Human, Social, and Cultural Behavior Modeling for Stability, Security, Transition, and Reconstruction Operations

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1. Introduction

Stability operations emerged as a core U.S. military mission in 2005 with the release of DOD Directive 3000.05 (England 2005). Its goal is to help establish order that advances U.S. interests and values, and it is a key component of Stability, Security, Transition and Reconstruction Operations (SSTRO). The integration of military operations in SSTRO is now a DOD requirement and they be exercised, gamed, and when appropriate, red-teamed.

The SSTRO Working Group within the Human, Social, and Cultural Behavior (HSCB) Workshop at the National Defense University's Center for Technology and National Security Policy (NDU CTNSP) explored required modeling capabilities for HSCB with emphasis on the full spectrum of warfare (Center for Technology and National Security Policy 2008).

This paper presents concepts and issues in HCSB modeling for SSTRO, examines several tools in development or use, and outlines a new approach, called Dynamic Natural Attribute (DNA) modeling, for generating unique computer-generated entities.

The DOD Directive cited above establishes two essential definitions that frame this discussion:

Stability Operations are defined as, "Military and civilian activities conducted across the spectrum from peace to conflict to establish or maintain order in states and regions." Noteworthy policy guidance in the directive includes:

- Stability operations shall be given priority comparable to combat operations.
- Their immediate goal is to provide the local populace with security, restore essential services, and meet humanitarian needs.

- Their long-term goal is to help develop indigenous capacity for securing essential services, a viable market economy, rule of law, democratic institutions, and a robust civil society.
- While many tasks are best performed by indigenous, foreign, or U.S. civilian professionals, the U.S. military must be prepared to accomplish them when civilian cannot.

Military support to Stability, Security, Transition and Reconstruction includes DOD activities that support U.S. Government plans for SSTR operations which lead to sustainable peace while advancing U.S. interests.

A second set of terms important to this discussion relate to human, social, and cultural behavior:

Cultural behavior is the broadest of the three. Webster defines culture as, "The totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought typical of a population or community at a given time." (Webster 1999)

Social behavior is embedded within that larger context. It can be viewed as emergent behavior in social systems that lead to an evolution of values in human societies. (Hassan, Garmendia et al. 2008) In *Human Learning*, Ormrod states that learning occurs within a social context and that people learn from one another through observational learning, imitation, and modeling. (Ormrod 1999)

Human behavior addresses the actions of individual humans within their environments.

2. Case Study

The complex interactions of these factors can be seen in case studies from the U.S. Army War College's workshop on Information Operations and Winning the Peace. (Collings and

Rohozinski 2006) Their initial case study focused on the al-Aqsa Intifada and Operation Defensive Shield campaign in 2000. This study highlights several decision opportunities for stability and SSTR operations that did not appear to achieve the goals laid out for U.S. SSTRO. A brief synopsis from their report lists the primary events.

> "September 2000 marked the outbreak of the al-Aqsa Intifada, sparked by Ariel Sharon's provocative visit to the Haram al-Sharif/Temple Mount (site of the al-Aqsa mosque). The following day confrontations between unarmed Palestinian protesters throwing stones and Israeli police using rubber bullets and live ammunition resulted in four Palestinians shot dead, 200 injured and 14 Israeli policemen injured. From there, *'what began as a series of confrontations between Palestinian demonstrators and Israeli security forces, which resulted in the Government of Israel's initial restrictions on the movement of people and goods in the West Bank and Gaza Strip (closures), has since evolved into a wider array of violent actions and responses,'*. (Mitchell 2001) Unlike the first Intifada, whose enduring image was Palestinian youth throwing stones at tanks and soldiers, the al-Aqsa uprising largely involved 'adult, male, armed and partially uniformed' Palestinian fighters. (Hammes 2004) The violence of both the Palestinian 'resistance' and Israeli responses spiraled on for over four years, until January 2005. While all statistics in terms of deaths and injuries are contested, this episode of the conflict has left somewhere around 3,850 Palestinians dead and between 27-53,000 injured, and 985 Israelis dead, and between 5-7,000 injured.
>
> "The most infamous 'tactic' of the Palestinian Intifada, was the suicide bomber who targeted Israeli citizens in Israel proper. This method was initially the preserve of

