Information Technology, Military Change, and the Role of Simulation

Corey L. Lofdahl, Ph.D.

Science Applications International Corporation
Burlington, Massachusetts, U.S.A.
e-mail: clofdahl@bos.saic.com

Dr. Lofdahl holds degrees in electrical engineering, computer science, and international relations from the University of Colorado at Boulder, Brown University, and the Massachusetts Institute of Technology. He is a Senior Scientist with Science Applications International Corporation's Simulation Technology Division specializing in C4I system and information assurance simulation. He is currently working on the manuscript Environmental Impacts of Globalization and Trade: A Systems Study for the MIT Press.

ABSTRACT

The civilian economy has been transformed by the widespread application of information technology (IT), a development that has not gone unnoticed by the military. Looking at the civilian sector's successes, military leaders naturally wonder if a similar application of IT would produce similar results in transforming the force. Strong opinions have been revealed both for and against the military's widespread adoption of IT. To help in constructively focusing this debate, simulation is offered as a means to evaluate and test proposed IT applications before their incorporation becomes widespread. To actually accomplish this ambitious goal however, traditional military simulation — which has been dominated by large, general, singular, costly, and disappointing efforts — should be updated with new techniques that have proven themselves to be comparatively circumscribed, focused, varied, efficient, and effective.

INTRODUCTION

American society, economics, and business have all undergone fundamental change with the injection and incorporation of information technology (IT). The sometimes chaotic yet always competitive economics of IT are characterized by increasing returns on investment, rapid growth, and the "locking in" of emergent technologies. Understanding the success of IT is simple -- computers allow businesses to process information faster and more accurately, allowing them to do more work better. From the perspective of the individual, IT grants fast access to more and better quality information. Interpreting this accurate information grants a better understanding of the marketplace, which in turn leads to superior decisions.

Given IT's history of civilian success, it is envisioned that its incorporation by the American military — that is, *Network-Centric Warfare* (NCW) — will lead to a similar

revolution in military affairs. Military planners predict that in the NCW era, comparatively stodgy and static attrition warfare will fade away as advanced information networks grant commanders superior understanding of the battlespace, which in turn will grant superior speed of command and coordination of battle effort.

Some however question whether NCW is as inevitable or beneficial as its proponents maintain. The United States remains the world's only superpower after all, which implies that any possible adversary will not employ weapons of similar technical sophistication. Consequently, might American military preparations be better spent on comparatively low-tech solutions for comparatively low-tech conflicts like those in which America has found itself since the Cold War's end? If NCW does not adequately address probable conflicts against likely adversaries, then efforts made on its behalf can only serve to lessen the resources available to warriors who must still operate within such conflicts. Moreover, is it reasonable to expect that civilian businesses and military forces will both derive similar benefits from IT? Besides, the sheer volume of data may overload commanders with information, and the very speed of NCW may cause them to make hasty and incorrect decisions.

The transformation of the American military to meet the challenges of an evolving international context provides our analytic point of departure: how best to explore the tradeoffs and reconcile the disparities between those who favor NCW and those who are more circumspect of its benefits? That is, how to explore, weigh, and justify the decisions necessary to change the military institutions and their attendant command structures? Simulation is offered as the analytic lens with which to focus this effort, but not simulation as it has traditionally been undertaken. Whereas previous military simulation efforts have been singular, sprawling, general, and ultimately disappointing, a family of varied, circumscribed, and focused simulations would improve the evaluation of proposed changes. Not only would the proposed simulations allow for scenario analysis before actually implementing proposed changes, but the shared understanding that results from making assumptions explicit through simulation would allow organizational changes to be implemented more quickly, consensually, and thoroughly.

TECHNOLOGY-DRIVEN FORCE TRANSFORMATION

Over the past decades, information technology (IT) has transformed not only American industry but the global economy. Multi-National Corporations have extended their influence using advanced communications technologies and computers to handle the complexity of international taxes, tariffs, and regulations encountered by foreign factories and sales offices. More regionally focused companies use IT to empower employees, reduce costs, and react to market changes more quickly by making more information more available and more accurate. The incredible profits of the computer-based industries — especially those of California's Silicon Valley, Seattle, and Boston's Route 128 — provide dramatic testimony to the success of IT in the marketplace. The pervasiveness of computers has changed not only the companies that use them but also the markets in which the companies do business -- markets have become increasingly global, competitive, and changeable. This international economic transformation extends into the realm of national competition as continued American economic growth depends on the continued enlargement of foreign markets, globalization of labor and capital, and application of IT.

