. This was achieved by bringing together DoD and non-DoD analysts working on projects related to stability operations and agent-based models.

We recommend that MORS continues to reach out to non-DoD operations research analysts to become members and that MORS Sponsors consider formally inviting non-DoD analysis organizations to be MORS sponsors.

Military Operations Research Society Workshop

Agent-Based Models and Other Analytic Tools in Support of Stability Operations

Final Report

I Introduction

Background

Traditionally, stability operations were considered by many to be to the mechanism of transitioning from a full warfare footing to a peaceful situation. Joint forces use dominant maneuver and precision joint fires to achieve military strategic and operational objectives, culminating in conflict termination. With this viewpoint, stability operations are conducted as needed to ensure a smooth shift to the desired end state of the Joint Task Force commander and to relieve suffering. The goal is to ensure that the threat (military and political) does not resurrect itself. Traditional offensive operations are primary in this perspective; stability operations are secondary.

The world may have changed, however.

The September 11, 2001 terrorist attacks on the World Trade Center and the Pentagon have thrust the United States into the Global War on Terrorism (GWOT). As a result, the United States (US) has joined the rest of the world by entering into a new age of instability. Stability operations can no longer be relegated to a secondary level of importance. The US Department of Defense (DoD) needs to consider the use of modeling techniques to assess the emergence and development of stability operations as part of the DoD effort in nation-building.

Accordingly, the Military Operations Research Society (MORS) conducted a workshop entitled *Agent-Based Models and Other Analytic Tools in Support of Stability Operations*. The workshop took place at the SAIC Conference Center in McLean, VA from 25 to 27 October 2005.

Purpose

The military establishment of the United States is transforming itself and is preparing to conduct stability operations. The military operations research community is transforming itself as well. MORS has facilitated the transformation process by conducting recent special meetings that have assembled practitioners and users of military operations research for professional exchange and peer criticism, leading to a broader and more common understanding of what has been done and what should be done.

The purpose of this final report is to present the results of the MORS workshop - *Agent-Based Models and Other Analytic Tools in Support of Stability Operations*.

Workshop Description

Col Gregory C. Reuss, Director, USMC Operations Analysis Division, Marine Corps Combat Development Command (MCCDC) and COL George F. Stone, Director US Army Battle Command, Simulation, and Experimentation Directorate (BCSE, Army G-3/5/7) co-chaired the workshop to look into using agent-based models and other analyses in support of Stability Operations (including Distributed Operations). LTC Scott Schutzmeister, BCSE, and Steve Stephens, MCCDC, were technical co-chairs.

MORS President Col(s) Suzanne Beers, USAF, and Mr. Ron Adams of SAIC presented welcoming remarks.

Brigadier General Thomas D. Waldhauser, Deputy Commanding General, Marine Corps Combat Development Command, was the keynote speaker and vibrantly described stability operations from the tactical level.

Dr. Barbara Stephenson, Director of Planning, Office of the Coordinator for Reconstruction and Stabilization, US Department of State, was a featured plenary speaker and outlined a dynamic planning framework for conflict transformation during stability operations.

Dr. Barbara J. Sotirin, Deputy Director, Research and Development, US Army Corps of Engineers, was a featured plenary speaker and clearly described a national strategy for regional stability.

The workshop purpose was to bring together analysts working on projects directly or indirectly related to agent-based models as well as analysts working on projects directly or indirectly related to stability operations. Workshop goals were to determine the capabilities that agent-based models can provide for military analyses and to identify other techniques and methodologies that show promise for conducting analyses in support of stability operations. There were three working groups and a synthesis group. Dr. Michael P. Bailey, Marine Corps Operations Analysis Division, chaired the Synthesis Group.

Working Group 1 - Agent-Based Modeling and Simulation for Stability Operations, was chaired by Dr. Gary E. Horne, Marine Corps Warfighting Laboratory (Project Albert); LTC Jeffrey B. Schamburg, US Army, PhD, TRADOC Analysis Center, Monterey, CA; Mr. Lawton Clites, Referentia Systems Incorporated; and, MAJ Eric S. Tollefson, US Army TRADOC Analysis Center, Monterey, CA.

Working Group 2 - Metrics for Stability Operations, was chaired by Prof David F. Davis, George Mason University; Maj Victor D. Wiley, US Air Force, PhD, Air Force Studies and Analyses Agency *[Ed Note: now HQ USAF/A9]*; and, Mr. William G. Wright, Marine Corps Operations Analysis Division.

Working Group 3 - Analytic Support to Stability (Including Distributed) Operations, was chaired by Mr. Dennis M. Guzik, Systems Planning and Analysis, Inc; MAJ Eric C. Hansen, US Army, Center for Army Analysis; Ms Mary L. McDonald, Systems Planning and Analysis, Inc; Maj Eric S. Wolf, Headquarters US Marine Corps; and, Mr. Andrew D. York, Systems Planning and Analysis, Inc.

Plenary session remarks were given by three MORS Sponsors — Mr. Walter W. Hollis, FS, Deputy Under Secretary of the Army (Operations Research); Dr. Jacqueline R. Henningsen, FS, Director, Air Force Studies and Analyses Agency *[Ed Note: now HQ USAF/A9];* and, Dr. George Akst, Senior Analyst, Marine Corps Combat Development Command.

144 analysts and decision makers participated in the workshop. This number included ten foreign nationals (three each from the United Kingdom and Germany, and two each from Canada and the Slovak Republic) and 134 US citizens. Of the latter, 53 were new to MORS.

Scope

Section II describes stability operations and introduces the thought that agent-based models may be useful toward the analysis of stability operations. Section III reviews analyses and analytic approaches that pertain to stability operations. Metrics, specifically in the context of stability operations, is the focus of Section IV. Section V examines agent-based models. The final section, Section VI, summarizes techniques and methodologies that show promise for conducting analyses in support of stability operations and comments on agent-based models. Appendix A to this report describes the agent-based models reviewed during the workshop. Appendix B contains a list of report acronyms while Appendix C has the workshop Terms of Reference.

II Stability Operations and Agent-Based Models

According to Joint Publication 3-0, *Doctrine for Joint Operations* revision first draft (RFD), stability operations are a part of traditional Phase IV Operations (bold/italics added for emphasis) inasmuch as Phase IV Operations,

> "...enable the joint force commander to focus on synchronizing and integrating joint force activities to bring the joint operation to a successful conclusion — achievement of the termination criteria... ***This phase usually has three segments — stability, transfer of authority, and redeployment.*** A stability segment often is necessary to ensure that the threat (military and/or political) does not resurrect itself or, in noncombat situations, to ensure where possible that the situation leading to the original crisis does not reoccur."

Since stability operations are a key element of Phase IV Operations, many people have mistakenly considered the two synonymous. Here, from the same document, is a definition of Stability Operations (bold/italics added for emphasis):

> "...an overarching term encompassing specific types of developmental, cooperative, or coercive security cooperation and deterrence activities, small-scale operations, and/or missions that promote local or regional normalcy and protect US interests abroad. ***Stability operations may be conducted in all operational environments and during all phases of a campaign or major operation.***"

This definition clearly takes stability operations out of merely being a subset of Phase IV Operations. Although one cannot talk about Phase IV Operations without discussing stability operations; one can certainly discuss stability operations outside the context of Phase IV Operations.

Joint Forces Command states in *Stability Operations Concepts and Capabilities Emerging From JFCOM/Joint Experimentation* (bold/italics added for emphasis) that

> "Stability Operations are activities conducted by ***military and other government components*** to establish, reestablish or support a foreign government's ability to assure rule of law and internal security, to provide basic human services (healthcare, water, electricity, education), and to protect its borders and promote its foreign interests including cooperation with regional and international partners and deterrence of potential aggressors."

The key take-away here is that stability operations are inter-departmental, involving government agencies other than the military.

Finally, from the US Army's FM 3-07 *Stability Operations and Support Operations* (bold/italics added for emphasis):

> "Stability operations promote and protect US national interests by influencing the threat, political, and information dimensions of the operational environment through a combination of peacetime developmental, cooperative activities and ***coercive actions*** in response to crisis. Army forces accomplish stability goals through ***engagement and response***. The military activities that support stability operations are diverse, continuous, and often ***long-term***. Their purpose is to promote and sustain regional and global stability."

We can expect stability operations to be lengthy and bloody.

When do stability operations occur? The answer is anytime. They do not have to be associated with a larger conventional military campaign. Marine Expeditionary Units (MEUs) train to conduct several types of operations including Security Operations, Non-combatant Evacuation Operations (NEO), and Peace Operations. These all fit under the umbrella of stability operations and MEUs are deployed around the world to conduct these operations at a moments notice.

This does not mean stability operations cannot be part of a larger conventional operation. During the march to Baghdad in the first part of Operation Iraqi Freedom, even before Baghdad fell, an MEU was actively conducting stability operations in the city of An Nasiriyah. The Marines:

- Conducted vehicle and helicopter patrols;
- Engaged and destroyed uniformed personnel and irregulars;
- Conducted medical evacuation of civilians in support of local leadership;
- Produced potable water for An Nasiriyah;
- Provided emergency medical care for acute cases;
- Developed a partnership with local clinics;
- Conducted food distribution to needy areas and orphanages;
- Restored electrical power;
- Initiated police force training;
- Foiled bank robberies;
- Opened damaged bank vaults to recover and secure cash; and,
- Delivered a baby.

The Marines found themselves in a stability operations environment not quite by design. They provided a visible presence and demonstrated commitment through action.

Another key element of stability operations that emerges from the definitions and the Marines' experience is the critical significance of non-military factors. This means that military operations research analysts should become more adept at analysis techniques used outside of traditional military operations research, especially for stability operations. There may be a difference between how the military looks at stability operations analysis

and how civilians look at stability operations analysis. The culture of analysis on stability operations is not the same outside of the military as it is within the military.

The Office of the Coordinator for Reconstruction and Stabilization (S/CRS) was established within the State Department on 1 July 2004 to lead, coordinate, and institutionalize the US Government civilian capacity to prevent or prepare for post-conflict situations, and to help stabilize and reconstruct societies in transition from conflict or civil strife so they can reach a sustainable path toward peace, democracy and a market economy.

