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MANEUVER WARFARE DISTILLATIONS: ESSENCE NOT VERISIMILITUDE

Gary E. Horne

Marine Corps Combat Development Command
Quantico, VA 22134, U.S.A.

ABSTRACT

When should we engage the enemy directly and when should we maneuver? Of course, the answer depends on the circumstances and the simulations presented here are simply illustrative. The purpose here is to describe one aspect of an on-going Marine Corps research program called *Project Albert*.

This aspect is our attempt to capture, i.e. distill, the essence of a subject in as simple a simulation as possible. We don't even call our models simulations, preferring the word distillations. Because they are by nature simple, we can run them many times to try to gain insight into our questions. And we have the ability to grow even more data to explore interesting regions of output, a process we call *Data Farming*.

The process of looking at many manifestations of an operation and then trying to build a deeper understanding of the whole structure is a sample of what we call *Operational Synthesis*. A contrasting approach would be to increase the verisimilitude up to the limits of computing power and run a small number of iterations. Many current military applications efforts are in line with this contrasting approach and yet don't seem to meet the challenges required to answer our questions.

1 THE CHALLENGES

The following is one question important to the Marine Corps: when should you engage the enemy directly and when should you maneuver? This fundamental question will provide a context for this paper. Many analytical challenges confront us as we attempt to get insight into this and other questions. These challenges include dealing with deterministic chaos in analytical simulations, understanding the nonlinearities of actions and behaviors of combatants, and capturing cohesion, morale, leadership, and other characteristics which will determine the outcome of future military evolutions. At the Marine Corps Combat Development Command we don't claim that we have yet to meet any of these challenges. But we are trying something different, because our ultimate task is not to accurately simulate warfare in excruciating detail. It is to provide answers to our questions in order to help Marines become better maneuver warriors.

As our analytic simulations become more sophisticated, we are beginning to observe examples of deterministic chaos in the results. Deterministic chaos refers to irregularity in behavior due to sensitivity to initial conditions (i.e. the "butterfly effect" where small changes in input, say a butterfly flapping its wings, may cause large changes in output, such as altered weather patterns). The challenge is to recognize the phenomena, resist temptations to ignore anomalous results, and begin to understand the reasons behind them. There are, however, regions of stability in current model results which we need to not just identify but understand.

Another challenge is to come up with models that more accurately capture the nonlinearities of actions and behavior of combatants. Sometimes a small and ostensibly insignificant action matters immensely in the larger scheme of things. The challenge is to begin to recognize such actions and model them in ways that hypotheses can be tested which may eventually lead to an understanding of what actions are likely to nudge the outcome in a positive direction. In order to test these hypotheses, another challenge is to develop better visualization and computational tools that will help us interpret the data representing the complex, chaotic behavior we are modeling.

The determining factors in warfare are often the intangibles and a final challenge is to capture them. General Charles C. Krulak, Commandant of the Marine Corps, recently stated that we must not only address combatant behavior, "but also their cohesion, morale, and fighting spirit. If we can model those intangibles and couple them with advanced technologies and our philosophy of maneuver warfare, we will be unbeatable!"

Our current models and approaches don't appear to meet the challenges required to answer many of our military applications questions. They can not cope with complex, dynamic processes. They ignore the dominant variables in combat. They don't address the most relevant issues. At the Marine Corps Combat Development

Command we don't claim that we have all, or even any, of the answers. But we are pursuing something different under the umbrella we call *Project Albert*.

2 ESSENCE NOT VERISIMILITUDE

Project Albert is a question-based, multi-disciplinary scientific method of inquiry. Because our reductionist analysis methods don't seem to provide the insight into many of our questions involving complex adaptive systems such as warfare, we have turned to a process developed by Dr. Alfred Brandstein, Chief Scientist of the Marine Corps. This process, called Operational Synthesis, involves distillations of the essence of combat, visualization of the appropriate data, and understanding combat evolutions. This process is a complement to traditional Operations Analysis—it supports the study of asymmetries, risks, and potentials through the use, *inter alia*, of agent-based distillations. Operational Synthesis is outlined in Brandstein (1999).

