FUTURE LEADERSHIP, OLD ISSUES, NEW METHODS

Douglas V. Johnson II
Editor

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FOREWORD

Each year, the Army After Next Seminar students are asked to orient their Strategy Research Papers on topics that are potentially relevant to future defense programs. Thirty years is a challenging time horizon for planning. Thirty years ago, the United States Army was deeply involved in Vietnam and in the Cold War. Officers could reasonably expect to serve repetitive tours in Southeast Asia interspersed with tours along either the Korean Demilitarized Zone or the Inter-German Border. The tension between sometimes guerrilla, sometimes major warfare in the Pacific and the prospects of nuclear war in Europe made any projections of a future like that which we currently enjoy highly unlikely. Yet we are now asking officers to make such prognostications so that they might be less surprised by whatever future does eventuate.

The authors of the following papers have accepted, for sake of argument, that the future leadership environment will conform to a paradigm in which time and distance will be compressed while operational scope and information will be enormously expanded. Although there is consensus on this paradigm, the particulars are not well-developed. Nevertheless, these authors put forward recommendations that, although focused on a distant future condition, have as much application to today as they do for that future. Careful to maintain the essential differences between leadership in business and industry and military operations, they highlight some of the most important and promising developments in leadership education and training. Their papers deserve serious consideration.

DOUGLAS C. LOVELACE, JR.
Director
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CHAPTER 1

INTRODUCTION

Douglas V. Johnson II

The monographs here assembled are the work of students in both the AY98 and AY99 Army After Next Seminar at the U.S. Army War College. Their focus is on the leadership development component of the human and organizational dimension of the Army After Next Program.

While the ultimate shape of the Army After Next is unclear, a consensus has emerged from the broader studies conducted through the Training and Doctrine Command (TRADOC) and elsewhere that the future command and leadership challenge will be significant. If a complete transformation of warfare occurs, as some posit, an accompanying transformation of command and leadership may likewise be required. This is not to say that the basics of leading soldiers is likely to change, but it suggests that the art of command, in which leadership is a component, is likely to be significantly transformed. The operating premise is that the tempo of operations will increase; the scope of action at each level will expand; the time constraints for mission accomplishment will diminish; and the tools for gaining and obtaining information will proliferate and provide near-perfect friendly and significantly improved knowledge of the enemy.

Lieutenant Colonel Kevin J. Bergner's chapter recounts this premise and examines in detail perceived mismatches between sets of cognitive requirements. If tomorrow's leaders need to know more about more in less time than today, something has to change; and those changes, an answer to the "How To?" questions, are the basis of Bergner's argument. Among his most intriguing propositions is our ability to develop "tacit knowledge," action-oriented knowledge, acquired without the help of others, that substitutes for the "On the Job Training."

Marine Lieutenant Colonel Arthur J. Corbett seizes on the concept of “consilience,” the ability to maneuver rapidly among cognitive domains—"a jumping together" as one author describes it—to produce a useable explanation of events. In this chapter, his work connects to Bergner’s through the need for cognitive development. Corbett’s monograph has a different focus, however, as he suggests that the root cause of the next Revolution in Military Affairs (RMA) will only come about with the proliferation of decisionmakers. In one sense this is a manifestation of the emerging consensus that the only way to manage the fast-paced, widely-dispersed, simultaneously executed future operations is to accept a much flatter, wider hierarchical command structure. The very thought of such a change is unsettling, partly because some of its roots lie in the business world. In that world profits are the goal and no soldier should be willing, rightly, to equate profit-generating mechanisms with the life and death decisions involved in combat mission accomplishment. Corbett takes the reader through a rapid historical review of dispersed military decisionmaking, then reviews the business literature as well. He also touches on the new sciences of chaos and nonlinearity, noting the growing proliferation of complex adaptive systems. At this point, he reinforces Bergner’s depiction of the future warfare environment, some aspects of which are already evident in contemporary operations.

Lieutenant Colonel Lawrence G. Shattuck is a Permanent Professor in the Department of Behavioral Science and Leadership at the U.S. Military Academy. His “Proposal for Designing Cognitive Decision Aids for Commanders in the 21st Century” is based upon his research and personal observations of a series of exercises conducted in June 1997. His research concluded that digitization and decisionmaking have a long way to go to achieve maturity. Employing historical examples, he illustrates several decisionmaking models prominent in the literature. Shattuck argues that human cognitive activity is going to require some augmentation in fast-paced future operations, and that the Army ought to take the time now to fully investigate which systems are best—even at the cost of delayed fielding of some systems.

Math for Leaders is probably enough to scare many readers off, and Colonel Glenn Mitchell's subtitle, *Ideas From Chaos Theory*, could be further motivation to skip that chapter altogether. The reader who succumbs to those twin fears will be the poorer for doing so. Yes, chaos theory is complex and is often described with mathematical formulae that make even the best engineer or artilleryman weep in despair. But Mitchell's self-appointed task is not only to explain the essentials of chaos theory in readable English, but to present that theory as something useful to military commanders. For those who are still skeptical, we strongly recommend Alan D. Beyerchin's monograph, "Clausewitz, Non-linearity and the Unpredictability of War," most accessible in *Coping With the Bounds*, edited by Tom Czerwinski (Washington: Institute for National Strategic Studies, National Defense University, 1998). Mitchell describes the Newtonian world, with its characteristic linearity, in which we all came to maturity. He then moves into the emergence of chaos theory and the Non-linear Military Organization. Among his recommendations is a startling proposition that jointness, when carried too far, may stultify by reducing inherent chaos below an essential level of creativity.

Colonel Andre H. Sayles is a Permanent Professor in the Department of Electrical Engineering at the U.S. Military Academy. As one might expect, his concerns are for the basic educational proficiencies required to fully understand and effectively practice his discipline. His chapter, "Educating Junior Officers for the Information Age," addresses what he perceives to be a required fundamental competency for future military leaders. He lays out a description of information operations and relates their centrality to future operations to the requirement for technical proficiency. He provides a program of instruction throughout a military career that will ensure essential competence in the future officer corps.