Decision makers and managers working within these increasingly competitive markets are encouraged to invest in IT to pursue growth, enter new markets, or fend off competition by improving their responsiveness to customer's needs. The implicit portrayal of IT is not just one of many options available to increase profits but instead is almost a necessity for survival in the modern marketplace. Given that world markets have been increasingly shaped by the corporate use of IT, and given that the competition one needs to ward off is likely using IT, the survival theme becomes even more pointed. Oracle (1998) goes so far as to maintain that companies need IT, "… to help guide their strategic and tactical decisions." With a company's very survival at stake from threatening rivals, the civilian use of such terms as 'strategic' and 'tactical' is not out of place. To help the modern decision maker survive and thrive in this environment, modern business information systems provide a range of reports and other information outputs including profit statements, trend analyses, and monthly financials. Buying IT "solutions" to compete against similarly equipped opponents is reminiscent of those militaries who are forced to purchase weapons to retain parity with similarly equipped opponents — businessmen and soldiers fight the battles, while computer and arms merchants increase their profits by selling their wares to both sides.

Such changes in the civilian economy have not gone unnoticed by military leaders. In the face of such powerful technical advances and social transformations, it is reasonable to ask how is it possible that the military not change? A similar, massive application of computer and communications capability to U.S. military forces is predicted by some to change fundamentally the way war is conducted, what is generally called the *Revolution in Military Affairs* or RMA. It might seem inevitable, but it is not. Real people still have to do real work to make the RMA happen. Conventional RMA articulations however tend to remain hazy, remote, and under-specified. That is, an attractive future vision is proposed, but few of the tough and inevitably contentious details regarding how RMA's promise might be achieved.

Cebrowski and Garstka (1998) help us to understand how a high-technology driven RMA might actually be incorporated by the U.S. military by specifying their vision of *Network Centric Warfare* or NCW. The goal of NCW is information dominance — that is, maximum relevant information content and accuracy achieved in minimal time — which is achieved through a sensor and transaction/engagement grids connected by a high-quality information backplane. Such a system is designed to grant future U.S. forces not only superior speed of command but also the more subtle quality of self-synchronization — the spontaneous and self-directed ordering of disparate and diffuse units. The difference between present warfare and NCW is analogous to that between football and soccer: football is more centrally directed and punctuated by interruptions that allow for reorganization, while soccer in contrast is more diffusely directed and continuous. Arquilla and Ronfeldt (1997) make a similar contrast between chess and the Japanese board game go, with chess being more concentrated and direct and go more spread out and subtle. Forces are envisioned to be diffuse in NCW; it is the fires and effects that are to be massed. NCW however delivers aggregate results akin to those achieved in the computer-driven civilian marketplace: increased return on investment, competition between and within complex systems, and an emphasis on timeliness.

Lest we be carried away by the promise of NCW however, it is instructive to recall that this is not the first attempt to revolutionize the command structure of the U.S. military. So common is the urge to improve command that Van Crevald (1985, Ch. 1) characterizes the manner in which command structures generally change over time. First, as command complexity increases, the need to coordinate and communicate among disparate groups

increases, leading to an increase in the time it takes to make command decisions. Second, this increased need to communicate leads to advances in data communication and processing technology. Third, as a result of increased command complexity and advances in information processing technology, the amount of data processed per mission greatly increases. Fourth, as command centers have grown to process an ever expanding amount of data, they have become more vulnerable. This makes sense as crippling an ever more important command center would deliver an ever more destabilizing blow to the enemy. Fifth, as a result of the previous four trends — increased command complexity, information flow, data processed per mission, and vulnerability — the costs of command have increased mightily. Envisioned by NCW's proponents as a force multiplier, command systems are now the most expensive component of airborne and naval systems and an increasingly expensive part of land-based systems as well.