Islamist groups (with an average of 2.6 attacks per month during the first 14 months of the Intifada). After January 2002, however, the conflict entered a far more violent and dangerous phase when militant groups linked to the Palestinian secular organizations (e.g., the Fatah al-Aqsa Martyr's Brigades) joined the suicide campaigns, and a deadly competition ensued over which groups could execute the largest number of suicide attacks, and so claim enhanced political authority within the Palestinian political landscape of resistance to the Occupation.2 By September 2004, the total number of suicide bombings had reached 135, killing at least 501 Israelis and injuring some 2,823. Eight of these attacks had been carried out by women.

"Suicide bombs had a devastating psychological effect in Israel, inciting fear and galvanizing popular opinion in favor of decisive IDF action against the militant groups. In the discourse of the Palestinian street, however, suicide bombers became 'martyrs,' honored for their bravery and a symbol of the resistance. Placards and posters of every new martyr plastered the walls in all Palestinian towns and villages. Websites operated by militant groups and their supporters circulated photographs of martyrs.

"On the Israeli side, the Intifada was met with general military engagements, actions to close off and contain Palestinian population centers (with increasingly formidable military force), and the targeted assassinations of political figures and suspected militant leaders. By September 2004, some 273-372 Palestinian 'targets' had been successfully taken out, which also resulted in the death of some 300 civilian bystanders. The IDF also undertook some 19 Cabinet-approved operations in the West Bank and Gaza, ranging from air strikes on the offices and infrastructure of the

Palestinian National Authority (PNA) and militant targets, to the reoccupation and sealing off of the Palestinian towns and villages that had been handed over to the authority of the PNA during the Oslo peace process. Related measures included curfews, house demolitions, land clearances and confiscation, and mass arrests.

“Interpretations vary as to the ‘strategic’ nature of the al-Aqsa uprising and its militarized dimensions. Israeli sources tend to assume a unified Palestinian strategy, orchestrated by the PNA and specifically designed by President Arafat to pressure the Israelis to make territorial concessions. Israeli sources highlight the financial support that Arafat was said to provide to the militant Palestinian groups involved, including payments to the families for suicide bombers. However, other sources knowledgeable of the dynamics of Palestinian politics and society emphasize that Arafat’s authority over the militant groups was limited. His support for the militant groups was an attempt to capitalize on events, and thus, they believe, was an indication of the weakness his authority rather than a measure of his real power.

“In addition, a ‘top-down’ perspective that focuses only on Arafat’s maneuvering ignores the deeper pressures and motivations that led to widespread Palestinian support for the uprising. Thus, some seven years after the Declaration of Principles in 1993, which was supposed to result in peace and prosperity for both peoples, and the Israeli withdrawal from the Occupied Palestinian Territories (OPT), ‘per capita income levels in the OPT were estimated to be about 10 percent below their pre-Oslo level [and] despite considerable external assistance living standards were lower than before the process began. Aggravating the political situation were continuing Israeli policies of land and water confiscation, settlement expansion, movement restrictions,

> and numerous violations of important elements of signed agreements with the Palestinian Authority.' By 2000, the number of Israeli settlers in the West Bank had doubled 'settler-only' bypass roads, that further constricted and cut-off Palestinian living space and movement around the West Bank.
>
> "In early 2005, following the death of Arafat and a changing political landscape, President Mahmoud Abbas declared an end to the Intifada. To date, while the level of violence has decreased dramatically, low-level attacks (shootings, rocket attacks, and occasional suicide bombs) continue, usually in lockstep with Israeli targeted killings, arrests of militant actors and closures of Palestinian towns and cities."