In sum, these monographs offer a collection of ideas in response to a perceived future leadership environment. Some offer solutions that are available right now, some for later, but all of them suggest that it is time to focus on the issues, analyze them, and set to work on overcoming barriers to progress. One may argue that adoption of all these suggestions would set leadership education and training on its ear. With the exception of Sayles' proposal to revamp and reorient basic and continuing education into more electronic disciplines, all the proposals could be implemented today with a solid promise of significant improvement in officer education across the board. It is worth considering.

CHAPTER 2

INFORMATION, KNOWLEDGE AND WISDOM: LEADER DEVELOPMENT IMPLICATIONS FOR THE ARMY AFTER NEXT

Kevin J. Bergner

There is an evolving mismatch in the U.S. Army between the strategic environment and institutional leader development. To prepare soldiers to lead in the Army After Next, the developmental process must be accelerated and enriched through utilization of emerging technology and performance enhancement techniques.

THE HUMAN DIMENSION OF THE ARMY AFTER NEXT

As the Army rapidly progresses into the information age, the professional dialogue concerning how to harness the enormous potential of information becomes more intense. It is too frequently centered on equipment/technology solutions as opposed to human performance solutions. The Army After Next initiative is a rare example where a healthy balance between equipment-technology and human performance is emerging. Maintaining this focus is becoming ever more challenging as the allure of high-payoff, high-technology equipment and digitization overshadow the more "touchy-feely" explorations of human behavioral science and leadership.

Recent operational experience reinforces the fundamental importance of the human dimension, particularly to leadership. There is little disagreement that leader development played a central role in the Army's decisive combat victories in Panama and the Gulf War, as well as in the military operations other than war in Haiti and Bosnia. Indeed, most senior military leaders point to the Army's institutional commitment to leader development since 1973 as a central component in this series of overwhelming successes.[1]

Another consideration which compels an enduring focus on leader development is that the human dynamics of the Army of Excellence culture (1986-present) will not necessarily remain constant as we move further into the information age. In that regard, there already are glimpses of the potential effect that at least one institution—the media—may have on the learning patterns and values formulation of future soldiers and leaders.

For example, the average number of shifts in attention required of a viewer during a typical hour of television programming exceeds 800. That is more than 13 shifts per minute. One result among students is "difficulty concentrating in classrooms and impatience with analysis of issues and ideas beyond a few minutes."[2] Clearly, that raises concern for future Army leader development training and education. Alternately, it may suggest positive implications for leader capacity to rapidly process increasing amounts of information.

By age 18, young people now entering the Army have spent 11,000 hours in the classroom and 22,000 hours watching television. They have seen more than 750,000 commercials, "each crafted to short-circuit judgment and stimulate irrationality and gullibility to buy something."[3] These are troubling implications for developing the sound, intuitional judgment, character and values that future Army soldiers must have if they are to be members of a values-based organization.

These facts represent just the tip of the information age iceberg. They also illustrate that human performance is vulnerable to a variety of influences. By inference, leader development for the Army After Next is no less susceptible to changes in the strategic environment.

THINKING AND OPERATING: EVOLVING MISMATCHES WITH LEADER DEVELOPMENT

Throughout this century and particularly during the Army of Excellence era, the Army made a concerted effort to match leader knowledge and experience to the appropriate level of operational responsibility. A junior lieutenant was responsible for directing and executing tasks in a relatively well-bounded tactical environment, consistent with his level of training and experience. A colonel, on the other hand, was generally performing in a more abstract and complex environment, consistent with 20(+) years of experience and education. A robust leader and training development program emerged in the late 1970s that provided leaders a progressive and sequential educational system to prepare them first for the tactical, then operational, and ultimately the strategic level of responsibility. The result was a fairly strong match between level of thought, level of war, and level of institutional training and leader development. Today, there are glimmers of change in two areas which, if left unattended, may dramatically alter the relevance and hence the effectiveness of the Army's leader development system now, and even more profoundly, by 2025 for the Army After Next.

The first change is a shift in leader focus from information gathering to rapid learning. It is driven by the broad application of information technology and results in information overload. The most direct implication for leader development is an increasing need to focus on "how" to think, as opposed to "what" to think, and to accelerate the development of rapid learning skills.

The second area of change is as a shift from a linear and compartmented relationship between tactical, operational, and strategic levels of war to a more over-lapping and inter-connected relationship. Leader decisions at the tactical level now may have direct consequences at the strategic level. This change is driven by the increasing complexity of operations such as peace implementation in

Bosnia and broader access by the media. The most direct implication for leader development is the need to purposefully nurture strategic savvy earlier in professional development, as opposed to waiting until the 20th year of service.

These indications of mismatch between leader development and the emerging operational environment are defined principally by a universally broader access to information and a more complex operating environment. For the purposes of further discussion and examination, the terms cognitive mismatch and operational mismatch will be used to describe these two challenges for Army After Next leader development.

COGNITIVE MISMATCH: INFORMATION-KNOWLEDGE-WISDOM

> Army After Next Leaders will have access to more decision-relevant information than ever before, but there will be too little time to consider it sufficiently.
>
> Brigadier General Huba Wass de Czege
> (U.S. Army Retired)

The evolution of the Encyclopedia Britannica provides a useful start point in examining the differences between information, knowledge, and wisdom in the information age. In 1768, the 3-volume encyclopedia was limited, not by the information available, but by the printing and binding technology. Today the 32-volume Encyclopedia contains 44 million words and 23,000 illustrations. In computer terms, it equals a gigabit of data that can now be transmitted over fiber-optic lines in about a second.[4] No matter how fast it can be transmitted though, it is still more *information* than any one person could ever *know*, because the human ability to test, learn, or memorize it is inadequate.