Casti (1997) provides several examples of agent-based computer simulations. He describes how these artificial worlds are changing the way we are able to perform experiments that are too impractical, costly, or dangerous to perform outside of the computer. But haven't we been simulating military applications for many years? What now appears to be different is that agent-based models show the promise of distilling the essence of a subject and meeting the challenges outlined in the preceding section without the never-ending requirement for greater and greater verisimilitude.

Hoffman and Horne (1998) describe some initial efforts by the Marine Corps to understand the potential mesh of the nonlinear sciences and complex adaptive systems with the study of warfare. One such effort is the development of an agent-based model called ISAAC, developed at the Center for Naval Analyses by Dr. Andy Ilachinski. ISAAC is a mobile cellular automata model in that the individual fighting entities, called agents, move through a lattice and carry information with them as they go. The agents are given characteristics which include: a default local rule set specifying how to act in a generic environment, goals directing behavior, sensors generating an internal map of environment, and an internal mechanism to alter behavior. An interactive presentation with real time model runs is a better way of demonstrating the model and how we try to distill the essence of a situation. Here on paper we will present just a snapshot (with arrows added for discussion in next section) from one of our maneuver warfare distillations called AMY_M and give a brief description of ISAAC.

For both red and blue agents, the first group of parameters represents capabilities such as sensor and fire range. The next group of parameters, or "p-weights," represents the "personalities" of the agents, or how they will move and select strategies. This is done by inputting a set of weights, which are used to rank possible moves according to the agent's proximity to the various types of agents and goals. The other inputs represent another tier of adaptability, perhaps sociology, whereby the default personality is altered according to local threshold constraints. And finally, below the dark lines we see a tally of alive and injured agents—one "hit" creates an injury and two removes the agent from the play.

3 MANEUVER VERSUS ATTRITION

In the scenario depicted in Figure 1, a blue force of 25 agents starts from the northeast corner and is trying to reach the red goal in the southwest corner defended by 150 red agents. The blue agents have been given higher individual fighting capability than the red agents. The blue force has also been given a propensity to move away from the reds (but not as strong as their propensity to move toward the goal). This is not to say that they won't engage the reds, but their tactic takes on the appearance of a "maneuver" type tactic versus a more "attrition" type tactic of simply barging straight toward the goal with no regard for what might be in the way. Who will win when we pit the more capable fighters against the numerically stronger force? As always, the answer is: it depends. But in this example, at time step 75 depicted in figure 1, the blue force has already made it more than half way to the goal along the path of the first arrow. And the curved arrow shows that in succeeding time steps the blue agents will exploit the gap between the two lower red groups and make it to the goal.

Before we proceed to the next example, it should be emphasized that these examples bear little resemblance to reality. The opposing "forces" are simply blue and red dots from a computer screen. We may be motivated by reality and our questions concerning maneuver warfare, but this work represents simply some preliminary attempts to begin to take small steps in perhaps getting some slivers of insight into our questions.

Figure 2 again depicts two forces opposing each other and again the snapshot is taken at time step 75. The red force is exactly the same as before. The only difference in the blue force is that the agents now have some propensity to go after the enemy (again, not as strong as their propensity to head toward the goal). This change in propensity results in a mad dash straight for the goal and much more attrition of red in the process. The figure shows that the blue force has made more progress toward the goal by time step 75. And they will, in fact, get to the goal much faster than in the first example.