To illustrate these trends, Van Crevald (1985, Ch. 7) focuses on the negative command consequences — or more specifically, *information pathologies* — that resulted from the application of advanced communications technologies during America's involvement in Vietnam. The first consequence is complexity: a full 25 per cent of the jobs, 33 per cent of the equipment, and 50 per cent of the spare parts in Vietnam pertained to communication and signals. With this complexity came new ways of studying war, specifically *systems analysis* with its foundations in statistics and focus on quantities. The problem was, such techniques illuminated corporate finances far better than the political and ideological questions that dominated Vietnam. Implicit within the adoption of systems analysis the need for an insulated commander to understand what was happening beyond his view. The statistics of the Vietnam — kill ratios, body counts, hamlets pacified – combined in the commander to create a mental picture of the battlespace, albeit an inaccurate one. But this lack of well-formed, overall view was not particular to command: specialization, the flip side of complexity, helped insure that nobody really knew what was going on. And if somebody did by chance develop an accurate picture of his area of responsibility, personnel were reassigned and rotated frequently enough to ensure that such expertise was quickly lost. The final consequence was centralization, which took the form of quite senior people making relatively minor decisions. As more data converged on commanders, information backlogs occurred, which led to workarounds that only further clogged the information pathways.

The Vietnam experience may seem like ancient history given the great technological advances that have occurred since then, but two observations keep them fresh and relevant. First, one must question whether any amount of processing power would have kept America's Vietnam-era command pathologies at bay? And second, although communications and computer technology have improved, human organizations and the people who inhabit them remain pretty much the same. Keeping these observations in mind, let us turn to more contemporary concerns. Johns (1998) reminds the weapons acquisition community that systems operated in the field by servicemen are not the same as those operated in the lab by developers and engineers. Too often servicemen are saddled with ill-conceived systems that increase, not decrease workload. Moreover, such systems need to be serviced and upgraded, easy-to-fix bugs often aren't, and the real world is much bigger and more complex than can be accounted for in a canned lab demonstration. Finally, it makes sense to gradually deploy systems so that difficulties may be worked out on the small scale, which tends to be much more workable initially.

Debugging and deploying a computer system is hard enough, but what if the system isn't even aimed at the correct problem? Barnett (1999) points out that NCW is indeed high-tech,

but any conceivable opponent would be low-tech by comparison. Consequently, Barnett fears that NCW might detract the U.S. military from lower-tech military operations other than war, which seem to be America's most likely threat (Van Crevald 1991; Kaplan 1994; Kennedy 1999). NCW, with its promise of dispersed forces and concentrated fires, seems to hold out the promise of decisive and painless victory through overwhelming force as did the strategic bombing arguments offered earlier this century. Strategic bombing however did not prove as powerful, decisive, or painless as originally conceived, and it is fair to wonder if NCW will suffer the same fate. Finally, Barnett wonder whether the military covets the civilian economy's self-synchronization. In making analogies between civilian and military organizations, it is easy to forget how civilian-style synchronization is achieved. Businesses engage in similar patterns of behavior, day after day and year after year; after a while, they get good at it. Military units, in contrast, may practice as much as they like, but real-world conflicts have the nasty habit of throwing unique situations at the forces tasked to deal with them. This seriously hinders iteration, optimization, and synchronization. Hence Moltke's observation that, "… in war, with its enormous friction, even the mediocre is quite an achievement." (Kessel 1957)

Others are even more skeptical of the RMA, going so far as to question the motivations of NCW's proponents. Helprin (1998) maintains the RMA is little more than a ruse offered to mask the systematic enervation of U.S. military forces by the present administration. To illustrate his argument, Helprin contrasts and compares the Israeli Defense Force (IDF) of the '70s with the U.S. forces of the '90s. The IDF thought itself invulnerable due to its superior weapons, and so it did not concern itself with Helprin's observations of sentries who deserted posts, tanks that wouldn't start, or fights among IDF soldiers. So pervasive was this view that it took a surprise attack by Egypt to convince the IDF leadership to the considerably less rosy reality. The United States currently views its forces as the world's best and with good reason given its recent victory over Iraq. But Helprin questions how many military revolutions have occurred in times of declining budgets. How many revolutions have come from civilian demands on the military sector rather than military demands on the civilian sector? Servicemen who disagree with current military decisions and directions are put in the difficult position of following orders and keeping quiet or resigning, and many are choosing the latter. Recent articles with the titles "Listen to the JOs — Why Retention Is a Problem" (Natter *et al.*, 1998), "The Chiefs are not Happy" (Butler 1998), and "Wither the Warrior?" (Lanman 1998) indeed make one wonder if the vision of easy and bloodless victory courtesy of NCW might also lead to the neglect of more basic and mundane military duties.