The enormous amount of information in the Encyclopedia Britannica and the capability to access it quickly is symbolic of the information environment evolving for Army After Next leaders. A mismatch is being created by an overload of information available to the leader without an accompanying improvement in human thinking and learning skills. Fully understanding this challenge requires a more detailed examination of the cognitive process and the relationship between information, knowledge, and wisdom.

As leaders mature, they progress through developmental stages that reflect the increasing complexity of thinking processes.[5] These stages are not determined solely by the increased sophistication of a leader's cognitive processes, but are deeply affected by the depth, breadth, and complexity of the information the leader is processing.[6] In the simplest terms, Figure 1 shows a cognitive hierarchy consisting of information, knowledge, and wisdom.

Information

- Data collected from the environment and processed into a useable form. (FM 100-6)
- Unprocessed data of every description which may be used in the production of intelligence. The meaning a human assigns to data . . . (Joint Pub 1-02)

Knowledge

- Information that has been tested and accepted as factual. (FM 100-6)
- Facts, including procedures, that have been learned and can be reproduced from memory. (Jacques, Requisite Organization)

Wisdom

- Use of judgment to give knowledge relevance within a specific situational context. (FM 100-6)
- Soundness of judgment about the nature of people and the world. (Jacques, Requisite Organization)

Figure 1. Information-Knowledge-Wisdom Definitions.

The relevance of this hierarchy to leader development can be illustrated simply by relating it to the game of chess.

Information about chess is interesting in a limited way, but is only useful if your intent is to play the game competitively

From an Information ***perspective, chess is . . .***

- A game of strategy in which various pieces are moved in combination to attempt to capture the opponent's pieces.

From a Knowledge ***perspective, chess is . . .***

- Memorizing which pieces can be moved according to the rules of the game and some understanding of how an opponent will approach the game.

From a Wisdom ***perspective, chess is . . .***

Figure 2. Chess.

or develop a mastery of the game. That requires practice, memorization, and experiential learning to develop the requisite *knowledge* and *wisdom* described in Figure 2.

The point is that enormous amounts of information about chess will not, in and of themselves, create a chess master. However, unfettered access to information, coupled with rapid learning and experiential growth, offer an opportunity to develop a tremendous knowledge and wisdom advantage.[7] The same is true for the Army After Next. Leaders can have broad access to vast amounts of information, but without rapid learning and experiential growth, they will not have the knowledge and wisdom to exploit the information advantage.

The information age clearly demands redefining leader thinking requirements. The challenge for leaders is to shift from information deficit to information overload; to *know* how to use that abundance of information and have the *wisdom* to relate it to an increasingly complex operating environment. The Army must shift focus from teaching what to think, to how to think, and adopt rapid learning techniques to exploit the knowledge advantage. It must also shift toward more rapid experiential growth in order to exploit a wisdom advantage.[8] Institutional reluctance to make this transition will almost certainly broaden the mismatch between cognitive challenges in the future information environment and current leader development preparation.

OPERATIONAL MISMATCH: TACTICAL-OPERATIONAL-STRATEGIC

> Army After Next subordinate leaders will need experience and expertise currently enjoyed by their superiors.
>
> Brigadier General Huba Wass de Czege
> U.S. Army (Retired)

The relationship between tactical, operational, and strategic levels of military operations is the second area that shows an evolving mismatch between leader development and the future environment.

The challenge today, and arguably more so in the future, is that the sequential, progressive approach to leader development does not fully prepare junior leaders for the types of complex, strategic circumstances in which they are increasingly finding themselves. In the Cold War, for example, tactical, operational, and strategic levels of war were separated by echelon of experience. A lieutenant's actions had an impact at the tactical level which was also where the training and leader development system focused his preparation.

Today, that lieutenant's or captain's actions increasingly may have strategic implications, as seen recently in Bosnia and Haiti. For the most part, however, their institutional and leader development training remains consistent with their conventional war fighting responsibilities and rank at the tactical level. General William W. Hartzog describes this emerging mismatch as a shift from a linear relationship

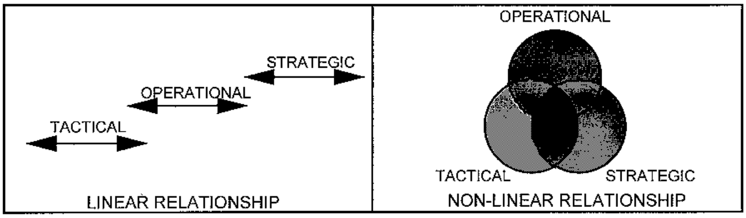

Figure 3. Tactical-Operational-Strategic Relationships.

between tactical, operational and strategic environments to a non-linear relationship as shown in Figure 3.[9]

Behavioral scientist Colonel George B. Forsythe helps frame this phenomenon in terms of organizational strata and functional domains (Figure 4). He confirms the notion that cognitive requirements increase in complexity as one moves from the "production domain (tactical level) to the systems domain (strategic level)." Cognitive requirements increase because the tasks at higher levels involve a greater number of elements, and generally longer time spans.[10]

ORGANIZATIONAL STRATA AND FUNCTIONAL DOMAINS

Stratum	Time span	Functional Domain
(vii) 4-star level	20 years	Systems (Strategic level) - unbounded environment, outward focus - create complex systems, envision future - build consensus, create culture
(vi) 3-star level	10 years	- oversee complex systems
(v) 2-star level	5 years	Organizational (Operational level) - exist within bounded open system - manage one complex system
(iv) Brigade CDR	2 years	- oversee operating sub-systems
(iii) Battalion CDR	1 year	Production (Tactical Level) - direct one operating sub-system - bounded within larger sub-system - face-to-face
(ii) Company CDR	3 months	- direct tasks
(i) Troops	<3 months	- perform tasks

Figure 4. Organizational Strata and Functional Domains.