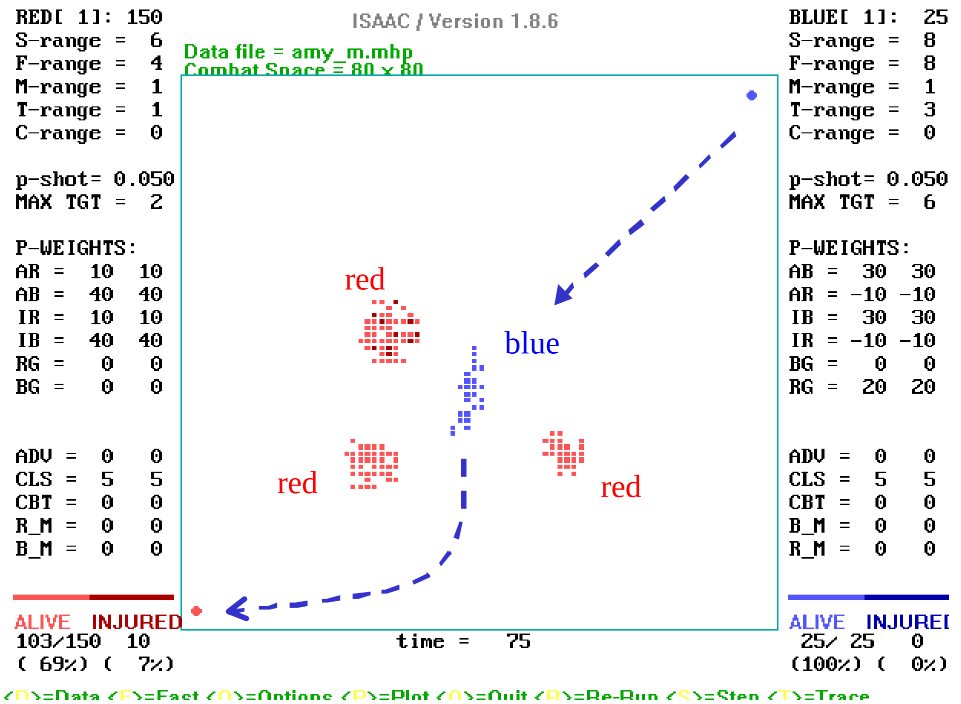

Figure 1: AMY_M Snapshot Taken at TIME Step 75

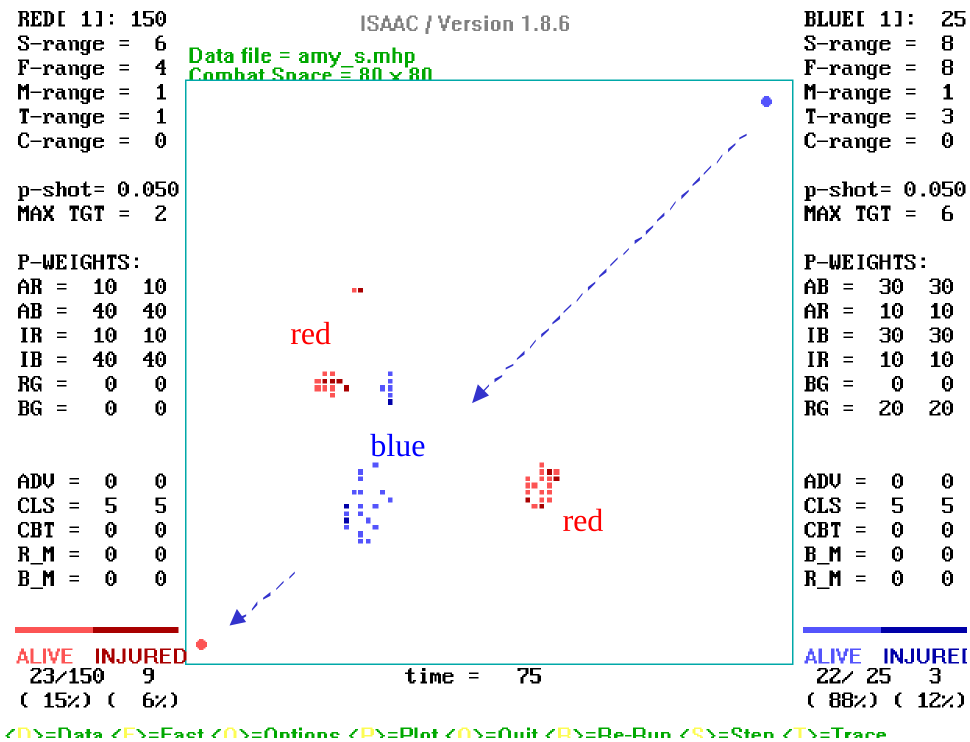

Figure 2: AMY_S Snapshot Taken at Time Step 75

When comparing the two examples above, the fact is that we are looking at just two simulation runs. Even if we have, in some sense, distilled the essence of maneuver versus attrition questions, we would want to explore many more runs. And, in fact, research is ongoing in this area. In particular, we have developed this family of scenarios referred to as an Attrition Maneuver Yardstick (AMY) because it serves as a tool to use in the process of beginning to understand how we might explore these questions. In pursuit of these questions we are applying our data farming meta-technique described in the third reference, and millions of AMY runs have already been performed at the Maui High Performance Computer Center (MHPCC). Figures 3 and 4 show fitness landscapes graphed from subsets of about a quarter million runs each.