S/CRS defines stabilization as the process by which underlying tensions that might lead to a resurgence in violence and a breakdown in law and order are managed and reduced, while efforts are made to support preconditions for successful longer-term development. S/CRS sets a viable peace as a goal for stability operations and defines a viable peace as the point in a conflict transformation process at which the means and motivations for conflict are sufficiently diminished and local institutional capacity is sufficiently developed to allow international actors to pass the lead to local actors without the country falling back into conflict. Otherwise stated, the country should be beyond major conflict and beyond major security, political and economic reliance on foreign interveners so that future transformation of the country to a free market democracy is largely and increasingly in the hands of benign, credible local authorities.

A new way to do analysis is needed, perhaps even new tools. Agent-based models may provide a new and stimulating approach to analyzing stability operations because of the semi-autonomous nature of their battlefield entities. The approach involves using multi-agent-based software tools to examine the relationship between numerous input variables and output measures. The self-adaptive nature of some of these models may facilitate broad exploration of battlefield scenarios and permit the possibility of gaining substantial insights into both military and non-military emergent behaviors on the battlefield. This may be especially pertinent for a non-linear battlefield with distributed tactical units.

III Analytical Approaches to Stability Operations

The conduct of stability operations is military, civilian, and multi-national. It stands to reason that analytical approaches to stability operations should also be military, civilian, and multi-national.

There are several key areas of stability operations that merit analytic effort:

- Policy, Doctrine, Concepts of Operation (CONOPS), Tactics, Techniques, and Procedures (TTPs), Rules of Contact/Engagement, etc.
- Training Requirements
- Humanitarian Assistance (HA), Civil-Military Collaboration and Coordination Requirements (Multi-National)
- Situational assessment (current and predictive)
- Force Structure requirements (Interagency and Joint)
- Capability analysis (equipment, systems)
- Course of Action Analysis, Wargaming

In addition, there are several possible analytic constructs to determine if there were gaps in the types of analyses being conducted. Working Group 3 notionalized the construct that appears in Figure 1 as an example.

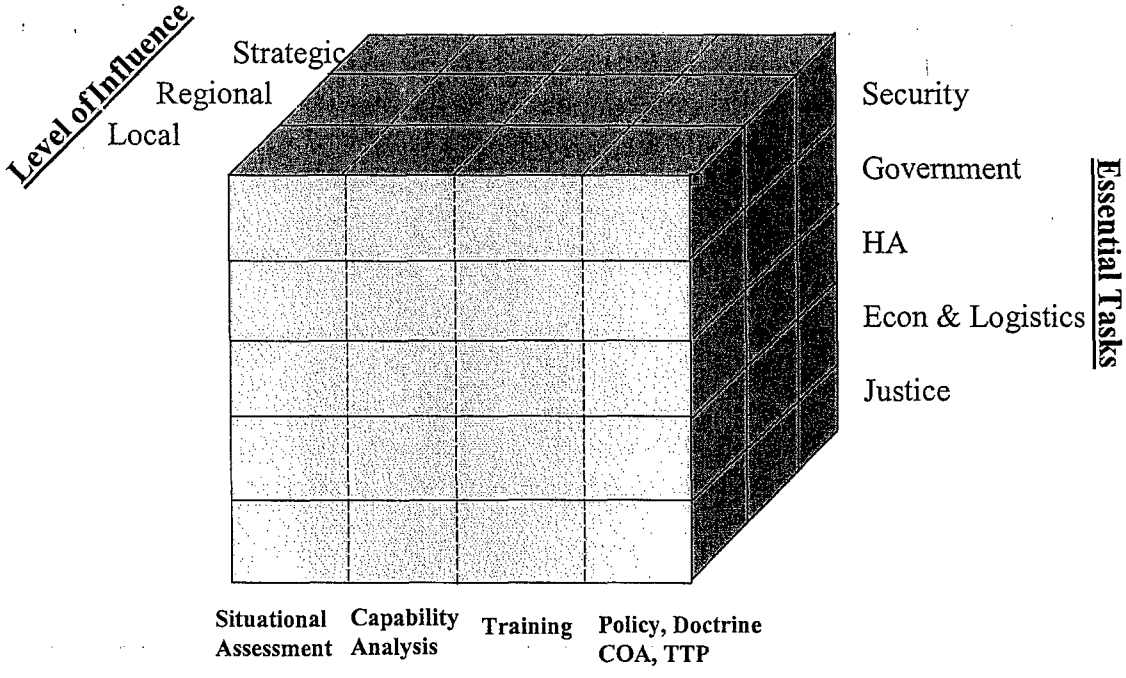


Figure 1

Overall, Working Group 3 definitely established that there are in existence several excellent analytical tools to assess the military aspects of stability operations. One such example is the Distributed Operations Modeling Environment (DOME). Distributed operations are non-linear and deploy tactical units across the depth and breadth of a battlespace in order to maximize opportunities to achieve favorable intelligence driven engagements. Massing forces and pre-planning voluminous fires are not the critical enablers for distributed operations. The critical enablers are a robust, easily accessible information structure and prompt, responsive, precision fires. DOME is not a model as much as it is a modeling environment. DOME can be described as an agent-based environment that can simulate not only distributed operations but also Special Operations and other innovative small unit operation concepts.

The Joint Staff Force Structure, Resources, and Assessment Directorate (J8) and the Defense Modeling and Simulation Office (DMSO) have developed a suite of tools to analyze stability operations in what is referred to as the "Military Operations Other Than War (MOOTW) Flexible Asymmetric Simulation Technologies (FAST) Toolbox." Components of FAST include the Unit Order of Battle Data Access Tool (UOB DAT), the Interim Semi-Static Stability Model (ISSM), the Diplomatic and Military Operations in a Non-Warfighting Domain (DIAMOND), and Pythagoras (an agent-based model).

The United Kingdom's Ministry of Defence has been active in this area. Its Policy and Capability Studies Division of the Defence Science and Technology Laboratory has conducted a Peace Support Operations Model (PSOM). They realized that military capabilities are relatively well understood by analysts but in stability operations, military capabilities should never be considered in isolation. Their analysts acknowledged limited knowledge of the interaction between military and other agency capabilities and their "effect" in stability operations. PSOM insights thus far have been that softer principles (e.g. minimum use of force, understanding local people and their ways) are more effective on the whole and that overwhelming firepower is impotent without excellent intelligence.

The State Department's Humanitarian Information Unit (HIU) serves as an interagency center to identify, collect, analyze and disseminate unclassified information critical to decision makers and partners in preparation for and response to humanitarian emergencies worldwide, and to promote best practices for humanitarian information management. Analysts at HIU have developed the Visualized Information Synthesized Temporal Analysis tool, or VISTA. VISTA provides an interactive, query approach to create a customized "common operating picture" featuring a map of the affected area, a timeline of key events, graphs, charts, tables, and hyperlinks to full text documents.

Conducting stability operations is no different from almost any other endeavor inasmuch as increased preparation yields increased effectiveness. The same is true for analysis of stability operations. The Fund for Peace is a non-governmental organization whose mission is to prevent war and alleviate the conditions that cause war. The Fund for Peace favors a pathological tactic. Pathology is a medical science that deals with symptoms. The earlier symptoms can be detected usually means that the chances of defeating a

disease are greater. Working on the premise that internal conflict is a pathology of the state and that state collapse can lead to violent conflict, their analysts have developed the Conflict Assessment System Tool (CAST). CAST diagnoses the symptoms or indicators of state pathology to provide both an assessment of susceptibility to state collapse and internal conflict as well as an evaluation of stabilization efforts.

As stated at the beginning of this section, it is important to realize that stability operations are not strictly military operations in the sense that joint and coalition military capabilities are not the only resources involved. Stability operations involve multinational civilian organizations whose role may very well be greater than the military role. These organizations include:

- Inter-Governmental Organizations (IGOs) – Organizations established and funded by sovereign nations, and directed by their designated representatives.
- International Humanitarian Organizations (IHOs) – Non-profit organizations of private citizens that have been established under international law and custom, and are often granted privileges and immunities from national laws.
- International Commercial Businesses – Profit seeking organizations created and managed by private citizens for the purpose of providing goods or services.
- Non-Governmental Organizations (NGOs) can be:
    - Independent, non-profit-seeking organizations formed from a variety of religious and humanitarian motives.
    - Private Voluntary Organizations (PVOs) pursuing a common purpose.
    - Transnational organizations of private citizens that maintain a consultative status with the Economic and Social Council of the United Nations.

Military forces are certainly involved in stability operations but civilian organizations, governmental and non-governmental as well as US and non-US are also required partners. These partners have different, but interdependent, roles towards the common goal. Moreover, the interdependent roles of the different partners will vary based on the cause and urgency of the situation and will vary over time as conditions change. It is the inability to assess this interdependency that is the major shortcoming in analytic approaches that pertain to stability operations.

Stability operations are military, civilian, and multi-national. Analytical approaches to stability operations are also military, civilian, and multi-national. There is no shortage of good analysis being done. A failing is that we are conducting military, civilian, and multi-national analyses independently. It may be that analysts from the military, civilian, and multi-national analytical communities, working together, can address the most significant shortcoming — the inability to assess the interdependency of military, civilian, and multi-national efforts during the conduct of stability operations.

IV Metrics for Stability Operations

There are basic rules of metrics, regardless of whether they are for stability operations or any other analytic endeavor. First, an analyst should never start with metrics, or asking about metrics. An analyst should always start with goals and objectives. Sometimes it is useful or necessary to cast the problem first as a question (i.e., "What are you trying to accomplish?"), then transition to goals and objectives.

For military operations, again irregardless of whether they are for stability operations, developing metrics to determine the importance or value of something is a definition of assessment. Military assessment relies on the proper metrics. Military assessment is not analysis, per se, but is a key function of a military staff. According to Marine Corps Doctrinal Publication 1- 0 *Operations*, military assessment is "The continuous appraisal of military operations to determine progress towards established goals." Military assessment focuses on outcomes and is oriented to the future. History has shown that operational and strategic ambushes occur when we get caught up in the "current fight." The key is know what to measure and why before deciding how to measure it. What to measure is a function of goals and objectives.

Analyses that incorporate simulations also rely on the proper metrics. Those metrics that prove useful to military and civilian decision makers who are conducting stability operations are the same metrics needed to fuel simulations of stability operations.