Colonel Forsythe's model highlights the increasing levels of complexity leaders face as a result of advancing through higher strata, generally associated with rank, level of responsibility within the organization, and approximation to a level of war or military operation other than war (tactical, operational, and strategic).

The trend we observe in operations today, however, is increasing complexity and higher levels of responsibility at lower rank and duty positions. For example, an Infantry Battalion Commander implementing peace operations in Brcko, Bosnia, was arguably operating in an organizational domain, but with complexity commensurate with Strata V or VI, and with profound strategic implications for his actions. His training and leader development, however, was only consistent with the Strata III level.[11] Likewise, the rifle platoon leader patrolling the streets of Port-au-Prince, Haiti, before deciding whether to open fire on hostile police, must consider the broad strategic implications for his tactical decision.[12]

Behavioral science experts suggest that recent success by tactical leaders confronted with strategic implications happens, despite the mismatch, because the quality of the individual allows rapid adaptation. The question, then, becomes "Can the quality of individual leaders be sustained to assure success in the increasingly complex circumstances of the Army After Next?" Another way to phrase the question is to ask how much more effective Army After Next leaders might be if strategic savvy was more purposefully nurtured earlier in their leader development.[13] This is not to suggest that we can expect captains to develop broad strategic skills. Rather, it acknowledges that junior leaders today and more so in the future, must have more strategic comprehension than the existing leader development paradigm offers. The challenge is to explore the means to accelerate and enrich that component of leader development.

ACCELERATING AND ENRICHING LEADER DEVELOPMENT

> Part of the [leader development] solution will require us as individuals and the Army as an institution to discern and enable new methods. They may require us to alter or give-up some long held and cherished cultural sentiments.
>
> Brigadier General Huba Wass de Czege
> U.S. Army (Retired)

Behavioral scientists also suggest we are entering a new era of previously unthinkable possibilities. There is almost universal agreement that, while enduring principles and basic qualities of leadership still appear relevant, there is no significant impetus in the area of learning new techniques to stimulate, condition, and develop leadership.[14] We appear to be complacent with current rates and techniques of development, and worse, resistant to examining emerging possibilities that offer profound, if not revolutionary opportunities to enhance leader development.

Among other techniques and technologies, there are five emerging capabilities to accelerate and enrich leader development for the Army After Next. In the near-term (1998-2010) performance enhancement techniques, virtual reality technology, and high-fidelity personal performance assessments offer broad applicability. In the longer term (2010-2025), expanded understanding of tacit knowledge, coupled with bio-technology memory enhancement, will provide the means to finely tune the learning process and increase the efficiency of leader development.

Performance Enhancement (U.S. Military Academy).

For the past 9 years the U.S. Military Academy's Performance Enhancement Center has driven a focused effort to explore methods of enhancing leader performance through effective thinking, goal setting, stress management, attention, imagery, and relaxation. In many respects, the program focuses on teaching cadets "how to think" as opposed to the more traditional focus on "what to think." The program's charter is to build the key mental skills for the cognitive and conceptual complexity of the 21st century.[15]

One specific approach is built around state-of-the-art bio-feedback training. This tool for enhancing performance utilizes sophisticated environmental-control to help an individual relax, focus on a specific thought, and then mentally practice desired performance. For example, in the case of a football player, the challenge might be to improve quickness in identifying a complex defensive arrangement requiring an immediate decision whether to hand off or run with the ball. In this case, the player must learn how to visualize the situation to be encountered and then mentally practice the appropriate responses. While traditional football practice may accomplish that learning objective, it can be greatly enhanced when players mentally rehearse their parts and can begin practice having already visualized the desired performance.[16]

The same requirements apply to war fighting leadership. One specific example is the aide-de-camp for the Commanding General, Joint Readiness Training Center, who I interviewed during a visit in 1994. When asked why he selected this lieutenant to be his aide, the general replied that he was unquestionably the best small unit leader he had ever seen.

When asked how he achieved such a level of excellence, the lieutenant replied simply, "I can visualize the battlefield better than my opponents." He went on to say that it was not a result of more experience, but because of his experiences with the Performance Enhancement Center at the Military Academy.

> As a football player at West Point, I routinely practiced visualizing the offenses that I would face and mentally practiced my responses. Though this isn't football, I find that if I use the same techniques, my decisions are quicker and

better. And, on the battlefield, quicker and better decisions equate to engaging the enemy before he can engage me.

The Performance Enhancement Center is quick to point out that there are no high-tech bio-feedback systems on the battlefield, but leaders who can learn the art of visualizing the kinds of situations they will encounter and mentally practice desired performance, can take that advantage with them where ever they may go.[17]

For the Army After Next leader, the environment and the decisions will be infinitely more complex than football or small unit leadership. Nevertheless, improvement of leader confidence under pressure, concentration amidst distraction, and composure during times of stress can clearly be accelerated and enriched through performance enhancement techniques.[18] The acquisition of state of the art electronic training devices, or similar technology, should also be considered for improving peripheral awareness, visual concentration, and reaction times. The potential pay-offs for improving "how" a leader thinks are becoming increasingly evident through the data and experience of the Performance Enhancement Center at West Point.

Virtual Reality Simulations (Research Triangle Institute).

The development and fielding of a prototype mission planning, rehearsal, and training simulation (MPRTS) at Fort Leavenworth's Battle Command Battle Laboratory is providing early insights into the war fighting pay-off of being able to visualize plans and alternative courses of action before having to conduct combat operations. In it's simplest form, the MPRTS is an "interactive, three-dimensional computer representation of the terrain and force circumstances to be encountered during a military operation." The capability for leaders to examine "multiple options and visually experience the outcomes greatly enhances the fidelity of the commander's cognitive analysis." In many respects, it also allows him to learn necessary lessons before they happen in the course of the actual operation.[19]

Aside from it's primary purpose of providing an aid for battle command, the MPRTS has another useful application directly related to leader development. By providing leaders the means to "virtually" experience actual circumstances of past operations or interpersonal encounters, in an interactive environment, the potential exists to create the kinds of critical experiential learning from which important tacit knowledge emerges. The result is the institutional capacity to "teach" tacit knowledge through virtual experiences. For the Army After Next this equates to an opportunity to accelerate individual leader learning and develop knowledge and wisdom-based leader competencies vital for success in the complex environments of 2025. The efficiencies of Virtual Reality learning also offer dramatic improvements in time management. What would normally take up to 10 classroom days of instruction can be accomplished in as little as 1.5 days with Virtual Reality media.[20]

Personal Performance Assessment: Strategic Management Simulations (Penn State University).