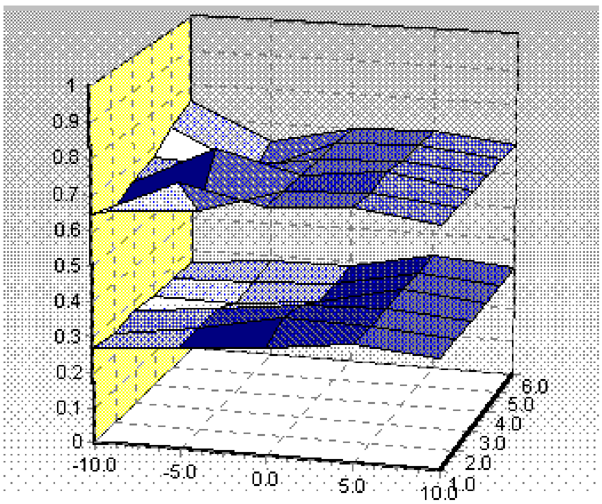

Figure 3: AMY_M Fitness Landscapes

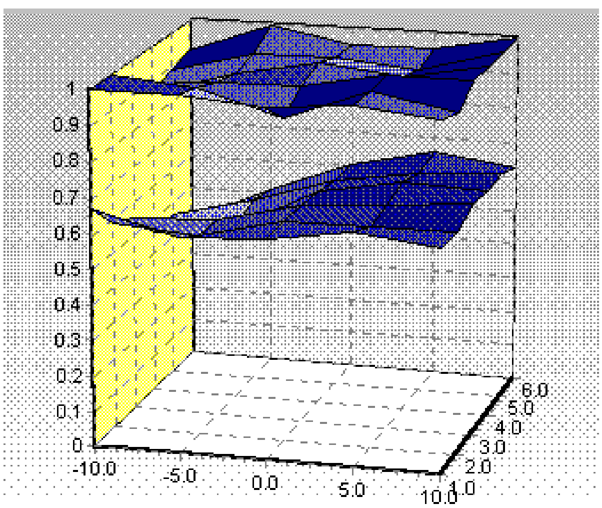

Figure 4: AMY_S Fitness Landscapes

The z-axes in the figures above represent "fitness" of the blue force. In these cases, fitness is a measure of how well the blue force accomplished the mission of getting to the goal in a timely fashion. A fitness of 1 represents blue getting to the goal in the fastest possible time, i.e. the red force unable to slow the blue force at all. Five values of a parameter representing the aggressiveness of the red force are shown on the x-axis (the lower the value the more aggressive the force). Six values of the parameter representing the maximum number of blues that red can engage on each time step are shown on the y-axis. For each of the 5 times 6 = 30 values, the model was run 100 times. The top surface represents the maximum fitness achieved over these 100 iterations. The lower surface represents the mean fitness over the 100 iterations.

Figure 3 shows results from a blue force with maneuver behavior as previously illustrated in figure 1, and figure 4 shows results from a blue force which tends to move straight toward the goal as previously illustrated in figure 2. These landscapes show that blue accomplishes the mission much more quickly in the second case across this parameter space. But notice in the back left corner of the bottom landscape in figure 4, when the aggressiveness and the maximum engagement number of the red force are both high, the fitness seems to drop off. Thus, in future runs we may want to expand the range of these parameters. We may also want to look at other red parameters and, although we don't depict them, we actually examined 7 values of red shooting accuracy, 4 values of red clustering, and 3 values of red communication. The data visualization tool developed by MHPCC allows us to look at any combination of these parameters.