Much is being done in the stability operations arena towards setting goals and objectives, then developing metrics. The Defence Science and Technology Laboratory, Ministry of Defence, United Kingdom has developed a *Code Of Best Practice for use of Measures of Effectiveness (MOE) in Support of Operations*. Their analysts felt a code of best practices was needed because, in stability operations, metrics may be unique to each operation, difficult to define, and possibly difficult to collect. Good MOEs are: mission related, comprehensible, meaningful, measurable (to include opinion), sensitive, timely, cost effective to obtain, and culturally/locally relevant.

Section III indicated that increased preparation yields increased effectiveness. There are country and regional indicators that can be measured in critical areas before stability operations occur. These cannot only alert us to potential areas of risk, but could also identify key indicators towards setting goals and objectives (leading to metrics) for recovery. Indicators could be:

- Political — percent of women and minorities in government leadership positions, extent of press freedom, human rights adherence, transparent public budgeting, corruption, border controls, appropriate power-sharing, etc.
- Security related — civilian control of the military, proper funding for military and police, judicial oversight of police, presence and impact of militias, arms flow, violent crime rates, etc.
- Economic — income distribution, inflation, unemployment, under-employment, existence of Black Market, economic shocks, transparent public budgeting, price of staple goods, etc.

- Social — literacy rates, disease rates, government response to natural disasters, population growth rate, urbanization, life expectancy, etc.

Public health is a key factor in stability operations. Goals and objectives have to be set and metrics developed. NGOs are prolific in the international public health arena. Increasingly, the humanitarian NGO community is committing itself, as a community, to standards for what each member is expected to do. They are agreeing on what the goals and objectives should be. Not only is this community converging toward agreement about goals and objectives, the NGO community is also converging toward agreement concerning metrics for monitoring and evaluation. There is increasing agreement on minimum standards such as 3.5 square meters of space per person, 15 liters of water per person per day, 2,100 kilocalories per person per day, and at least one community health worker per 1,000 people. Regarding metrics, this community feels that numbers without denominators tend to be meaningless and useless. ***Much*** more important are rates and ratios. NGOs stress obtaining cognizance of the distribution of the entire population, not just focusing on the convenient "average."

Working Group 2 conducted an exercise to exemplify the process of goal setting first, then metric development. During a plenary session, Dr. Barbara Stephenson, S/CRS, outlined a dynamic planning framework for conflict transformation during stability operations. That framework involved a Post-Conflict Reconstruction Essential Task Matrix as a reference tool for comprehensive planning. Using this structure, Working Group 2 divided into five subgroups according to the below areas:

1. Security
2. Humanitarian Assistance and Social Well-Being
3. Economic Stabilization and Infrastructure
4. Justice and Reconciliation
5. Conflict Transformation

Each of the subgroups was to select representative tasks in its assigned area, propose measures for those tasks, and then to review the measures using the attributes presented in the previously mentioned Code of Best Practices (COBP) from the Defence Science and Technology Laboratory, Ministry of Defence, United Kingdom. An additional subgroup was formed to look at the overall concept of stability operations and to identify the theories that the measures would be supporting.

Summary findings are presented here for each subgroup.

1. Security – This subgroup chose to identify four tasks that would require measures and identified four tasks that would be implied by the chosen four.

Goal: Establish a safe and secure environment

Task 1: Implement a plan for disposition of Armed and Other Security Forces, Intelligence Services and Belligerents

Task 2: Identify future roles, missions and structure

Task 3: Vet senior officers and other individuals for past abuses

Task 4: Coordinate and integrate with a Plan for Disarmament, Demobilization and Reintegration of Combatants

Implied Tasks

- Develop an Effects-Based Plan
- Coordinate and integrate the Plan with Plans to disarm, demobilize, and reintegrate combatants
- Develop a feasible Data Collection Plan
- Validate Inventory of Personnel and Materiel

Metrics: The metrics chosen for this group, which were reviewed against the attributes of the COBP, were oriented toward the sub-goal of managing the disarmament and demobilization of various forces and militias as well as war crimes aspects. Some of these metrics were percentages and rates for the number of personnel involved (an inventory), and those who were prosecutable, in custody, in the judicial system and so forth. Each of these metrics depends on the judicial process established and, in their whole, would provide insight into the functioning of that process.

2. Humanitarian Assistance and Social Well Being – This subgroup chose to approach the task matrix at the goal level. They chose the goals of Education of Children, Shelter, and Humanitarian Non-Food needs.

The Education of Children metrics that were reviewed against the COBP included percentage and counts of children enrolled in legitimate places of learning as well as actual capacity availability of these places of learning. The group was definitive on the need to look at all legitimate places of learning and not to fixate on formal, constructed, schoolhouses.

The Shelter Metrics included percentages and counts of both short-term minimal housing and sustainable long term housing. The subgroup also chose the goal of 'Non-food items' which is not intuitive as stated. However, when the subgroup explained that this is the element of shelter that includes blankets and clothing and results in non-medical trauma and environmental deaths, the relationships were made clearer. The metric proposed for this was a count of the number of people diagnosed with non-medical trauma.

Other insights from this subgroup included the need to broadly choose data sources across both governmental and non-governmental domains.

3. Economic Stabilization and Infrastructure – The goals surrounding employment generation issues were reviewed by this subgroup. This review was conducted using the three phases of the Task Matrix (Initial Response, Transformation, and Fostering Sustainability). The subgroup's corresponding goals were: respond to immediate needs; establish a foundation for development; and, institutionalize a long-term development program. Each of these had identified objectives and potential metrics identified.

For Employment Generation Initial Response, the objectives were –

- A demographic of the skill sets by township, province, region, and nation.
- A priority list of required skill sets including public and private sector jobs.

These objectives can be measured by identifying the number of local leaders who have been approached and interviewed. Note that this is not the employment number but an initial measure of the progress toward the goal.

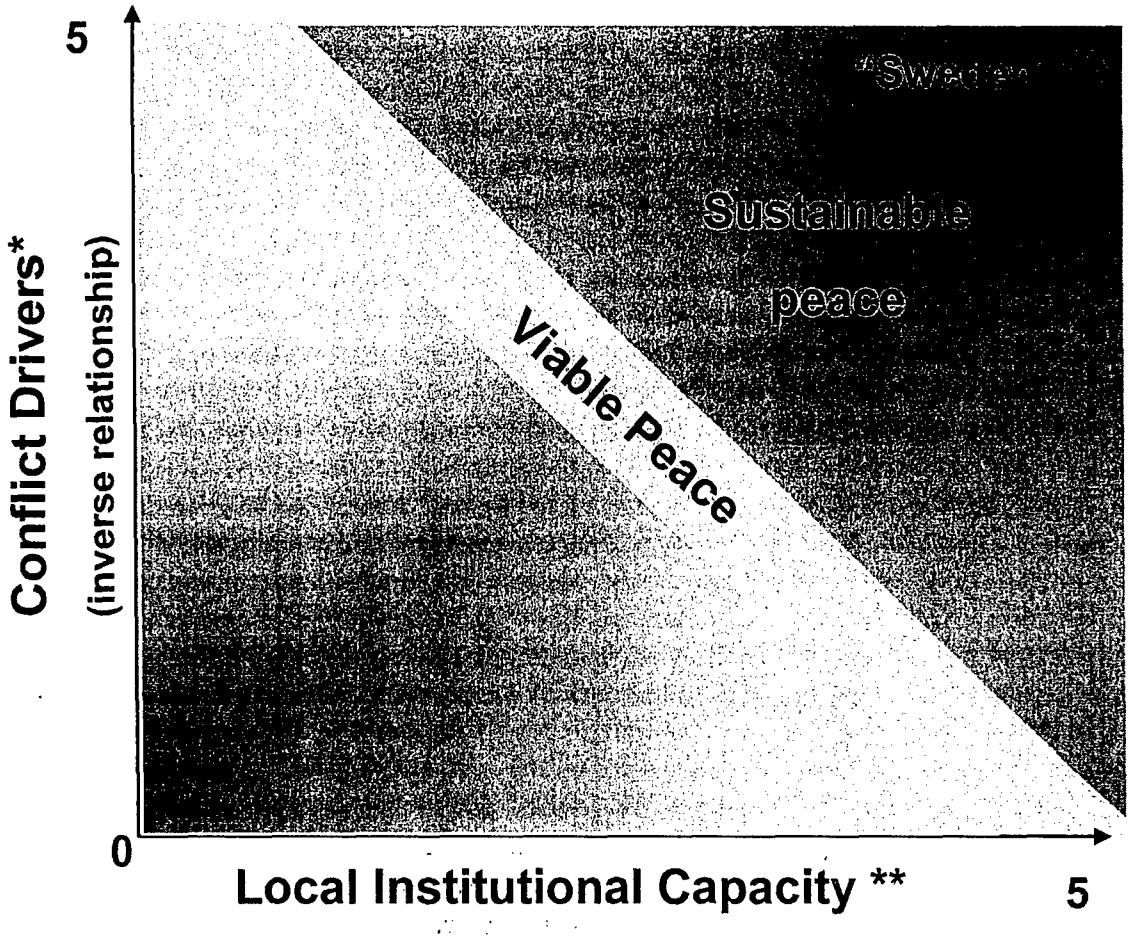
For Employment Generation Transformation the objective was Institutionalized Human Resource Offices (employment centers). The metric identified counted the number of offices that were needed and opened as well as comparative employment rates within the local and neighboring regions. A constructed measure of fill rates by skill set was identified as useful if the data could support its development.

For Employment Generation Fostering Sustainability, the final phase, the objective was an internally supported job market. Unemployment rates (suitably defined for the culture), growth rates and external support were all identified as potential metrics.

4. Justice and Reconciliation – This subgroup looked at the Criminal Justice System, the Legal Code, Organized Crime, Law Enforcement Operations, Indigenous Police, and several other tasks. They provided the overall working group a list of potential, reviewed, metrics. These are, in part:

- Number of police/investigators/other personnel per 10,000 population
- Proportion of police trained to specified (Interpol?) standards
- Proportion of police who are indigenous
- Time from arrest to arraignment
- Time from arraignment to trial (broken down by categories of crime)
- Number per 10,000 population — proportion of all detainees held more than 3(?) days without arraignment
- Proportion of detainees who died in police custody or shortly after release
- Number of police killed/number of people killed by police/ratio of these
- Number of complaints about police corruption/brutality [set up anonymous phone tip line]
- Number/capacity of secure facilities to store evidence, especially of alleged war crimes
- Amount/importance of lost evidence

5. Conflict Transformation Concepts – At the specific request of the representative from S/CRS, the working group created a special subgroup to look at the theory and conceptual issues involved in Stability Operations. This was a huge task but the subgroup was able to synthesize several differing theories and to propose the graphical tool shown in Figure 2 to help understand the issues surrounding these operations.