The level of complexity involved in strategic thinking, interpersonal relationships, and decisions arguably demands specific capabilities not necessarily consistent with individual competencies at lower levels of leadership. The challenge is to first accurately gauge an individual's propensity to perform at the strategic level, and then condition desired responses that transcend any one job or any one task. Dr. Siegfried Streufert's Strategic Management Simulations are "scenario based simulations which place leaders in realistic settings that allow observation and analysis of how they perform."[21] Not unlike the Army War College's Strategic Crisis Exercise, individuals perform strategic planning and confront emergencies requiring more extemporaneous and immediate responses during the simulations. Through computer-based measurement of various aspects of performance, the simulation generates "profiles of effectiveness" which are predictive of success.[22]

The capacity not only to predict individual success, but to condition desirable performance distinguishes Streufert's work from other simulations. In addition, the breadth of performance indicators for "complex, interactive situations, and fluid environments" is remarkable, particularly given reliability of the validity coefficients exceeding .60.[23]

As the Army After Next Wargame series continues to explore the collective dimensions of time and knowledge at the strategic level, the development of a strategic simulation model to examine the quality of leader competence offers a parallel means to enhance strategic leader skills in complex environments. Additionally, the insights into individual planning and decisionmaking offers an opportunity to enhance the fidelity of future Army After Next wargames.

Tacit Knowledge: (U.S. Military Academy and Yale University).

Every Army leader learns personal lessons from experiences in what we typically refer to as the "school of hard knocks." It is the school of the motor-pool, the night road-march, the rifle range, and countless other experiences on the job. Collectively, these lessons amount to an individual's "tacit knowledge" or the practical know-how necessary to succeed.[24]

Tacit Knowledge refers to action-oriented knowledge, acquired without help from others, that allows individuals to achieve goals they value.[25] It differs from academic knowledge in that it is goal-oriented and acquired without direct teaching. Extensive research proves that tacit knowledge is extremely relevant in predicting performance in real-world endeavors, more so than intelligence testing or classroom academic performance.[26] The study of tacit knowledge, therefore, offers compelling insights as well as opportunities for developing leaders for the Army After Next.

A 7-year joint study recently completed by the U.S. Military Academy, Yale University, and the Army Research Institute demonstrates that tacit knowledge can be extracted from individual leaders. It offers some useful insights into the ways leaders use tacit knowledge. These personal lessons are "best related as stories, though the actual leadership lessons are frequently difficult to articulate and must be coached out by skilled interviewers and then converted using a complex set of analytical tools."[27] It should be noted that this study specifically focused on "leader" tacit knowledge as opposed to "technical" tacit knowledge about specific battlefield operating systems or other subjects. That type of tacit knowledge exists as well, though is not the focus here.

Researchers found that the content of military leader tacit knowledge varies by organizational level and, perhaps not surprisingly, the tacit knowledge for a particular level reflects the leadership issues and challenges at that level. For example, at platoon level, establishing credibility and authority over others with generally greater experience is a common theme in their military leadership tacit knowledge.[28]

At company level, the emerging need to take an institutional perspective is added to the challenge of direct leadership. A company commander's increased discretion (as compared to the platoon level) is reflected in his tacit knowledge about directing and supervising others. The other company level tacit knowledge theme centers on requirements to balance subordinates needs with supporting the higher headquarters. In that regard, tacit knowledge about cooperating with others and balancing mission accomplishment is dominant.[29]

At battalion level, systems level thinking is a key developmental change. Tacit knowledge for protecting the organization and managing organizational change is characteristic at this echelon. Tacit knowledge for communicating is uniquely centered on indirect methods and systems. Knowledge about dealing with poor performers is the other distinguishing aspect of leadership for the battalion commander.[30]

Aside from the leadership insights, the real power of this body of research lies in the potential to structure and organize experiential learning in such a way as to accelerate and enrich those high-payoff opportunities. The study specifically focused on leadership knowledge as opposed to technical knowledge, but there appears to be a similarly profound opportunity to enhance experiential learning in that area as well. Finally, the research also proves the capability to export or share tacit knowledge. Interestingly, the researchers consider this to be the least promising implication because the real power of tacit knowledge is largely derived from its contextual source, which at this point is enormously difficult to replicate.[31]

Corporate and commercial perspectives on exporting and sharing tacit knowledge differ from the military research conclusions. This is illustrated in at least one software application specifically designed for the purpose of sharing tacit knowledge. The “6DOS Interpersonal Linking Technology” is a system based on the theory of interpersonal linkages known as the Six Degrees of Separation or 6DOS. It facilitates sharing or exporting tacit knowledge by electronically connecting people who need answers to those who have them. The stated purpose of the software is to “discover, track, and promote the conversion of unspoken expertise into a form that is useful to customers, vendors and employees.” It’s marketing strategy centers on the notion that tacit knowledge is a tremendously valuable corporate asset.[32]

When considered in isolation, the potential to tap into tacit knowledge for any of the three purposes discussed above has the potential to broadly enhance and accelerate the learning of leadership competencies relevant to the Army After Next. Future studies should couple tacit knowledge with emerging simulations technology, bio-technology memory enhancers, and performance enhancement strategies, to gain broader understanding of the potential impact.

Bio-technology Memory Enhancement (Military Health Services System).