3. The Current State of HSCB Models

No models currently exist that can adequately or completely describe complex human, social, and cultural behavior interactions at the local, national, or regional levels, according to a Broad Area Announcement (BAA) issued in February 2008 by the Office of the Secretary of Defense's Combating Terrorism Technology Support Office (OSD CTTSO). (Combating Terrorism Technology Support Office 2008) The CTTSO goal is to acquire an easy-to-use, plug-and-play hybrid in which two or more modeling techniques (game-based, agent-based, systems dynamics, etc) are integrated and applied in an open systems oriented architecture. The BAA specifies that efforts emphasize counterinsurgency (COIN) strategies, SSTR operations, and options for strategic communications. The model or federation must support operations analysis and planning, intelligence support to operations, as well as training, experimentation, and mission rehearsal.

Several models and approaches accomplish one or more of these requirements. Two that are often cited are the U.S. Air Force's System Effectiveness and Analysis Simulation (SEAS) and the U.K. Ministry of Defence's Peace Support Operations Model (PSOM).

The SEAS model shown in Figure 1 is a stochastic agent-based simulation designed for use in evaluation of the military utility of airborne and space-based communications and intelligence, surveillance, and reconnaissance (ISR) assets, according to a RAND briefing cited in a Master's thesis by DeStefano. (DeStefano 2004) Its use has been extended to address the political, military, economic, social, information, and infrastructure (PMESII) dimensions of stability operations. (Martin 2005)

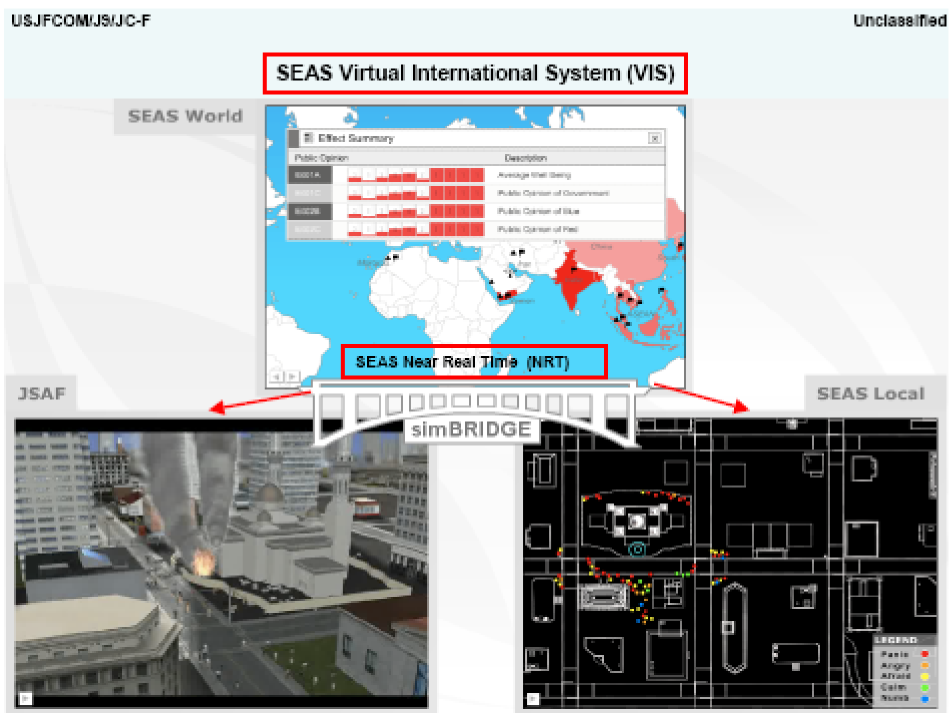

Figure 1: SEAS link with JSAF (Martin 2005)

The PSOM model is a human-in-the-loop (HITL), time-stepped war game that measures success against three criteria: consent, security, and stability. (Parkman 2005) The area of operations is divided into 50 kilometer squares with each square represented as open/desert, urban/suburban, or dense terrain. Each square also contains values for consent and security, population density, infrastructure and human capital values. Each side has allocated forces with various "stances" (e.g., enforce, stabilize, recon, disrupt). Move outcomes are determined by the ratio of effectiveness between Red and Blue/Green based on the stances of the forces. For example, in a successful Blue "stabilize" stance, security and consent usually increase, Red casualties are moderate, and collateral damage is minimal. The PSOM map is shown in Figure 2.