* **Currently using the Failed States Index**

** **Currently using the World Bank Institute metrics**

Figure 2

From their discussions they proposed several principles for consideration. These were:

- Establish determinable strategic goal(s).
- Identify and have common interagency agreement on the Center of Gravity (CoG)
- From CoG, determine critical capabilities, requirements, and vulnerabilities.
- Identify, in political, military, economic, social, infrastructure, and information (PMESII) framework, those observable things that would be different in the environment if the strategic goal(s) were met.

The principle contribution of this subgroup was a reworking of the tipping point graphic used in the book[1] cited by Dr. Stephenson in the plenary presentation. The graphic cited

[1] Covey, Jock, Michael Dziedzic and Len Hawley (Eds), 2005, *A Quest For Viable Peace*, United States Institute for Peace Press, Washington, D.C.

compared the strength of spoilers in a peace process to the strength, or capacity, of the local governmental institutions. The tipping point was then defined as the point in time when the growing capacity of the governmental institutions equaled the diminishing strength of the spoilers of the peace process. The subgroup took this concept further in Figure 2.

The vertical axis of Figure 2 represents a measure of the fragility of a state or region. It is indexed from a low of zero – failed state, indicating maximal fragility, to a high of five indicating minimal fragility. It is actually an inverse relationship inasmuch as the number and strength of conflict drivers is at its maximum at fragility level 0. The horizontal axis represents the institutional capacity from a complete lack, zero, to a notional maximum of five. The annotation of 'Sweden' is simply to represent a fully functional and capable state.

There are databases and indexes that would allow every country of the world to be plotted in this space. However, all of those plots would be entirely subjective. If, a region or state were identified as in the lower left portion of this space, the goal of the international community's intervention should then be to take actions that would increase the measures until the lower bound of the Viability zone is reached. This viability boundary represents the same concepts as the tipping point previously discussed, but also allows for the possibility that the point is not singular but represents a zone of change. If the international community continues to work towards the upper right of this space, crossing the upper boundary of the Viability zone is seen as a hand off from the intervener to the local government. The assumption is that in the upper right space, the country or region should have sufficient capacity to continue stability. There may still be development programs that are required from the United Nations or other bilateral sources, but the country is managing its own future.

This concept helps one to understand the movement of a region or state, and to conceptualize end states and objectives. It does not, yet, provide the intervener with the information needed to design the specific set of tasks that will move a state in one direction or the other. That theory is still needed.

Clearly, there is no set list of metrics that the international community must use. However, as seen in the working group, there is a need to more clearly understand the various measures that are being used, and to understand the way that those measures provide insight into the achievement of the overall goals of the operation. The key, as illustrated in each subgroup, is to start with realistic, achievable, clearly defined goals and objectives. In stability operations, most of the goals and objectives will not be military.

V Agent-Based Models

During a plenary session, Mr. Walter W. Hollis, FS, Deputy Under Secretary of the Army (Operations Research) and MORS Sponsor, specifically challenged the workshop concerning agent-based models.

What are agent-based models and how good are they? Needless to say, examples of agent-based models abound. Appendix A of this report describes the agent-based models reviewed during the workshop.

There can be no examination of agent-based models relative to stability operations or any other application without a clear description of what an agent-based model is. Working Group 1 conducted a session to develop agent-based modeling definitions and concepts. The results of this session included: agent characteristics; the definition of an agent, agent-based modeling characteristics; the definition of agent-based modeling; the definition of agent-based models; and, agent-based model dimensions. The results of this session follow:

Agent Characteristics

- Software object
- Embedded in a simulated world (in silicon)
- Individual world view/model (sense, perceive, think, decide, act)
- Autonomous ("Agents can say no") (no external or centralized control)
- Set of interfaces with its environment and other agents

Agent Definition

- An autonomous software object that makes decisions and takes action based on its perceptions about its environment.

Agent-Based Modeling Characteristics

- Has agents
- Has environment
- Agent interactions with agents and environment
- Scenario (rules/story/initial conditions/scripts/etc)

Agent-Based Modeling Definition

- *Agent-Based Modeling:* Act or process of representing a real-world or conceptual system or process through interactions among multiple agents situated within an environment.
- *Agent-Based Model:* Software representation of a real-world or conceptual system or process achieved through interactions among multiple agents situated within an environment.

Agent-Based Modeling Dimensions

- Autonomy
- Multiple agents
- Heterogeneity
- Complexity (Intelligence level) of agent
- Interactions with other agents
- Interactions with the environment
- Environment

The most important thing to realize about describing ABMs is that there are many models and simulations may have degrees of "ABMness" characterized by the dimensions above. The workshop did not view a binary classification of a model's "ABMness" as useful. To some extent, all current and future military simulations may have a degree of "ABMness."

Another issue concerning agent-based models oft expressed within the military operations research community concerns Verification, Validation, and Accreditation (VV&A) of agent-based models. Working Group 1 addressed the following questions:

- Can agent-based models be validated?
- If so, how?
- For what purposes?
- Should agent-based models be validated?

Definitions: Informal

- Verification: Did I build the thing right?
- Validation: Did I build the right thing?
- Accreditation: Should it be used?

For informal definitions there was consensus that VV&A issues should be addressed in the development of any agent-based (or other) model.

Definitions: Formal

- **Verification:** The process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications.
- **Validation:** The process of determining the degree to which a model and its associated data provide an accurate representation of the real world from the perspective of the intended uses of the model.
- **Accreditation:** The official certification that a model, simulation, or federation of models and simulations and its associated data is acceptable for use for a specific purpose. [DoDI 5000.61]

Considering the formal definitions there was a range of views, ranging from strong interest in having some VV&A'd agent-based models to concerns that forcing agent-

based models into the current VV&A process will severely restrict their application and limit their utility.

Current VV&A efforts include using engineering and physics-based components, often relying on data from real world (accredited) sources. For agent-based models, however, not all applications fit into current physics-based paradigms. Accrediting data of human behavior such as decision making, for example, simply may not be available. This particularly applies to stability operations. Nevertheless potential approaches include Turing tests and establishing credibility via transparency.

Quite often, in the case of legacy models, accredited data are known to be wrong. This may be accepted for existing models but cause validation problems for new models. Are conventional models held to the same scrutiny as newer agent-based models? Are other non-accredited models (e.g., spreadsheets, etc.) held to the same scrutiny?

Current VV&A efforts predominantly focus on avoiding risk in acquisition decisions and providing a stamp of approval that a model is suitable for training. Agent-based models, however, have been used for much more than acquisition and training and have been most effectively used as exploratory tools. Avoiding the questions agent-based models are exploring is also a risk. Agent-based models are no different from any other model inasmuch as assumptions should be clearly documented. Accreditation should not be used as a crutch to avoid thinking about the model.

In summary, there are fundamental stability operations questions with substantial risk that cannot be addressed with current models.

- Agent-based models are currently being used by a wide range of military organizations.
- Agent-based models provide the ability to conduct many runs and screening for higher-resolution methods (live experiments).
- Agent-based models provide the ability to begin to address stability operations analysis issues that legacy simulations and methods might not be able to address.
- Agent-based models may be used as planning tools for stability operations.
- Agent-based models appear to provide promising ability to represent behavioral and social concepts that are important to success in stability operations.

All models are wrong,
but some are useful.
-- E. P. Box

VI Wrapup

Two things are patently obvious. First, stability operations currently are and, more than likely in the foreseeable future, probably will be the primary occupation of the United State's military forces in a joint and coalition environment. Second, the fundamental basics for analysis in support of stability are the same fundamental basics as for any other analysis. Analyses require a decision maker customer. They also require an assessment framework, tools, metrics, data, experienced analysts, and funding. Analysis in support of stability operations, however, places a premium on a traditional hallmark of operations research - the interdisciplinary approach.

This workshop has shown that not only are analysts within the military operations analysis community wrestling with the problem of conducting analyses in support of stability operations but, in addition, analysts outside of our military operations analysis community are doing a considerable amount of good analytical work on the same problem. There are a lot of different analytical approaches being developed and numerous metrics being worked out for stability operations in general and for specific cases.

Our normal military operations research excels at aggregating companies into battalions. Analyses in support of stability operations face the task of aggregating emotions, motivations, and needs into security, permanence, and consent. The interdisciplinary approach calls for a different set of players sitting around the analysis table than we are accustomed to. In order to make it work there will need to be common terms and definitions as well as a transparent and compatible planning process for the conduct of stability operations.

Current analytical tools are inadequate; more appropriate tools are needed. This workshop has put forward a definition of agent-based models, realizing full well that its proffered definition, similar to other definitions of agent-based models, apply to many models, legacy and otherwise, that are not considered to be agent-based models. Near the end of the workshop, the Synthesis Group summarized the "good" (features we want to keep), the "bad" (features we do not want to keep that can be fixed), and the "ugly" (features we do not want to keep but are inherent and cannot be fixed) of agent-based models. Not surprisingly, all of the assets and liabilities did not apply to all agent-based models and many of the assets and liabilities pertained to models that are not generally considered to be agent-based models.

This workshop has looked into the verification, validation and accreditation of agent-based models and has raised some interesting issues. In a larger sense, however, one does not "VV&A" a class of models. No one does that. It is a process for an individual model relative to a particular application. The fundamental basics for good analysis have not changed. Problem definition is first. The analyst then defines appropriate measures of effectiveness, and then selects or develops the best tool for the job.

This workshop recommends that analysts in the military operations community continue to follow good analytical procedures by evaluating potential analytical tools for the task at hand. This workshop does not recommend that MORS treat agent-based models as a special topic in future workshops or other venues, because the term 'agent-based model' does not have unique meaning.

This workshop recommends that MORS Sponsors, within their organizations, examine, consider the use of, and provide analytical feedback to the S/CRS on the "Post Conflict Reconstruction Essential Task List."