This section has outlined and developed some basic tensions. First, it is obvious to some that computer advances in the civilian sector are forcing the U.S. military to modernize. Quite beyond weapons system advances, it is envisioned that computer technology will transform command itself to a revolutionary extent. Others are not so sure. Historically, the over-application of communications technology in Vietnam probably created more problems than it solved. More recently, valid concerns have been raised regarding the transition of high-technology solutions to the field, the appropriateness of high-technology system development efforts given America's preeminent position in the international system, and even the political motivations behind such efforts. These concerns are all recognized as serious, empirically grounded, and well-intentioned. Such recognition does not, however, offer a clear path to their resolution. Short of a miraculous, amicable resolution, we must ask ourselves if there exists the means to reconcile these opposing positions by taking the best aspects of each and crafting a solution that is not only more palatable but also just plain better? This possibility is explored in the next section.

SIMULATION'S ROLE IN TRANSFORMING THE FORCE

A fundamental tension exists whenever a change as drastic as wholesale transformation is proposed, especially within an institution as resistant to change as the U.S. military. The basic contrast is between those who support and those who oppose change. While strongly divergent views are recognized as inevitable, the important question is how the energy of the debate gets channeled. That is, the danger always exist that a debate involving deeply held views by strong personalities will be overwhelmed by emotion and anger leading to more heat than light, more bruised egos than constructive action. Such a result is tragic because the participants almost universally are honorably motivated by a desire to further the common good, and yet internecine conflict occurs all too often because there is no mechanism or process to reconcile opposing views.

Simulation is offered herein as an instrument to direct the RMA and NCW transformation debates away from discord and toward a more constructive and consensual outcome. The proffered process is quite simple — normally when people disagree, an argument takes place. At some point however, the argument must stop. If the argument is civil and there is a clear final answer, then the outcome is amicable. If however the argument becomes emotional, the question is unclear, and the final answer is determined by verbal aptitude or rank, then the likely outcome will include bitterness. How much better it would be if both ways could be tested through simulation with the winner determined by the best outcome for all involved. Showing how this general simulation argument applies to military transformation is accomplished in four steps. First, the transformation discussion is continued and decomposed into a set of tasks. Second, simulation is offered as a means to achieve these tasks. Third, a brief history of traditional military simulation and its shortcomings is presented. Fourth, another simulation tradition is proposed as a viable alternative.

The overall goal for the U.S. military, preparing for possible conflicts, is obvious. Deciding what steps should be taken in the short-term to achieve this goal however is somewhat less clear. Davis et al. (1998) have attempted to do just this, outline a set of steps that will allow the military to achieve its 21st Century goals. The most basic is that of achieving strategic adaptiveness in response to the indeterminacy of potential opponent. The relative certainty of the Cold War is over and with it the ability to focus military preparations on the Soviet Union. Given today's more fluid international system, it is quite difficult to characterize potential foes generally except to say that they will almost certainly not be as technically advanced or well equipped as the United States. Beyond that though, the range extends from upcoming regional hegemons like China to smaller, sub-national forces that would call for military actions other than war. The United States must be able to counter both types of threats, anything in between, and other forms of conflict not yet imagined. To meet this ill-defined challenge, U.S. military forces must be flexible and able to adapt their power projection capability in protecting American interests.

How well has the U.S. military done in its recent efforts projecting power? The Gulf War, at first blush, appears to demonstrate that America is quite capable of projecting joint power. However, it must be remembered that it took almost six months to move the forces over to bases that had already been built and stocked. Moreover the enemy did very little to thwart our efforts throughout these six months, and when U.S. forces finally were ready to

operate, they did so in an open, desert environment ideally suited to its weapons. And no chemical, biological, or nuclear weapons were loosed, which further simplified operations. So U.S. forces performed well, but it took a very long time for them to prepare.