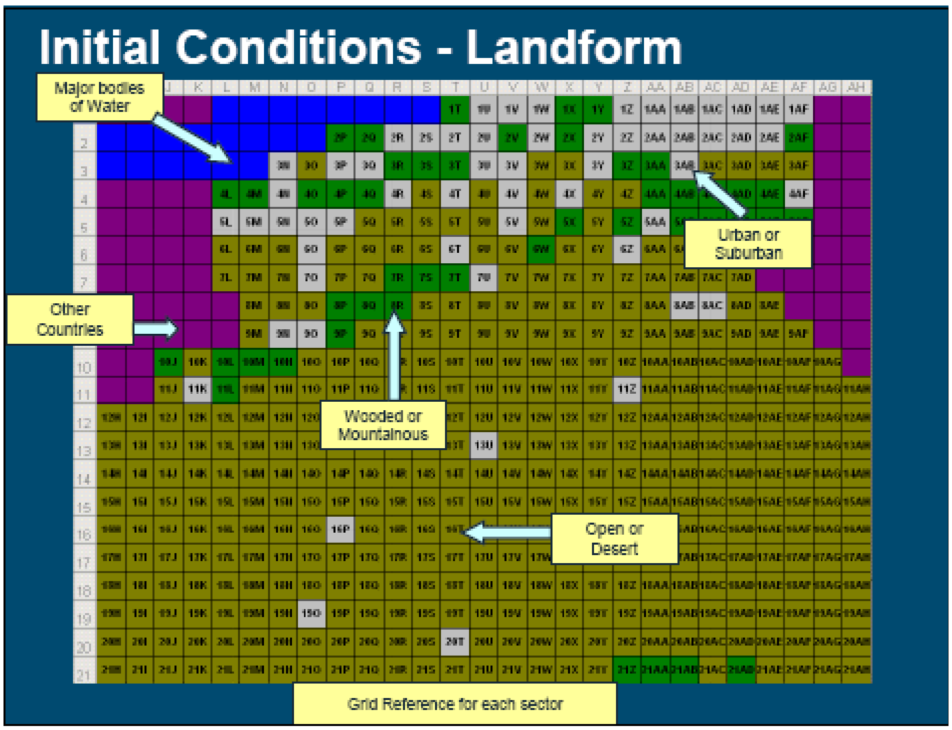

Figure 2: PSOM grid map (Parkman 2005)

Numerous other simulations, from Pythagoras and MANA to swarm models, leverage the strengths for which they were developed to address stability and SSTR operations. Several workshops have been conducted by military-oriented agencies and societies. The Military Operations Research Society (MORS) conducted a workshop on Agent-Based Models and Other Analytical Tools in Support of Stability Operations in October 2005. Presentations and Terms of Reference may be accessed at www.mors.org/meetings/abm_2005/abm_final.htm. MORS also conducted a workshop on Improving Cooperation Among Nations in Irregular Warfare Analysis in December 2007, which may be accessed at www.mors.org/meetings/ican_2007/icfinal.htm. Several relevant papers also were presented at the IEEE Computer Society's Fifth International Conference on Software Engineering Research, Management and Applications.

4. Using "DNA" to model computer-generated humans

This section introduces research by the author that approaches HSCB from the human, micro-level perspective. The Dynamic Natural Attribute model is designed to support individual human entities, although the methodology may work equally as well for populations. The research arose from a set of fundamental questions that could not be answered through standard high-resolution combat models:

- Why do some soldiers jump on a grenade to save their comrades at the cost of their lives?
- Why do some soldiers conduct heroic acts, while some flee?
- What conditions enable an Abu Ghraib debacle?
- What training might reduce U.S. forces incidences of non-combatant or wounded combatant killing?