We have shown examples of two basic blue forces against a variety of values for the red force. Thus, another area of exploration might be to look at changes in outcome due to changes in the blue force. Other areas to look at would be finer gradations in the parameters, more iterations, or different measures of effectiveness. The possibilities are numerous, so we will conclude with a brief examination of this last idea: a different measure of effectiveness.

Figures 5 and 6 depict the same parameters on the x and y axes as before, but now fitness is minimizing blue casualties. We have tilted the graphs to see the noticeable dip in fitness for the blue force, which plows straight ahead when red has high aggressiveness and ability to engage many blues. The two figures when compared show that, against a red force that is not aggressive, both the maneuver and attrition dispositions fare well. And if we go back to figures 3 and 4, we see that moving straight ahead gets the job done faster. However, if the red force is very aggressive, the blue force could still take minimal casualties if they were willing to use maneuver and have a longer time to goal.

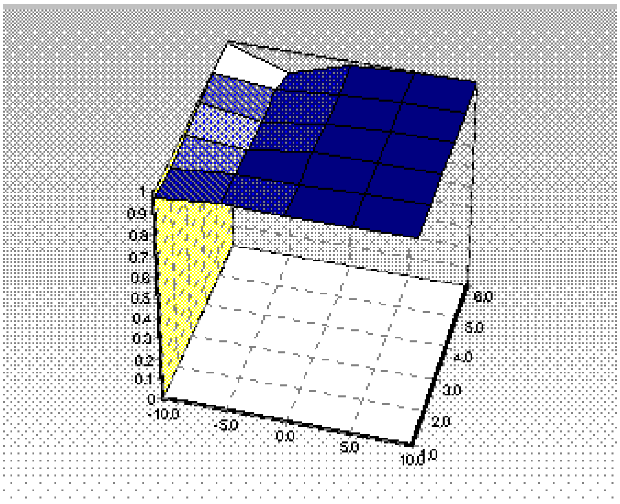

Figure 5: AMY_M Minimizing Casualties Landscape

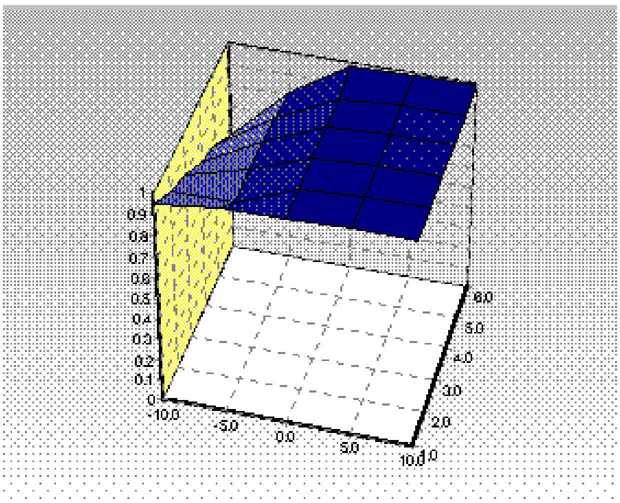

Figure 6: AMY_S Minimizing Casualties Landscape

4 CLOSING WORDS

In this brief paper, we can only scratch the surface of the possibilities even for this simple scenario. For example, what if blue wanted to get to the goal and also minimize red casualties? The blue force with the propensity to plow straight ahead shown here had more blue casualties and inflicted more red casualties than the maneuver force. But outcomes not shown actually include examples of the other possibilities: more blue and less red casualties, less blue and more red, and less blue and less red. In conclusion, the research in this paper/presentation merely shows some initial explorations where actual answers will ultimately depend on the distillation of the essence of warfare.

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AUTHOR BIOGRAPHY

GARY E. HORNE is the Center for Naval Analyses Representative at the United States Marine Corps Combat Development Command. He holds a B.S. in Mathematics and an M.Ed. in Education from the University of Maryland and a D.Sc. in Operations Research from George Washington University. His research interests include the application of complex adaptive systems theory and models to military evolutions. He is the originator of the Data Farming meta-technique and is the executive director of *Project Albert*, the primary Marine Corps effort in the area of Operational Synthesis.