Finally, this workshop recommends that MORS continues to reach out to non-DoD operations research analysts to become members and that MORS Sponsors consider formally inviting non-DoD analysis organizations to be MORS sponsors.

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Agent-Based Models and Other Analytic Tools in Support of Stability Operations

Appendix A

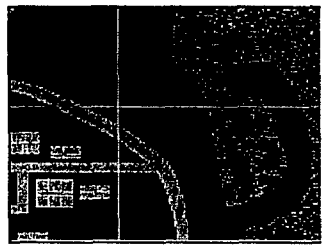
Examples of agent-based models abound. This appendix describes the agent-based models Working Group 1 reviewed during the workshop. Each page of the appendix contains a quad-chart and, in most cases, accompanying explanatory notes.

Agent-Based Modeling Efforts and Requirements in DRDC/CF Canada
Jed Woodill, DRDC-CORA: LFORT

Methodology: Validation of ABM (MANA).

- Output analysis
- Testing for significance across a suite of MOEs

Purpose: To give decision makers confidence about ABM's capability to contribute to decisions.



Analysis Issues that Need to be Addressed

- Decision maker acceptance of ABM is an issue, even for pre-screening
- Relationship between input variables under changing conditions is not well understood or modeled
- Currently conducting a series of tests to determine if MANA is capable of producing results consistent with CAEn

Capabilities

- MANA provides different capabilities vice CAEn
- Some better, some worse
- Have itemized over 1000 capability factors that would be useful in a conflict simulator
- Ratings:
  - CAEn ~46%
  - MANA ~28% (but much better on human factors)

Main Point

- CAEn is useful (decision makers accept it); trying to get to the same state with MANA.

Secondary Points

- MANA may end up just being a supplementary tool for more conventional conflict simulators;
- If so, will continue looking for better ABMs

Election Peace Support Operations in PAX

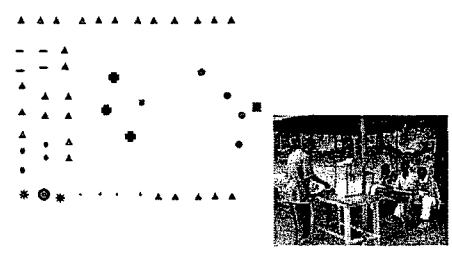
Susan M. Sanchez, Gunther Schwarz, Suat Kursat Gun, Han Hiong Ang, NPS

Description

Exploration of election operations in Iraq, involving

- Multiple ethnic/religious groups having different underlying motivations and behavior
- Controlled access to election region
- Various rule sets for peace support units' interactions with civilians
- Duty posts, media booths, barriers

Purpose of PAX: a modeling platform appropriate for exploring long and short term effects of peace support operations.



Areas that can be Addressed

MOEs:

- Escalation (overall, inside/outside election area)
- Voter participation
- Attacks by civilians against other civilians
- Civilians' motivations (fear, anger, readiness for aggression) at the end of the operation

Explore impact of, e.g.,

- Number of civilians/initial characteristics
- Leader of a civilian group
- Duty posts, media booths, barriers
- Civilian group average characteristics
- Diversity within civilian groups

Capabilities

Within data-farming framework, can provide

- Initial insights on drivers of participation/escalation across various civilian compositions
- Help identification robust tactics/training/rules
- Provide structured framework for discussion

MOEs are associated with short and long term success

Flexible modeling of civilian motivations, cultural characteristics, individual and group dynamics

Caveats

- Intended for insights, not numbers
- Uses theory from social sciences, but other theories exist
- Lack of "real data" for feeding model

PAX is a modeling environment developed for the German Army specifically to explore peace support operations. Motivated by recent events in Afghanistan and Iraq, NPS students have been using PAX to examine drivers of escalation and voter participation in elections.

Pythagoras

Edd Bitinas, Northrop Grumman, MCWL/Steve Burnett, NPS

Tool Description

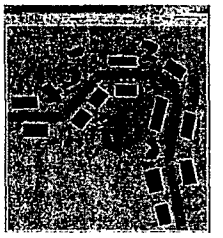
- Agent-based modeling environment
- GUI and CLI modes
- User defined agents

Analysis Issues

- Behavior driven scenarios
- Small unit combat
- Non-combat confrontations
- Influence and/or attrition
- Nothing else available

NPS Analysis

- Currently developing capability to import empirical behavioral inputs into Pythagoras



Capabilities

- Lethal/non-lethal weapons
- Dynamic affiliations
- Behavior changes
  - Commands, influence and/or events
- Soft rules

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Main Points

- A versatile, widely applicable modeling environment
- Applicable to traditional and non-traditional scenarios

Secondary Point

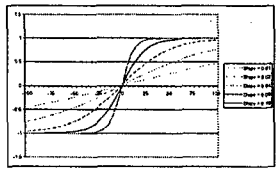
- Internationally disseminated and used

Agent-Based Modeling for Stability and Support Operations Analysis
Matt Koehler, MITRE

Tool Description: An agent-based model of civilian interaction and attitude change

Tool Purpose: This tool is for modeling the dynamics of population attitude change to understand how populations may be moved from dissatisfied to satisfied

The Ess Curve of Contentment



Ess curve used to transform unbounded experience into a bounded contentment

Analysis Issues that can be Addressed

- Given a frequency of negative events, what frequency/magnitude of positive events will counter them.
- With additional development the model could be validated against other accepted work, i.e. Dr. O'Brien at CAA

Capabilities

- Heterogeneous agents
  - Divided into relevant groups
- Explicit spatial effects of events
- Could include social networks and other communication media
- Could include other agent types

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Main Points

- NetLogo is a very good prototyping environment
- Many of these systems can be captured with few elements
- Can't overemphasize heterogeneity and explicit space

Secondary Points

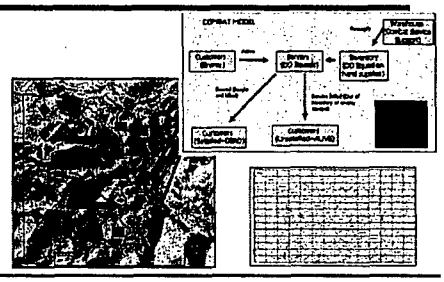
- There are potential methodologies for validating these types of models (eg, macroeconomics uses aggregate measures of individual behavior)
- In this particular case, the work of Sean O'Brien at CAA may be useful

Supporting a USMC DO Platoon: A Quantitative Analysis

Capt Matthew Bain, USMC, HQMC I&L LX

Methodology description

- Use MANA ABM to simulate DO border defense scenario
- NOLH and other efficient design techniques and supercomputing to generate data
- Apply simulation insights to requirements analysis to make logistical planning decisions



Issues it can address

- Small unit logistics challenges
- Long term effects of enemy action against various friendly capability and support sets
- Ability of a distributed unit to maintain security in a region over a long term mission
- Comprehensive decision making analysis problems in which simulation has a supporting role

Capabilities of Methodology

- Think through assumptions
- Distributional assumptions replaced by combat interactions which can be systematically varied
- Can be done quick turn-around

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Main Point

- To improve logistical planning capabilities, this work could augment real-world logistical experience with simulation-based experience

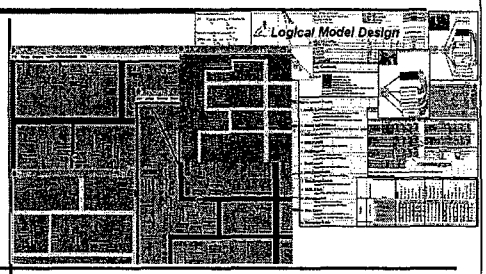
Secondary Points

- Methodology is useful for a wide variety of problems; can ask a lot of "what if?" questions
- ABM and data farming can be incorporated into iterative concept development to make it more quantitatively rigorous
- Research is relevant enough to brief to USMC decision makers

Comparison of a DO Force to a Traditional Force in Urban Combat
Capt Mike Babilot, USMC NPS

Tool Description: Agent-Based Model created in MANA modeling environment which includes a logical design spreadsheet tool, involves MOUT and Fallujah terrain.

Tool Purpose: Explores the application of Distributed Operation (DO) forces in urban combat on a variety of terrains.



Analysis Issues that can be Addressed

- Terrain of Fallujah and MOUT Range 200 at 29 Palms modeled
- Show DO platoon value in urban combat
- Clutter found to have a significant effect on battle outcome
- Target recognition found to be most critical in resulting battle outcome

Capabilities

- Modeling with sound logical foundation
- Fully reproducible
- Planning model/training tool
- Examine "What-If"
- Explore outcomes for relationships and discovery

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Main Points

- Vanguard effort that has created a viable model to explore distributed operations in urban combat
- Results briefed to CG, MAGTF TC; will be incorporated into MOUT site design

Secondary Points

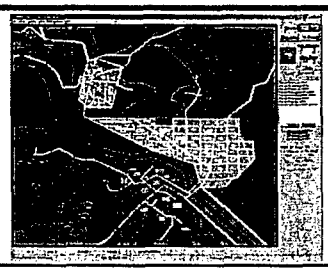
- Allows exploration of parameter space and tradeoffs in agent capabilities
- Logical Excel-based design tool that's useful to a broader ABM community
- LOS elements of MANA are being explored to be incorporated into TECOM software package (range control management software)

An Exploration of UAV in the Army's FCS Family of Systems

CPT Chuck Sulewski, NPS

Tool Description and Purpose

- Map Aware Non-Uniform Automata (MANA) ABS
- Explore the greatest range of possible outcomes with the least set-up time
- Excel Spreadsheet Modeling
- Provides methodology to transfer real world data into modeling parameters (SCALING THE SCENARIO)



Analysis Issues that can be Addressed

- Goal is to identify the number of CL I II and II UAVs where precision munitions enhance or hamper the UA's ability to fight
- Replicates a UA Combined Arms Battalion in the attack [North East Asia (NEA) provided by TRAC-WSMR]
- Research Scope does not include comparing analysis results to that of the CASTFOREM AoA

Capabilities

- Screening technique
- Local interactions among agents emerge into a "global" behavior
- Agents interact with each other in non-linear ways, and "adapt" to their local environment
- Examines a broad array of questions when complimented with a robust DOE

Main Points

- Research Scope does not include comparing analysis results to that of the CASTFOREM AoA, but:
  - a) It immediately provides a screening tool to weed out unnecessary parameters for CASTFOREM scenario building
  - b) If compared to CASTFOREM it can be the beginning of the MANA "V and V" process

Secondary Points

- Cataloging modeling methodology via spreadsheet modeling and MANA scenarios is of great importance because it provides quick set up and is flexible to changes
- Robust DOE compliments ABM

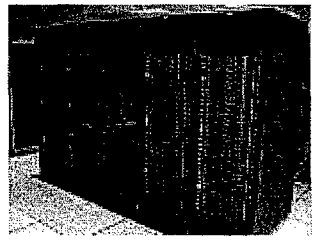
Data Farming

Gary Horne, Referentia Systems

Description

- Distillation Models
- High Performance Computing
- Data Visualization
- Rapid Prototyping Processes
- Parameter Space Exploration
- Collaborative Environments

Purpose: to collaboratively explore the vast space of possibilities inherent in the questions that our decision makers face in today's uncertain world.