High-resolution combat simulations generally focus either on single-soldier and squad-level tactics with high fidelity, or on brigade and below operations with coarse human fidelity. The first category, which includes simulations such as the U.S. Army's Infantry Warrior System (IWARS), models detailed human factors but tends to focus more on the physiological than the psychological. The latter group, including such simulations as the Joint Conflict and Tactical Simulation (JCATS), treat synthetic humans more as "little tanks" than people. This research explores a different approach: Can "soft" human factors such as personality, leadership, and morale be adequately modeled and integrated into combat simulations without overwhelming the computer? The hypothesis is that, given a distribution of personality traits from a target population, computer-generated humans can be imbued with unique individual personalities that affect their decision-making process.

The research approach consists of the following seven distinct phases:

1. Link personality to specific traits
2. Link behavior to personality
3. Map personality traits to behavior through the development of a model
4. Determine a method to interact with the host simulation
5. Implement modifications to the simulation using the developed model
6. Determine the effects of the model on output
7. Analyze and refine the model.

4.1 Big Five Factor Model – Linking personality to traits

The initial phase explored human traits that differentiate one person from another. A widely-used tool to link personality traits to behavior, the Neuroticism-Extroversion-Openness Inventory (NEO-I) was developed by Robert R. McCrae and Paul T. Costa Jr., in the 1970s and later revised as the NEO Personality Inventory (NEO PI-R). The model claims that in the broadest sense, personality encompasses five major traits, in which several more distinct personality traits could be established. The five broad dimensions of the so-called Big Five personality traits are Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (Goldberg 1995). These traits have become very well known and applied in business and many aspects of the society, although its validity is often challenged (O'Neil 2007).

- The *Neuroticism* personality category deals with the degree that an individual experiences negative emotions, with some relations to impulse control and coping. A low score in Neuroticism usually means the individual is emotionally relaxed and stable with the ability to face upsetting situations without getting upset and disturbed.

- *Extraversion* measures how much the individual enjoys being social and being in large groups or gatherings. Some characteristics of an individual with a high score in extraversion are talkative, active, energetic, and excitement seeking.
- The *Openness* of an individual reveals how curious he or she is about inner and outer worlds, with a tendency to entertain novel and unconventional ideas, experiences, and values. Open individuals experience both positive and negative emotions more intensely than closed individuals.
- The *Agreeableness* of an individual addresses interpersonal trends. An individual with a low score in Agreeableness will be egocentric, cynical, and skeptical of other people's intentions.
- The last personality category, *Conscientiousness,* is the individual's ability to resist impulses and temptations. High scores in Conscientiousness suggest a purposeful, determined, punctual, and reliable individual (Pervin and John 1999). The Big Five personality categories consist of six facets, shown in Table 1, for each domain to provide a more detailed analysis. This model provides one way to link personality to a given set of 30 traits (Butcher and Rouse 1996).

Table 1: Big Five traits and sub-traits

	Neuroticism		Extraversion
N1	Worry	E1	Warmth
N2	Anger	E2	Gregariousness
N3	Discouragement	E3	Assertiveness
N4	Self-Consciousness	E4	Activity
N5	Impulsiveness	E5	Excitement-Seeking
N6	Vulnerability	E6	Positive Emotions
	Openness		**Agreeableness**
O1	Fantasy	A1	Trust
O2	Aesthetics	A2	Straightforwardness
O3	Feelings	A3	Altruism
O4	Actions	A4	Compliance
O5	Ideas	A5	Modesty
O6	Values	A6	Tender-Mindedness
	Conscientiousness		
C1	Competence		
C2	Order		
C3	Dutifulness		
C4	Achievement-Striving		
C5	Self-Discipline		
C6	Deliberation		

4.2 NEO PI-R – Linking personality to behaviors.

Given these general personality domains and the six facets for each domain, the foundation for the Neuroticism Extraversion, and Openness Personality Inventory (NEO PI) was developed by using a procedure known as factor analysis (Piedmont 1998). These results were refined into developing the current 240 question test revised version known as the NEO PI-R. This test allows us to generate associated behaviors that are supported by the thousands of people who have taken the personality assessment. This test successfully develops one way to link personality to behaviors.