The 1997 Military Health Services Study predicts that over the next 20 years, biotechnology will take human health beyond our traditional treatment focus on curing or preventing illness and into the realm of enhancement or improving human performance. "Enhancements to memory, cognitive processing and physical capacity will gradually be accepted as normal."[33]

Biochemical enhancement of memory is one area where research is in full swing. Scientists at Cold Spring Harbor Laboratory on Long Island are examining proteins that underlie memory and learning, pinpointing genes that produce and control those functions. Helicon Therapeutics has since grown out of that research to pursue a focused effort to develop drugs to both treat memory loss and enhance normal memory functioning. Their research suggests that by the time the Army After Next comes to fruition, the ability to stimulate specific cognitive activity in the brain will be mature enough to dramatically improve certain human intellectual performance.[34]

When used in conjunction with advanced strategic or virtual simulations, and performance enhancement techniques centered on how to learn, the potential for cognitive enhancement through biotechnology is profound. They also suggest almost limitless implications for accelerating and enriching leader development for the Army After Next.

CONCLUSIONS

Research demonstrates that doing business as usual threatens to erode the relevance and effectiveness of the existing leader development system. It also suggests that there are viable means to accelerate and enrich leader development to compensate for those evolving mismatches caused by changes in the strategic environment.

Sophocles said, "Wisdom outweighs any wealth." Then, as today, knowledge requires time and experience to evolve.[35] Our Army's 25-year institutional commitment to leader development yielded extraordinary results and no small amount of wisdom at every level. The challenge for the future is three-fold. First, and foremost, the Army must fight to preserve the integrity of the existing, proven system. Second, to sustain the leader development advantage in the future, the Army must be willing to examine new technologies and emerging capabilities. And, finally, the institution must exercise the courage to become more aggressive in stimulating leader development.

The mismatch between the human capacity to handle a more complex operating environment and the information requirements generated by it are troubling. It also represents a useful catalyst to push the quality and pace of leader development ahead, particularly as it relates to more senior leader competencies for the Army After Next. We must seize the opportunity to develop the possibilities of improving leader development and our institutional capacity to groom the leaders of the Army After Next.

ENDNOTES - CHAPTER 2

1. Walter F. Ulmer, Jr., "Military Leadership into the 21st Century: Another "Bridge Too Far?," *Parameters*, Vol. XXVIII, Spring 1998, p. 23.

2. Vincent R. Ruggiero, "Thinking Instruction in the 21st Century," Speech delivered at the 6th International Conference on Thinking, Massachusetts Institute of Technology, Cambridge, MA, July 18, 1994.

3. *Ibid*.

4. Joseph Esposito, "Future of Knowledge," Speech delivered at the Smithsonian Institute, Washington DC, May 10, 1993.

5. Elliott M. Jaques, *Requisite Organization: The CEO's guide to Creative Structure and Leadership*, Arlington, VA: Cason Hall, 1989, p. 16.

6. *Ibid*., pp. 33-40.

7. Elliott M. Jaques, *Executive Leadership: A Practical guide to Managing Complexity*, Arlington, VA: Cason Hall, 1994, p. 53.

8. Huba Wass De Czege and Jacob Biever, *Battle Command and Teamwork: Realizing the Potential of 2020 Technologies*, Fort Monroe, VA, 1998, p. 3.

9. General William W. Hartzog, "Laying Foundations from Army XXI to the Army After Next," Speech delivered to the Association of the United States Army, Orlando, FL, February 16, 1998.

10. *Ibid*.

11. Colonel George B. Forsythe, "Cognitive Frames of Reference and Strategic Thinking," Carlisle, PA: U.S. Army War College, April 5, 1989, p. 14.

12. Lieutenant Colonel Steven R. Layfield, U.S. Army, Task Force 1-18 Commander, Brcko, Bosnia-Hercegovina. Interview by author, February 24, 1998.

13. General William W. Hartzog, U.S. Army, Commander, U.S. Army Training and Doctrine Command, Post-Haiti After Action Review conducted November 1994.

14. Lieutenant Colonel Scott Snook, U.S. Army, Department of Behavioral Science and Leadership, United States Military Academy, West Point, NY, telephone interview by author, February 23, 1998.

15. Walter F. Ulmer, Jr., "Military Learning: A Practitioner's Perspective," in *Tacit Knowledge in Professional Practice*, Robert J. Sternberg and Joseph A. Horvath, eds., Hillsdale, NJ: Lawrence Erlbaum Associates, 1998, p. 22.

16. Lieutenant Colonel H. Michael Hughes and Stephanie Cornelio, Peak Performance Program Fact Sheet, West Point, NY: Center for Enhanced Performance, U.S. Military Academy, 1998, p. 1-3.

17. *Ibid*.

18. Hughes and Cornelio, p. 2.

19. *Ibid*.

20. Professor Robert F. Helms, "Mission Planning and Rehearsal Trainer," Research Triangle Institute, *http://www.rti.org/vr/w/mprts.html*, Internet.

21. Professor Robert F. Helms, "Virtual Reality," Research Triangle Institute, http://www.rti.org/vr.html.

22. Dr. Siegfried Streufert, Strategic Management Simulations, Harrisburg, PA, p. 2.

23. *Ibid*., p. 12.

24. *Ibid*., p. 15.

25. Professor Robert J. Sternberg, "Testing Common Sense," *American Psychologist*, November 1995, pp. 912-927.

26. *Ibid*.

27. Professor Robert J. Sternberg, "For Whom the Bell Curve Tolls: A Review of the Bell Curve," *Psychological Science*, Vol. 6, No. 5, September 1995, pp. 257-261.

28. Colonel George B. Forsythe, "Experience, Knowledge and Military Leadership," in *Tacit Knowledge in Professional Practice*, Robert J. Sternberg and Joseph A. Horvath, eds., Hillsdale, NJ: Lawrence Erlbaum Associates, 1998, pp. 9-11.

29. *Ibid*, p. 13.