Given the Gulf War experience, can it truly be said that the Joint Task Force (JTF) concept works? Davis *et al.* (1998) maintain that more attention must be given to creating and coordinating joint forces. Joint exercises are indeed run, but they are made up of forces from the four services, to which they return when the exercise is complete. So the net effect of joint training is ephemeral with no lasting legacy and no direct responsibility. Creating truly joint forces will require more than coordination among the four services, it will require high-level visibility and responsibility at the level of the Office of Secretary of Defense, Joint Chiefs of Staff, or DARPA. To break off the critique here would leave the false impression that the required palliative is known: that is, the application of sufficiently high-level attention to the problem. This is not the case: RMA and NCW imply new ways of fighting, and the current military knowledge base is insufficient to support or direct the creation of the forces capable of operating in an NCW environment.

Operational simulation is offered as a mechanism to test and develop the military knowledge base necessary to carry out NCW. At the most basic level, simulation allows an analyst to experiment with multiple strategy and tactics packages in an afternoon at low cost rather than mount a fully equipped and manned exercise that would take months and cost a great deal. With the time and money at stake during an actual, fielded war game, there exists a considerable disincentive to experiment too radically as failed experiments waste resources. No such disincentive exists in the simulation world. With decreased costs and increased speed, lessons that might previously have taken years to discover can now be made in hours. Moreover, if an entirely novel situation is encountered — one to which no previously exercise applies — then it can be worked out through simulation before committing troops to the field.

The use of simulation promises multiple benefits. It allows for more experimentation and variation, which will result in the rapid evolution of military doctrine. The time delay between initial idea, implementation, experiment, and result can be shortened by orders of magnitude with simulation. The scenario analysis capability afforded by the technology also allows commanders to evaluate the flexibility of their plans as well as the uncertainties they may encounter, thus increasing their confidence when applying new strategies and tactics in the field. Scenario analysis also helps the warfighter to defend the additional resources necessary to achieve operational flexibility against over-optimized financial analyses. Libraries of completed simulations can serve both as a training resource and a repository of lessons learned, making the lessons of joint exercises more permanent.

While simulation's promise and potential for transforming the U.S. force of the future is bright, its past history contains ample evidence for caution and concern. Early, Vietnam-era analyses focused on the measurable, not the operationally important, and so they tended to generate mind-numbing data, not useful information or knowledge. More recent military simulations, in an attempt to be comprehensive (e.g., JWARS and JSIMS), have resulted in general and unfocused efforts that have failed to deliver the results promised. Military simulations have traditionally been used for training, not analysis. This trend persists as recent simulations remain inadequate to support high-level command decisions under uncertainty. What is certain however, is that being big programs, they have proven quite

expensive. Clearly, if simulation is to live up to its potential in the upcoming military transition, improvement is necessary.

Czerwinski (1998) provides a useful compendium of advanced simulation techniques that can be used to improve military simulation. This essay will focus on just one technique, *system dynamics*. MIT business professor Jay Forrester founded the discipline, interestingly enough, after having worked on military logistics during World War II, although its seminal publication was *Industrial Dynamics* (Forrester 1961). Thus system dynamics was born of military operations, not business and finance. As experience accumulated, certain generalizations regarding system dynamics models could be made (Forrester 1971). First, as system dynamics simulation is rooted in patterns of nonlinear relationships, large amounts of empirical data are not required. System dynamics can also model soft, qualitative variables like morale, patriotism, and propensity to defect, and so it is good for exploring ill-structured problems. It is sometimes tempting to assert that system dynamics models generate forecasts, but this would be a mistake. It is more accurate to say that system dynamics enables scenario analysis by allowing one to explicitly formulate one's mental models and then test them. Successive iterations of formulating, testing, and changing a model tighten and focus one's understanding of an unformed problem. The final model is not perfect by any means, and so it cannot generate 100 per cent accurate forecasts. However, decisions based on a combination of mental and system dynamics models tend to be better informed and more accurate than those based on untested mental models alone.