Some Areas that can be Addressed

- UAVs in FCS
- Urban Combat
- Peace Support Operations
- Logistics in Distributed Operations
- Human Behavior in SASO
- SASO decision support

etc.....

Capabilities

Agent-based models may be more useful in addressing SASO and other questions when put into the larger process of Data Farming, allowing for...

- The understanding of huge landscapes of possibilities
- The screening of variables
- The discovery of outliers
- Understanding the nature of variables

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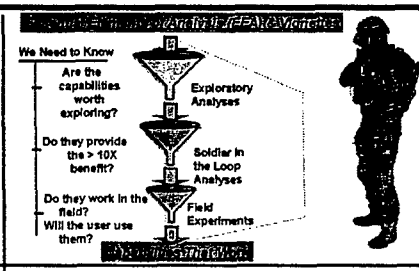
Future Force Warrior ATD: Integrated Analysis and Experimentation
Bill Harris, Natick Soldier Center

Description: Future Force Warrior is an Advanced Technology Demonstration sponsored by the US Army Natick Soldier Center for the purpose of enhancing the capabilities of dismounted Infantrymen and small combat units.

Purpose: Units equipped with the Future Force Warrior technologies, ideally optimized for combat, will also be required to conduct Stability Operations.



Analysis Issues that can be Addressed

- Do FFW capabilities increase the effectiveness of the small combat unit in Stability Operations?
- How?
- How much?
- What is the cost benefit of FFW capabilities employed in the conduct of Stability Operations?

Capabilities: An ABM used to simulate FFW capabilities in Stability Operations could be required to model -

- Enhanced situational awareness
- Enhanced unit mobility
- Enhanced mission planning and rehearsal
- Interoperability with Future Combat Systems platforms such us Unmanned Aerial Vehicles, Unmanned Ground Systems, and Unattended Ground Sensors

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Main Point

- Looking for different approaches to analyze increased small unit effectiveness in SASO due to DOTMLPF changes

Secondary Points

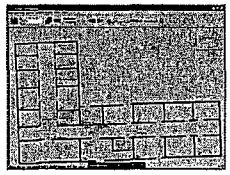
- Currently have an approach for optimizing small combat units for combat applications
- May be appropriate to understand that approach for M&S efforts elsewhere

Utility of Conventional Simulations of Combat in the Analysis of SASO
Rob Alexander, SAIC

Tool Description: Conventional simulations of combat may still have some utility in the modeling of SASO. Entity-level models that address dismounted infantry operations are most applicable to SASO.

Tool Purpose: Sims that model small-unit dismounted combat operations, construction of infrastructure, resupply operations will be most useful in SASO

Example Conventional Sim: SUTES



Infantry platoon clearing a building.

Analysis Issues that Need to be Addressed

- Characterizing the SASO domain
- Operations Planning
- Effectiveness of various capabilities in conducting SASO
- Cost-effectiveness of various technologies in equipping SASO forces
- Effectiveness of various TTP in SASO

Conventional Simulations Capabilities

- **Could address**
  - Reconnaissance, patrolling, checkpoints, point protection, cordon-and-search or clear-and-hold operations.
  - Infrastructure repair.
  - Resupply operations
- **Cannot address**
  - Social, civil, and religious structure
  - Model infrastructure dependencies
  - Attitudes and behaviors of populace.

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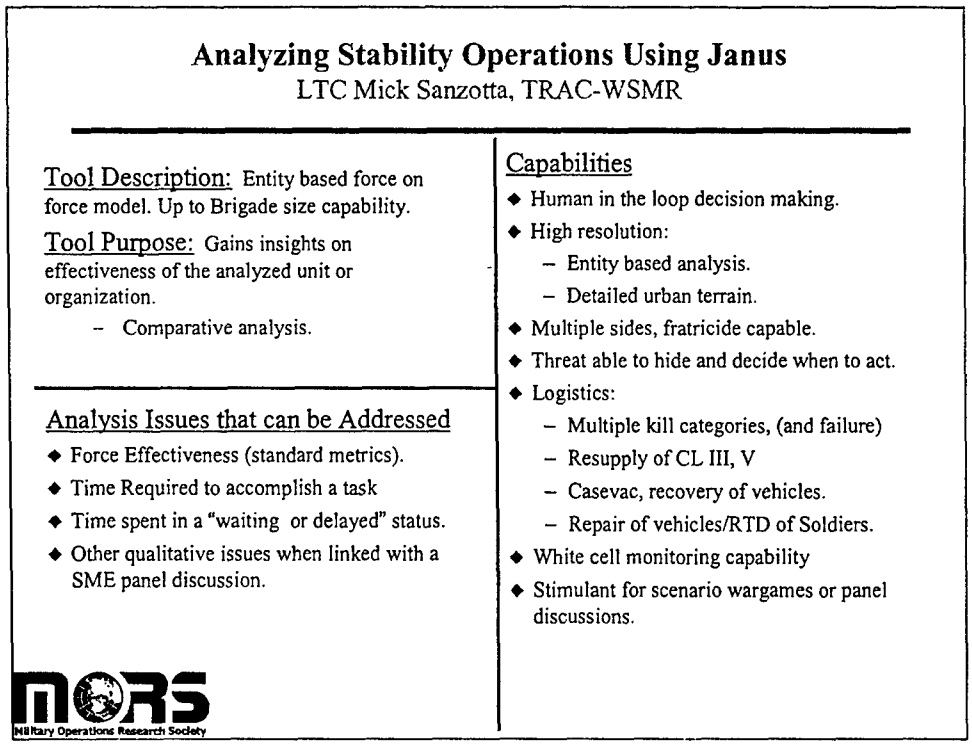
Main Point

- Conventional simulations retain some utility in modeling SASO.

Secondary Points

- ABMs can be used to inform conventional simulations.
- ABMs may be appropriate to address issues that conventional simulations are incapable of addressing
- Might imbed agent-based behavior into the decision making aspects of conventional simulations



Main Points

- Time required to accomplish a task
- Time spent in a "waiting or delayed" status

Secondary Points

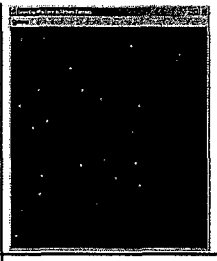
- Sustain: Ability to play 6 sides in Janus
- Improve: Add ABM as a White Cell stimulator

Army Model of Indigenous Guerilla Operations (AMIGO)

LTC Rob Kewley, Department of Systems Engineering, USMA

Description: Proof of principle model of population support during counter-insurgency operations.

Purpose: To capture the high level interactions between military actions and indigenous support or non-support of counter-insurgency operations.



Red areas represent the population's perception of a secure environment

Analysis Issues

- What resources are required to secure populated areas given a certain level of guerilla activity?
- What resources are required to provide and secure civil activities in order to develop and maintain a stable and secure environment resistant to guerilla activity?
- What are the interactions between combat action and indigenous support for either guerilla activity or the US-supported regime?
- What are the critical factors which have the greatest effect on guerilla activity, and how can they be managed to enhance US success?

Capabilities

- Indigenous attitude model – Quantifies population perceptions and support
- Simple combat action model – creates events that effect perceptions of the population
- Intelligence model – Crudely represents the relationship between population support and the availability of HUMINT.
- Civil assistance model – Crudely represents impact of generic civil assistance on perceptions

Main Point

- Proof of principle model of population support during counter-insurgency operations

Secondary Points

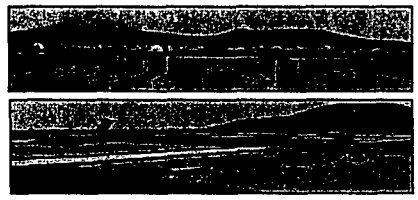
- Captures the high level interactions between military actions and indigenous support or non-support of counter-insurgency operations.
- Limitation: Highly abstract representations of population support and the actions that affect them.

Agent-Based Simulation in Operational Environments

Christopher Ludka, SAIC

Tool Description: EXPEDITER is a high fidelity agent-based simulation model of USAF airbase ground operations and sortie generation

Tool Purpose: EXPEDITER allows detailed analysis of base operations and operational impacts of full spectrum of threat. Supports Operational Effectiveness Assistance (OEA) to study ground-based functions during the sortie generation process for counter-CBRN implementation of a full range of USAF flight operations



Fighter turn operations (top), Airlift turn operations (bottom)

Analysis Issues that can be Addressed

- Scheduling and resource capacity studies (flight schedule, minimum equipment analysis)
- Threat, vulnerability, and degrade analysis
- Planning and Doctrine (C-CW CONOPS, alternative basing analysis)

Capabilities

- Detailed event driven representation of airbase sortie generation/airlift operations
- Dynamic C2 design allows realistic interactions between airbase systems, facilities and processes
- Allows direct integration of a full spectrum of threats and avoids cascading operational deterioration with excessive stresses
- Ability of the system to recover from abnormal stresses (such as a chemical attack) in a meaningful and graceful manner
- Scalability of all of the above

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Main Points

- Agent-based simulation provides a scalable architecture for modeling operational environments
- Allows the ability to widen the scope and breadth of analytical questions that can be addressed
- Analytical results are verifiable, logical consequences of interacting of systems

Secondary Point

- These agent-based simulation advantages have led to our ability to evaluate stresses (i.e. threat, resource surge demand, etc.) on an airbase within an operational context (i.e. sortie generation)

MOOTW FAST Toolkit: Integrated Analysis for SASO

Tom Couture, Joint Staff, J-8 WAD

Tool Description

This is a loose coupling of four distinct applications:

UOB-DAT: A database querying tool

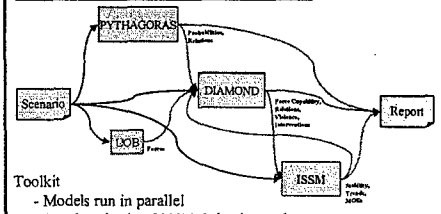
Pythagoras: An Agent-Based Model

DIAMOND-US: A "ground truth" simulation depicting interactions between players (Military, paramilitary, population, factions, terrorists, etc.) as SASO Missions are executed in a defined Region.