30. *Ibid*, p. 14.

31. *Ibid*, p. 15.

32. *Ibid*, pp. 24-25.

33. Professor Merrick Furst, "Connecting to Tacit Knowledge, p. 6DOS," Carnegie-Melon University, *http://www.6dos.com*.

34. Science Applications International Corporation, *White Paper, Biotechnology—Military Applications*, Washington DC: The Strategic Assessment Center, December 1995, p. 11.

35. Robert Olson, *Military Health Services System (MHSS) 2020 Focused Study on Biotechnology and Nanotechnology*, Washington DC: U.S. Department of Defense, July 29, 1997, pp. 2-41.

36. Jill and Stuart Briscoe, *Family Book of Christian Values*, Elgin, IL: Chariot Publishing/Cook Communications, 1995, p. 131.

CHAPTER 3

PROLIFERATING DECISIONMAKERS: ROOT CAUSE OF THE NEXT REVOLUTION IN MILITARY AFFAIRS

Arthur J. Corbett

INTRODUCTION

In his recent book, *Consilience,* Edward O. Wilson asserts, "The greatest enterprise of the mind has been and will always be the attempted linkage of the sciences and the humanities."[1] Explaining the origin of the apt title for his book, Wilson defines consilience as "a jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common ground work of explanation. This chapter addresses the possibility of a "revolution in military affairs" (RMA) from the broad perspective of interdisciplinary consilience. It is an attempt to expand the RMA debate beyond its current emphasis on new technologies and innovative concepts, and to focus on the human dimension of warfare. Following the admonition of Sun Tsu to first "know yourself," we must expand the range of disciplines from which military institutions derive insight into human potential if we are to achieve the consilience of thought required to produce a genuine revolution in military affairs.

Discerning the character of future war is more a process of intuitive appreciation than logical proof. Consequently, this chapter will embrace a methodology of consilience from a variety of disciplines to demonstrate the relative direction and potential velocity of the next RMA. It will examine the emerging lessons of chaos and complexity theory in light of the theory and nature of war, compare economic systems to discern the effect of proliferating decisionmakers, interpret the historical lessons of previous RMAs, and adapt lessons learned from contemporary military history to provide insight on the next revolution in military affairs.

THESIS

A "proliferation of battlefield decisionmakers" will be the proximate cause of the next RMA. The discontinuous advance in military capability will be harnessed by the nation that first reforms the institutional values and organizational structures of its military forces to unleash the full potential of human nature. The next RMA will initially be dominated by the first nation to capture the essence of the free market dynamic, i.e., the proliferation of trusted and empowered decisionmakers, and to incorporate that dynamic into its military institutions. That nation's forces will develop an entrepreneurial battlefield ethos that values initiative and trust over order and inspection; where success is determined not by a smarter centralized coordinator or adherence to a rigid plan, but through decentralized initiative and timely decisions to exploit fleeting opportunity.

HISTORICAL PRECEDENT

Current efforts to precipitate an RMA seek to incorporate emerging technologies into innovative operational concepts to produce synergistic military capability. Numerous historical examples, from *blitzkrieg* and amphibious assault, to the development of carrier aviation and nuclear weapons, validate the effectiveness of the conceptual and technological method to evolve decisive force on the battlefield. Nevertheless, this approach is evolutionary, not revolutionary. While the result of this evolutionary method may be operationally or strategically decisive in the short term, the effects will not compel adversaries to radically modify their social structures and political institutions in order to field competitive capability. Human ingenuity being what it is, the duration of technical or operational dominance over an adversary is limited, since technology or technique is quickly emulated, and often improved, once it is shared on the common laboratory of the battlefield. Yet genuine, and somewhat enduring, RMAs do occur. The French "nation in arms," created following the French Revolution, is a particular example worthy of attention.

The French Revolution changed the status of the French people from royal subjects to national citizens. Although this did not alter the education, intelligence, health, or diet of the individual citizen, it dramatically increased the sense of responsibility, loyalty, and initiative that he was willing to exercise in defense of the state. Consequently, the intangible factors of initiative and motivation were calamitous for the kingdoms of Europe. Unable to compete with a nation that could mobilize its entire population in support of national wars, the monarchies, with their traditionally recruited, trained and fielded armies, suffered repeated defeats. The *levee en masse* was a genuine RMA, achieved without any significant disparity between nations in the technical means of war. The French Army leveraged its intangible advantages, derived from the enhanced empowerment of its populace, to achieve extraordinary success in battle.

The operational dominance generated by the French RMA was long lived when compared to conceptual innovations such as *blitzkrieg*, or technical advances such as gas warfare and the atomic bomb. The defeated Allied armies, entrenched in military systems supported by benevolent despotism, were slow to comprehend or even acknowledge the changes. The difficulty of changing emotionally charged social and political attitudes of long duration, what contemporary thinkers might call a paradigm shift, is far more challenging and complex than adjusting to technical innovations. Consequently, nontechnical and nonmethodological RMAs have a precedent for being rare, but more enduring. The Prussians, for example, were not about to subject the military institutions that gave such remarkable success to Frederick the Great, to rigorous analysis. Victory in their last great war justified their contemporary methodology; their recent defeats were attributed to individual mistakes or allied disputes.[2]

Denial, however, was not a method tolerated by the German military reformers. Under the rigorous intellectual leadership of General Gerhard von Scharnhorst, the German general staff was compelled to contemplate what effect the French Revolution had on military capability. Enhancements in battlefield morale, initiative, leadership, operational mobility, and flexible tactical doctrine were among the many by-products of the revolution discerned by Prussian military thinkers. Since the origins of these enhanced military capabilities were found in social institutions, they were overlooked in the first glance of traditional military theorists. Indeed, most Prussian officers accepted the existing social, political, economic, and military structures of Prussian society and refused to consider nonmilitary factors in their operational analysis.[3] Scharnhorst saw this ignorance of French national character as the major reason for the Allied defeat.[4]