Early models were spare, but this initial period was followed by rapid increase in model size. These larger models were generally unsuccessful because in making the models all-encompassing in an effort to be accurate and inclusive, they also became unfocused (Meadows 1982). Consequently, there is now an increasing emphasis on model focus: system dynamics students are encouraged to spend time sharpening the question they wanted to answer. This in turn helps to circumscribe the topic by making clear what should and should not be included in the model. The goal is now to have a "medium" sized model: large enough to capture and describe the problem, but not so large as to be slow, cumbersome, and confusing. This emphasis on medium-sized models implies that a truly large and complicated problem might require a family of models to describe it. This is not a big problem as system dynamics models do not require a long lead-time or a large development team. A single experienced user can sometimes develop an adequately comprehensive model in a single day. Incorporating other methodologies only increases the analytic power.

The power of system dynamics comes from its ability to represent systemic feedback relationships, whether the problem is more related to control theory or organization theory. Another name for the study of feedback-based systems is *cybernetics*. The ability to analyze feedback relationships is important because, while they might be pervasive, they are manifestly non-intuitive. Consequently, actions and policies undertaken to achieve one set of goals often generate a completely different if not opposite set of results. Consider, for example, the information pathologies experienced by U.S. forces in Vietnam (Van Crevald 1985, Ch. 7). The most advanced communications technologies and analytic techniques were implemented for all the right reasons but delivered disaster. Forrester (1971) maintains that most policies undertaken within a feedback-dominated social system hardly ever push the right policy levers, which are seldom obvious. If by chance the right policy lever is located, then as often as not is will be pushed in the wrong direction.

Despite the fact that certain policies generate results diametrically opposed to those desired, they can prove quite persistent. After all, without correcting the mental model responsible for the policy, there is no reason to expect the policy to change. Much comment has been made about decisions under uncertainty, but what is potentially more dangerous are decision based on incorrect assumptions -- in other words, "It isn't what you don't know that hurts you, it's what you do know that isn't so." In recognizing this as a problem, persistent conflicts become slightly more understandable. Perhaps a persistent policy is just plain wrong? Testing such propositions is possible with system dynamics. Operationalizing such inquiries is accomplished by having a system dynamics practitioner implement a model based on the understanding of members from multiple levels of an organization. It is important that they be involved throughout the modeling process in order to achieve buy-in. Models created by experts in isolation tend not to be persuasive. When the model is ready, the system is run and the propositions and underlying assumptions can be tested. In this manner persistent disagreements can be tested not in the social realm of arguments and personalities, status and rank, but through an analytically disinterested computer model. If the model is valid, and all can agree on its relationships and assumptions, then simulation can serve as the foundation for reconciling conflict, establishing consensus, and building team feeling.

CONCLUSION

This essay has presented the debate between those who favor RMA and NCW and those who have concerns. However, no position is taken favoring one over the other. Instead, simulation has been offered as one way to diffuse the debate and turn it in a more constructive direction. In doing so, simulation has been examined from three different perspectives: (1) how simulation can help to transform the force, (2) how military simulation has performed in the past, and (3) how simulation might be improved in the future. One particular simulation methodology has been offered as an example — system dynamics — although several advancements drawn from several may ultimately be required.

As positive as the contribution of simulation might prove to force transformation though, massive applications of high-technology will not solve all of the military's 21st Century's command problems. Organizational, political, and institutional changes will prove just as important, if not more so, than technical ones. Five general command rules (Van Crevald 1985, Ch. 8) provide a reminder of this lesson. First, freedom of action should be pushed down the chain of command to prevent over-centralization at the top. Second, decision-thresholds should be kept low so that information flows can be reduced and individuals can retain freedom of action. Third, regular reporting should be required in both directions through the chain of command, from the top-down and bottom-up. Fourth, commanders should supplement this information through additional searches in the organization. Fifth, in a healthy organization information flows through both formal and informal channels, and so providing opportunities for people to interact within informal settings should be encouraged. However, these organizational changes combined with advanced C4I systems and tested through simulation will provide the most potent combination in transforming the force.

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