The Infantry Warrior Simulation (IWARS) was selected as the test host simulation due to its physiological fidelity and autonomous behavior engine. IWARS is a constructive, force-on force combat simulation developed by the Natick Soldier RD&E Center (NSRDEC) and the Army

Materiel Systems Analysis Activity (AMSAA). It is *constructive* in that the “soldiers,” their weapons and the environment all operate within computer software. It also is an agent-based model used to represent the individual fighter whether as a single entity, team, or a small unit in combat operations (AMSAA 2006). The objective of the simulation is to provide a robust modeling capability needed to conduct integrated, multi-domain analyses that allow the complex relationships between soldiers, their equipment, and the battlefield environment to be explored. Given this analysis, the program allows for better decisions to be made to avoid unnecessary cost, reduce program risk, and support the development of better equipment (Borgman 2007).

The IWARS architecture was analyzed to determine which aspects of the synthetic soldier could be modified. IWARS entities have 18 common “skills,” listed in Table 2, along with descriptions of their functions.

Table 2: IWARS entity skills

Skill	Description
Change Facing Direction	Change facing direction of entity
Change Field of Regard	Change sensor scanning fan
Change Posture	Change to prone, crouching or standing position
Change Visual Sensor	Change visual sensor used
Communicate	Determines how entity sends/receives messages
Follow in Formation	Gives entity to follow unit leader in given formation
Light Flare	Tells entity to light a flare
Move	Tells the entity to change its current position
Reload	Tells entity to reload its weapon
Remove Message	Command takes away message from entities decision making loop
Seek Cover	Entity goes and seeks suitable cover from fire
Select Weapon	Entity selects an available weapon
Set Formation	Entity in lead sets the formation others will follow
Set Path	Entity in lead sets the path the others will follow
Shoot	Allows entity to engage targets
Throw Grenade	Tells entity to throw a grenade
Wait	Tells entity to not move for a give period of time

These skills were categorized into three capabilities: the ability to *shoot*, *move*, and *communicate* – skills fundamental to any combat operation. Table 3 matches IWARS skills with the basic combat functions.

Table 3: Alignment of skills to category

Category	Skill
Shoot	Change Facing Direction
	Change Field Regard
	Wait
	Change Posture
	Change Visual Sensor
	Reload
	Seek Cover
	Select Weapon
Move	Change Facing Direction
	Change Field Regard
	Wait
	Change Posture
	Change Visual Sensor
	Follow in Formation
	Set Formation
	Set Path
	Seek Cover
Communicate	Change Facing Direction
	Change Field Regard
	Wait
	Remove Message

The IWARS skills were further sorted into those that directly and indirectly affect the combat functions of *shoot*, *move*, and *communicate*. The *shoot* function, for example, consists mainly of tasks that affect how often shots can be made and their accuracy. Skills such as *select weapon* and *change field of regard* were considered indirect, supporting skills. Table 4 shows the mapping of those skills that directly affect the three basic combat functions.

Table 4: IWARS direct-effect capabilities

Category	Aspect of IWARS to modify.
Shoot	Reload Time Accuracy of Fire Acquire Time
Move	Speed Direction/Path Take
Communicate	Time to send/receive messages Likelihood of entity to send /receive message

4.3 Relationships – Determining how traits affect performance

Causal relationships between traits and actions identify possible effects of modifying a trait and the ensuing actions. For example, an increase in N1 (worry) would have a positive (+), neutral (0), or negative (-) impact on all of possible capabilities of Table V. We also determined the evaluation measure descriptors such as *more is better* (MIB), *less is better* (LIB), or no change. In the case of reload time, for example, a smaller amount of time used to conduct the task is considered better than a longer time. On the other hand, speed was a characteristic in which more speed brings added value.

Values shown in Table 5 are based on interviews with subject matter experts at the United States Military Academy at West Point.