ISSM: A spreadsheet application used to "score" the status of lasting and durable peace, and evaluate interventions in regions functional sectors.

Tool Purpose: Analyze SASO at Theater Level

MOOTW FAST Toolkit Architecture



Toolkit
- Models run in parallel
- Synchronized at 30/60/90 day intervals
- Man-In-The-Loop Integrated Analysis

Analysis Issues

- Toolkit can address impact of actions taken by regional "players" on Stability.
  - Could be used to test possible impact of interventions.
  - Could be used to investigate "trades" between generic assets (infantry) and specialized resources (military police and engineers)
- Requires extensive use of analysts/subject matter experts (SMEs)

Capabilities

- The toolkit provides an adequate representation of activities and resources used in SASO.
- The toolkit allows planners to investigate possible consequences of interventions upon functional sectors of the region.
- NOTE: Toolkit does not provide a detailed representation of Combat.

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Main Point

- Show an approach to modeling SASO using a suite of tools:
  - A conventional simulation
  - An ABM simulation
  - A spreadsheet model
  - A database
- Each of the tools could be used independently
- Proof of concept – not used yet to inform decisions

Secondary Point

- Still an immature suite; heavily SME/analyst dependent
- Going through a transition; current development is stalled

Synthetic Environments for Analysis and Simulation (SEAS)

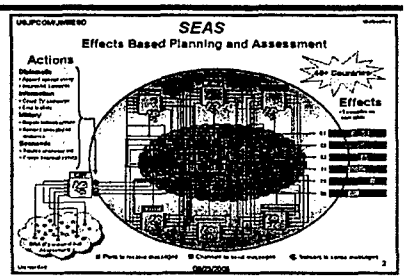
CDR Gregg Martin, JFCOM J-9 / Dr. Alok Chaturvedi, Simulex

SEAS is

- Comprehensive modeling framework that integrates both inverse and forward points of view, applicable at multiple levels of analysis in diverse fields of study, in a structured manner
- Computational architecture that is flexible, scaleable, and adaptable
- Persistent "world" for continuous replication, verification, validation, uncertainty quantification, and margins of error estimation

SEAS can

- Support experimentation, planning and wargaming as well as analytic studies



Analytic Issues SEAS can Address

- SEAS captures many aspects throughout the PMESII domains and therefore can inform on many metric across the socio-economic and politically realms.
- Metrics associated with winning the hearts and minds
- Information operations
- Capturing unanticipated and unintended 2nd and 3rd order effects

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SEAS Capabilities

- Robust, scalable, extensible engine to support a variety of experimentation domains
- Persistent experimentation environment
- Repository of organizational memories through play books
- Plurality of thoughts
- An approach to bridge the micro-macro divide
- Complete transparency of data, algorithms, and assumptions
- User configurable and extensible
- Multiple courses of action analysis with time travel capability

Main Points

- Provides the capability to examine how different military COAs can affect population behavior
- Part of a suite of tools, including JWARS, JSAF, live experimentation, in looking at SASO issues
- Used to support joint experimentation to investigate how DIME actions might contribute to achieving effects and strategic endstates.
- Used for concept development; supports wargames and limited objective experiments

Secondary Points

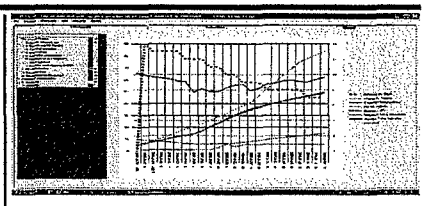
- Being used by Army Accessions Command, Fortune 50, Purdue Institute of Homeland Defense, and JFCOM
- OSD Policy investigating use of SEAS
- ABM at the operational level

Global Aggregated Model for Military Assessment (GAMMA)

Stephan Leitner, Dan Eustace, Dr. Uwe Dompke (NC3A)

Tool Description: GAMMA is an open framework of simulations able to deal with High-Intensity Conflicts as well as (low-level) Asymmetric Conflicts. Referring to the latter, the Incident Model (the ABM model) and the ZETA Model within GAMMA form an excellent "team."

Tool Purpose: GAMMA is focused on the development of future military concepts, requirements, and planning for ongoing operations for NATO HQ. It displays the interrelationships between Agents (e.g. Terrorists) on a low level on the one hand, the influence of Resources (DIME) and their allocation to Tasks on the Agents' ability to create incidents (of specific types at specific locations) on the other hand and the impact on the playground (PMESII) in order to analyze asymmetric problems of current operations.



Survivability of a government depending on number of incidents, Alliance Forces/Tasks e.t.c

Analysis Issues that can be Addressed

- How long does it take to reach an operational endstate?
- How should resources be distributed?
- What is the impact of the alliance in theatre?
- What type of incidents will be created?
- What are vulnerable Nodes?

Capabilities

- Deterministic simulation
- Agent-based modeling
- Geographical display
- System-dynamic modeling (mathematical interrelationships)
- Optimizing algorithms
- Open framework for other sub-models

GAMMA is:

- A decision support tool to assess operational plans (What if? Analysis) by exploring action-effect options and consequences (functional view)
- A framework for a family of models which provides a 'plug and play' architecture for the integration of specific models for the assessment in symmetric and asymmetric environments (technical view)
- GAMMA is used by NATO HQ OA Cells and has been Selected to Support MNE 4 as Decision Support Tool

GAMMA's ABM:

- Some degree of aggregation
- Incident creation
- Embedded in a scalable structure
- Allows system of systems (SoS) analysis

NC3A (NATO Command, Control, and Communications Agency)

Lines on the graph show number of incidents vs stability

ZETA (Effects Based Tool for Assessment) "Z" signifies the NATO scenario

Agent-Based Models and Other Analytic Tools in Support of Stability Operations

Acronyms

ABM	Agent-Based Model
AMIGO	Army Model of Indigenous Guerilla Operations
AoA	Analysis of Alternatives
ATD	Army Tactical Data
BCSE	US Army Battle Command, Simulation, and Experimentation Directorate
C2	Command and Control
CAA	Center for Army Analysis
CAST	Conflict Assessment System Tool
CBRN	Chemical, Biological, Radiological and Nuclear
C-CW CONOPS	Counter-Chemical Warfare Concepts of Operations
CG	Commanding General
CLI	Command Line Interface
COA	Course of Action
COBP	Code of Best Practices
CoG	Center of Gravity
CONOPS	Concepts of Operations
DIAMOND	Diplomatic and Military Operations in a Non-Warfighting Domain
DIME	Diplomatic, Information, Military and Economic
DMSO	Defense Modeling and Simulation Office
DO	Distributed Operation
DoD	Department of Defense
DOME	Distributed Operations Modeling Environment
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities
DRDC	Defence Research and Development Canada
EEA	Essential Elements of Analysis
FAST	Flexible Asymmetric Simulation Technologies
FCS	Future Combat Systems
FFW	Future Force Warrior
GAMMA	Global Aggregated Model for Military Assessment
GUI	Graphical User Interface
GWOT	Global War on Terrorism
HA	Humanitarian Assistance
HIU	Humanitarian Information Unit
HUMINT	Human Intelligence
IGO	Inter-Governmental Organization
ISSM	Interim Semi-Static Stability Model
JFCOM	Joint Forces Command
JWARS	Joint Warfare Analysis and Requirements System
M&S	Modeling and Simulation

MAGTF TC	Marine Air-Ground Task Force Training Command
MANA	Map Aware Non-Uniform Automata
MCCDC	Marine Corps Combat Development Command
MCWL	Marine Corps Warfighting Laboratory
MEUs	Marine Expeditionary Units
MOE	Measures of Effectiveness
MOOTW	Military Operations Other Than War
MORS	Military Operations Research Society
MOUT	Military Operations in Urban Terrain
NC3A	NATO Command, Control and Communications Agency
NEA	North East Asia
NEO	Non-combatant Evacuation Operations
NGO	Non-Governmental Organization
NPS	Naval Postgraduate School
NPS	Naval Postgraduate School
OEA	Operational Effectiveness Assistance
OSD	Office of the Secretary of Defense
PAX	Programming, Administration and Execution System
PMESII	Political, Military, Economic, Social, Infrastructure and Information
PSOM	Peace Support Operations Model
PVO	Private Voluntary Organization
RFD	Revision First Draft
RTD	Returned To Duty
S/CRS	US State Department - Office of the Coordinator for Reconstruction and Stabilization
SAIC	Science Applications International Corporation
SASO	Stability and Support Operations
SEAS	Synthetic Environments for Analysis and Simulation
SME	Subject Matter Expert
SoS	System of Systems
TECOM	USMC Training and Education Command
TRADOC	US Army Training and Doctrine Command
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Ariel Vehicles
UOB DAT	Unit Order of Battle Data Access Tool
US	United States
USAF	US Air Force
USMA	United States Military Academy
USMC	United States Marine Corps
VISTA	Visualized Information Synthesized Temporal Analysis tool
VV&A	Verification, Validation and Accreditation

MORS Workshop

Agent-Based Models and Other Analytic Tools

in Support of Stability Operations

Terms of Reference

Background

Traditionally, stability operations were considered by many to be to the mechanism of transitioning from a full warfare footing to a peaceful situation. Joint forces use dominant maneuver and precision joint fires to achieve military strategic and operational objectives, culminating in conflict termination. In this viewpoint, stability operations are conducted as needed to ensure a smooth shift to the desired end state of the Joint Task Force commander and to relieve suffering. The goal is to ensure that the threat (military and political) does not resurrect itself. Traditional offensive operations are primary in this perspective; stability operations are secondary.

The world may have changed, however.

The September 11, 2001 terrorist attacks on the World Trade Center and the Pentagon have thrust the United States into the Global War on Terrorism (GWOT). As a result, the United States has joined the rest of the world by entering into a new age of instability. Stability operations can no longer be relegated to a secondary level of importance. The United States (U.S.) Department of Defense (DoD) needs to consider the use of modeling techniques to assess the emergence and development of stability operations as part of the DoD effort in nation-building.

DoD uses simulation models to support its decision making process. These models help evaluate war plans against adversaries, assist in assessing what equipment to acquire, determine the best combination of forces, determine the best combination and use of weapons, and much more. Since it is nearly impossible to conduct actual physical experiments to determine the effectiveness of war plans, force designs, or weapon system capabilities in actual conflict, the DoD relies on these simulation models to capture significant insights that enable senior leadership to make informed decisions.

A new and stimulating area of combat models involves Agent-Based Models (ABM). The concept is to use multi-agent-based software tools to examine the relationship between numerous input variables and output measures. The self-adaptive nature of some of these models may facilitate broad exploration of battlefield scenarios and permit the possibility of gaining substantial insights into emergent behaviors on the battlefield. This may be especially pertinent for a non-linear battlefield with distributed tactical units. The potential application of ABM to stability operations should be investigated.

According to the U.S. Army's FM 3-07 *Stability Operations and Support Operations*,

> "Stability operations promote and protect U.S. national interests by influencing the threat, political, and information dimensions of the operational environment through a combination of peacetime developmental, cooperative activities and coercive actions in response to crisis. Army forces accomplish stability goals through engagement and response. The military activities that support stability operations are diverse, continuous, and often long-term. Their purpose is to promote and sustain regional and global stability."

In Joint Publication 3-0, *Doctrine for Joint Operations* revision first draft (RFD), stability operations are defined as

> "an overarching term encompassing specific types of developmental, cooperative, or coercive security cooperation and deterrence activities, small-scale operations, and/or missions that promote local or regional normalcy and protect U.S. interests abroad. Stability operations may be conducted in all operational environments and during all phases of a campaign or major operation."

Finally, Joint Forces Command, in *Stability Operations Concepts and Capabilities Emerging From JFCOM/Joint Experimentation*, states that

> "Stability Operations are activities conducted by military and other government components to establish, reestablish or support a foreign government's ability to assure rule of law and internal security, to provide basic human services (healthcare, water, electricity, education), and to protect its borders and promote its foreign interests including cooperation with regional and international partners and deterrence of potential aggressors."

It is clear that stability operations can be stand-alone operations or part of a campaign or major combat operation and it may be that stability operations will become primary in the GWOT strategy and traditional offensive operations become secondary. Globalization, the unfettered spread of free market capitalism (and the institutions required to sustain it), will probably continue to place tremendous strains on populations at risk, on the governments that cannot provide for the basic needs of their people, and on wealthy societies that will be forced to deal with growing problems of religious and ideological radicalization, communal violence, illegal immigration, and the marginalization of international institutions. It seems then, that our most likely adversaries will have one or more of the following traits: ideologically driven; networked; technologically sophisticated; and non-state actors operating with either tacit or active support of states or ostensibly legitimate international or trans-national organizations.

The non-linear battlefield now figures in the list of consideration factors for planning, organizing, training, and equipping our fighting forces. At the same time, tactical

emphasis shifts towards distributed operations to cope with the new environment. Distributed operations are non-linear and deploy tactical units across the depth and breadth of a battlespace in order to maximize opportunities to achieve favorable intelligence driven engagements. Massing forces and pre-planning voluminous fires are not the critical enablers for distributed operations. The critical enablers are a robust, easily accessible information structure and prompt, responsive, precision fires.

Purpose, Goals, and Objectives

The military establishment of the United States is transforming itself. The requirement to conduct stability operations is part of that transformation. The military operations research community is transforming itself as well. Conducting analyses in support of stability operations is not an area that the military operations research community has focused on in the recent past. Much of the current effort of the military operations research community is directed towards supporting decision-making during the tumultuous transformation process. Some of the operations research effort is directed towards developing analytical methodologies that will be needed after the transformation has taken place.

During transformations such as the one we are going through, it can be expected that several related analytical initiatives will take place in different organizations throughout the military operations research community. Although the initiatives are being undertaken, for the most part, independently, it is essential they proceed from a common foundation if there is to be any meaningful integration of their results in the future.

Of particular interest is determining the value and benefits of ABM in supporting military analyses and decisions, especially those relating to distributed operations. These models were used in limited and sporadic instances, but the military operations analysis community still needs to examine the advantages and disadvantages of ABM.

The Military Operations Research Society (MORS) has facilitated the transformation process by conducting recent special meetings such as

- *Combat Analyst: Deploying Quantitative Support to the Combatant Commander*,
- *Decision Aids / Support to Joint Operations Planning*,
- *How Cognitive and Behavioral Factors Influence Command and Control*,
- *Operations Analysis Support to Network Centric Operations*, and
- *The Global War on Terrorism: Analytic Support, Tools and Metrics of Assessment.*

These special meetings have assembled practitioners and users of military operations research for professional exchange and peer criticism, leading to a broader and more common understanding of what has been done and what should be done.

The purpose of this workshop is to continue the trend towards this common understanding by bringing together analysts working on projects directly or indirectly related to ABM and stability operations. The goals of this workshop are to determine the capabilities that ABM provides for military analyses and to identify techniques and

methodologies that show promise for conducting analyses in support of stability operations.

Specific objectives are to:

1. Examine the state-of-the-art of ABM and other modeling and simulation techniques to identify likely applications to military operations with a focus on stability operations

2. Survey the progress to date (or lack of progress), in the context of stability operations, towards developing metrics to
    i. Measure progress toward the attainment of operational objectives (not limited to military objectives)
    ii. Assist the decision maker in determining tradeoffs for the allocation of scarce resources

   and produce an initial list of metrics and measures of effectiveness applicable to stability operations for eventual inclusion in a MORS publication

3. Review analyses and analytic approaches that pertain to stability operations, including those conducted via distributed operations, in order to identify promising approaches and areas needing further work

Approach

The workshop will take place at the SAIC Conference Center, 1710 SAIC Drive, McLean, VA from 25 to 27 October 2005 and will consist of three parts. There will be an opening plenary session, followed by three simultaneous working group sessions. It will end with a closing plenary session.

Fees are $260 for U.S. Government participants and $520 for non-U.S. Government participants.

The opening plenary session will take place on Tuesday morning, 25 October. The opening plenary session will consist of a keynote speaker and other speakers, perhaps in a panel format. The thrust of the opening plenary session will be stability operations, not analysis. In order to analyze stability operations, analysts first need to understand what they are. Understanding involves, for example, military missions typically involved in stability operations, along with some of the objectives of these missions. Stability operations will be presented in two contexts. The first context will be the applicability and role of stability operations in GWOT. The second context will be the operational challenges in carrying out stability operations in a Joint, coalition, multi-national, and interagency environment.

There will be three working groups. The thrust of their sessions will be analysis. The working groups will orient on the three areas of analytic interest stated in the objectives of the mini-symposium:

- Working Group I – Agent-Based Modeling and Simulation for Stability Operations
- Working Group II – Metrics for Stability Operations
- Working Group III – Analytic Support to Stability (Including Distributed) Operations

The groups will meet during Tuesday afternoon, 25 October, all day Wednesday, 26 October, and during Thursday morning, 27 October. Working Group Chairpersons will assemble analysts who are, or were recently engaged in projects in the specified areas of analytical interest. The analysts will share their experiences, successes, failures, and results. The goal of the working groups is to determine the potential applicability (or non-applicability) of the discussed techniques and methodologies towards analyzing stability operations. Each working group will prepare a report summarizing description and scope of the areas of analytical interest and the working group's opinions concerning its role in conducting analyses in support of stability operations.

There is, of course, overlap among the working groups. This is intentional and desirable because different groups will have different points of view. There will also be a synthesis group to identify techniques and methodologies discussed during the working group sessions that show exceptional promise for conducting analyses in support of stability operations. The synthesis group will evaluate the usefulness of a full workshop on ABM. In addition, the synthesis group will look for other operations research issues amenable to follow-on examination in a MORS workshop.

The closing plenary session will be hosted by the synthesis group on Thursday afternoon, 27 October, and will feature presentations by each of the working groups. Each working group presentation will summarize what was accomplished in that working group for the benefit of the analysts in the other working groups. The synthesis group will comment on each working group's presentation and set forth its recommended issues for follow-on examination, if there are any. It is important that ample time be set aside for questions and answers.

The primary products of this workshop will be a written report on the results and brief to the MORS Sponsors. There will also be a *PHALANX* article and a presentation at the 74th MORS Symposium.

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MORS Workshop: Agent-Based Models and Other Analytic Tools in Support of Stability Operations

SAIC Conference Center, McLean, Virginia

25-27 October 2005

DRAFT AGENDA

Day/Time	Activity	POC
Monday	**24 October**	
1430	Set up	MORS Staff
1630	Final Organizing Committee Meeting	Working Group Chairs/ Program Committee
Tuesday	**25 October**	
0700	Registration/Continental Breakfast	MORS
0800	MORS President's Welcome	MORS
0810	SAIC Host's Welcome	SAIC
0820	Sponsor's Welcome	Invited Speaker
0830	Keynote Address	Invited Speaker
1030	Break	
1000	Opening Plenary #1	Invited Speaker
1100	Opening Plenary #2	Invited Speaker
1200	Lunch	
1315	Workshop Overview Plenary	Workshop Chairs
1330	Working Groups	WG Co-Chairs
1600-1730	Mixer	
Wednesday	**26 October**	
0715	Continental Breakfast	MORS
0800	Working Groups	WG Co-Chairs
1130	Lunch	
1300	Working Groups	WG Co-Chairs
1630	Hot Wash	WG Co-Chairs
Thursday	**27 October**	
0715	Continental Breakfast	MORS
0800	Working Groups	WG Co-Chairs
1130	Lunch	
1300	Closing Plenary Session Working Groups Present Briefings	Workshop Chairs
1530	Closing Remarks	Workshop Chairs
Friday	**28 October**	
0800	Post-Workshop Session Working Group Chairs Complete Written Summaries	Workshop Chairs