Table 5: NEO-PIR/IWARS mapping

Trait	Reload Time (s)	Speed (m/s)	Time to send receive message (s)	Probability to send and receive message (%)
N1	-	+	-	-
N2	-	+	-	-
N3	-	-	-	-
N4	-	-	0	-
N5	+	+	+	-
N6	-	-	0	-
E1	0	0	0	+
E2	0	0	0	+
E3	+	+	+	+
E4	+	+	0	+
E5	+	+	0	+
E6	0	0	0	+
O1	0	0	0	-
O2	0	0	0	0
O3	-	0	0	-
O4	+	0	0	+
O5	0	0	0	+
O6	0	0	0	-
A1	+	+	+	+
A2	0	0	+	+
A3	+	+	0	+
A4	+	-	+	-
A5	0	0	0	-
A6	0	+	0	-
C1	+	+	+	+
C2	+	0	0	+
C3	+	+	+	+
C4	+	+	0	+
C5	+	+	+	+
C6	+	-	0	+
	LIB	MIB	LIB	MIB

4.4 Extent – Determining what effect traits should have on behavior in simulation

A spreadsheet model was developed that links each of the Big Five and their sub-traits into an overall personality score based on the NEO PI-R model. For initial model verification, pseudorandom numbers were generated to approximate and individual’s personality profile. These pseudorandom numbers mapped to specific scores on the NEO-PIR. Mean, minimum and maximum values were determined for each of the factors in Table 4.

Table 6 lists the aspects and their respective mean, minimum, and max values that affect the basic combat functions.

Table 6: Determining impacts on performance

Aspect in IWARS	Minimum, Mean, Maximum			
Reload Time (sec)	4	6.75	10	LIB
Speed (m/sec)	1 m/s	4 m/s	7m/s	MIB
Time to send/ receive message (sec)	0.01	1.5	5	LIB
Probability of Send/receive Message	0.1	0.5	1.0	MIB

Each trait was then mapped to a normal curve so that the tails of the distribution would end at the minimum and maximum value for that trait. For example, the mean, minimum and maximum speeds of a computer generated force are 1, 4, and 7 meters per second respectively. If an entity had a N1-Worry score of 75, the speed associated for a score of is 6.02 meters per second. A speed is determined for each of the thirty NEO PI-R traits. To calculate an entity's speed during the simulation, only those traits determined to have a relationship with the associated IWARS *speed* skill will be used to generate the associated overall value. In the case of the Less Is Better (LIB) factors, the group subtracts one hundred from the NEO PI-R value to determine the corresponding value that particular trait.

4.5 Verification Strategy: Manual inputs in a controlled scenario

An evaluation scenario was developed in IWARS that sets two combat forces in conflict in an urban setting. One force is defending a city and has firing positions in buildings and from covered and concealed positions on the street. The attacking force is on foot, approaching in the open. A map-view display of the IWARS scenario is shown in Figure 3. Given IWARS output data, the algorithms were verified as performing as intended.

The cluster of objects at the top of Figure 3 represents individual soldiers advancing on the city. IWARS also allows analysts to observe individual behaviors in a 3D view.

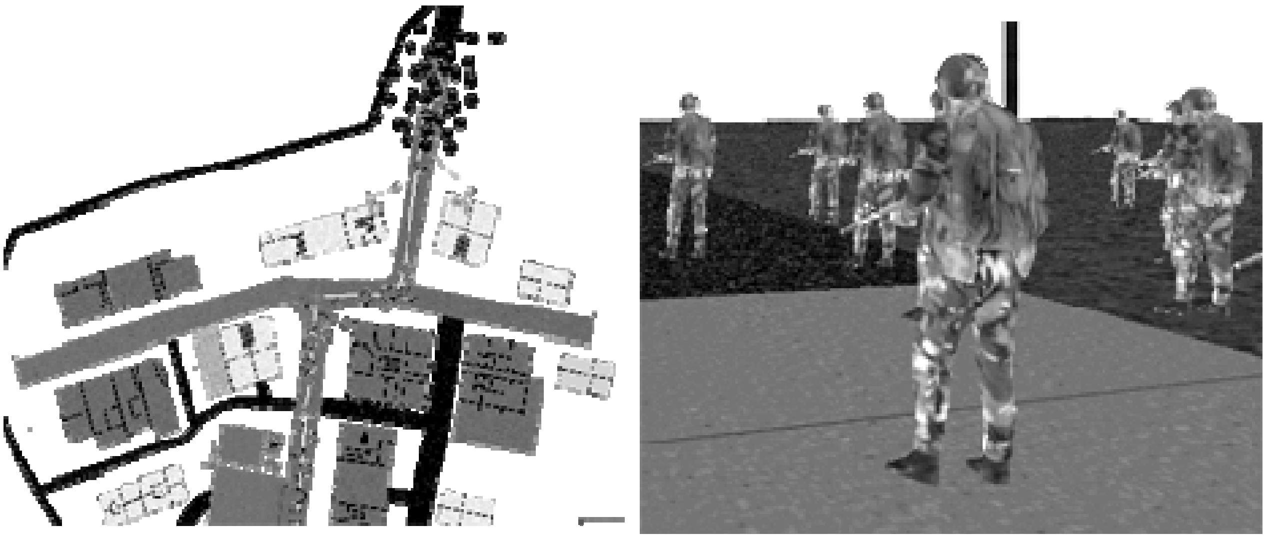

Figure 3: IWARS scenario views

4.6 Validation Strategy: The Ox and Bucks at Pegasus Bridge

The approach for validating the model is to compare output from an historical event with that of the enhanced simulation model. The validation scenario is a virtual recreation of the D-Day assault by D Co. of the British Oxfordshire and Buckinghamshire Light Infantry (the Ox and Bucks) on the bridge at Bénouville, France – an audacious attack that would go into history as the coup de main on Pegasus Bridge.

The rationale for this approach is that it is a very well-documented, small unit engagement that pitted highly trained and motivated British commandos against a collection of significantly less trained and motivated German defenders augmented by Eastern European conscripts.

Two variations of the simulation scenario will be used. The first will use a faithful timeline of the battle, but with unmodified simulation human characteristics. The second will use the identical scenario, but with the enhanced human factors model. Performance measures such as casualties, rounds fired and rounds-per-kill, and time to objective will be compared to assess the contribution of enhanced human characteristics on the battle's outcome.

The intent is not to precisely mirror history but to gain a confidence interval into which history hopefully will fall that will be sufficient for face validation.

4.7 DNA model - initial observations and issues

Initial results suggest that this methodology may prove valuable for analysts and trainers in high-risk conditions such as combat or disaster first-response.

The transferability of simulation insights into actual human training is unknown. It is thought that by altering the input distributions to achieve simulation results, useful insights might be gained into what training is needed in actual soldiers to better predict behavior on the battlefield. Questions such as whether the propensity for an individual soldier to violate such laws of war as shooting non-combatants or incapacitated enemy soldiers can be isolated to a set of targetable factors, and the effectiveness of training to alter those personality traits, is unknown.

Selection of population distributions is critical. The data used in this experiment was drawn from a nationwide population of white males, aged 18 to 24. Personalities drawn from this distribution would not be appropriate for other demographics. Acquiring source data for populations such as that of Eastern European conscripts in the Wehrmacht during World War II is problematic.

5. Conclusions

Stability, Security, Transition and Reconstruction Operations is a key policy initiative that permeates all agencies and levels within DOD. It also represents a significant shift for the modeling and simulation (M&S) community that has focused almost exclusively on force-on-force combat. SSTRO's co-equality with combat operations requires a significant re-thinking of the role of indigenous, foreign, and U.S. civilian professionals in M&S. Despite good-faith efforts to "bend" primarily force-on-force models to this new dimension, no single or federation of models exists "from the ground up" to adequately represent SSTRO.

Other significant challenges face the M&S community, including validation issues and a general lack of insightful measures of effectiveness. Accurate and timely information on local ethnic, cultural, religious, tribal, and similar issues also must be complemented by awareness on the global stage. The role and cooperation of the international community will be critical for successful SSTRO. Likewise, all levels of behavior from the individual human to the collective society must be sufficiently represented to gain confidence in the results of this modeling and simulation reality.

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