> Scharnhorst knew that war could not be studied in isolation. It had to be analyzed in context. This meant that the scope of military history encompassed much more than just "military" factors. Officers had to be taught to appreciate the social, political, economic, technological, and moral forces that influence military institutions and operations. The so-called "art of war" embraced all of these factors. Convincing the members not to base their studies on exclusively military or tactical considerations proved to be Scharnhorst's most formidable task.[5]

Scharnhorst demonstrated that effective study of the French success on the battlefield required a multi-disciplinary approach. Similarly, our ability to precipitate or predict a future RMA necessitates a consilience of multidisciplinary insights. Of course, Scharnhorst's true interest lay in the operational effects the French Revolution produced on the battlefield. He compelled his contemporaries to observe the beneficial operational effects exhibited by the French and then study their cause. Conversely, the architect of the next RMA must be able to cause or recognize social, political, and economic changes that may be leveraged to produce enhanced operational effects on the battlefield.

One enhancement the Prussians recognized was the use of *tirailleur*, or skirmisher tactics, by light infantry forces. Among the members of Scharnhorst's *Militarische Gesellschaft* was a Major Knesebeck, who had observed the French in six engagements. He noted that they could employ "their entire infantry" as light forces "and with decided superiority." Knesebeck perceived:

> It is here that the education of the individual is of such great benefit to the Republicans, because situations too often occur during the combat of light troops in which the officer's control ceases completely . . . in which each man acts on his own.[6]

Scharnhorst was convinced that French military superiority was the direct result of a new French social and political order and the most significant sign of these changes was the greatly enhanced capability of the common French soldier and junior officer to exploit his natural intelligence and independent judgment.[7] In contrast to the Prussian fusilier, the French *tirailleur* was free to think and respond as part of a team. Scharnhorst's biographer, Charles White makes this point emphatically clear in *The Enlightened Soldier:*

> The real problem here was the social, political, and moral implications of training the third rank of the line battalion to think and fight as individuals. The advent of the skirmisher marked the beginning of a new epoch in warfare, and his spirit embodied "the civil rights of the art of war." No longer could the soldier be treated like "a mere machine." Now he would have to be acknowledged as "an important participant" in any tactical scheme. This is why the French Revolution had such a tremendous impact on the art of war. It destroyed the shackles that had enslaved the will of the common soldier, and had released a force unprecedented in the history of warfare. In

> Prussia, the reality of the individual soldier fighting willingly for a cause he believed in was unimaginable to most officers and civilians . . .for most Prussian officers, skirmishing was politically suspect and militarily unnecessary.[8]

Scharnhorst's reforms did not end with advocating skirmisher tactics. He was a vociferous proponent of combined arms divisions capable of independent operations. By providing subordinate commanders with all arms, he structured divisions and corps that could fight apart. In creating combined arms divisions, he emulated Napoleon; but he did Napoleon one better by creating the Prussian general staff system. Scharnhorst not only advocated the proliferation of decisionmakers at the tactical level; he recommended expanding the number of decisionmakers at the operational level as well. In contrast to Napoleon, who relied on his individual instincts, Scharnhorst's staff system enabled multiple combined arms forces to disperse and reconcentrate under the direction of separate commanders, in accordance with a commonly understood vision. The reforms Scharnhorst initiated, and the staff system he helped to create, eventually brought about Napoleon's defeat at Leipzig.

Although most of Scharnhorst's reforms have been universally adopted and are commonplace in military institutions today, they generated considerable controversy in his own age.

> The idea of a soldier or officer who could think or act independently, even without orders, was simply too horrifying and altogether unprofessional to those reared in the traditions of Frederick the Great. Such notions would destroy the very fabric of the Prussian Army.[9]

But, Scharnhorst persisted. Although it took years for his ideas to permeate the Prussian Army, his acolytes eventually brought about the end of French imperialism. Remarkably, and in contrast to the French experience, where a revolution in political affairs brought about an upheaval in the military, it was the revolution in the Prussian military that prompted a liberalization of German society and politics. In order to compete with a free people, the Prussians were forced to emulate them.

From this quick glance at the *levee en masse* and lessons learned by the German reformers, we can glean insight to the characteristics of a genuine *revolution* in military affairs. First, the national character of a people and the nature of their social and political institutions will determine the capability and limitations of their military forces. The French RMA was not based upon technological innovation or advantage. Instead, the advantage went to the force that was best able to expand the number of competent decisionmakers and broaden the quality and complexity of the decisions for which they were responsible. Last, there is a strong tendency in highly developed military institutions to undervalue the competence and initiative of the individual soldier.

Significant to our study, this period of military history begins a parabola of progress based on the decentralization of forces and the expansion of combat decisionmakers. Although rudimentary by contemporary standards, the increased reliance upon the will, fortitude, and initiative of the individual soldier was truly revolutionary. Comprehending the changed social geometry, Scharnhorst positioned Prussia to be on the arc of the lofting parabola of human potential. Later German military theorists and practitioners would build on this initial success and advance higher on the path, with infiltration tactics and *blitzkrieg*.[10] The RMA we seek today will be found still closer to the ever expanding apex of this same progressive parabola of individual initiative, decentralization of authority and proliferation of decisionmakers.

Napoleon inherited the changed social and political conditions necessary to revolutionize warfare and exploited them comparatively soon after they occurred. The Prussians slowly recognized that their deficiency in operational capability resulted from asymmetries in social and political factors, and sought to better compete on the battlefield by liberalizing Prussian society and its values. Had the French not been so quick to capitalize on these social asymmetries for military ends, their military potential may have remained dormant and undiscovered for years. This begs the obvious question; are there dormant and unexploited social or political changes that have occurred since this last true RMA that can provide unrealized asymmetries for development by the contemporary military innovator?

ECONOMICS

The greatest asymmetry among modern nation states is in the realm of economics. Comparative economics demonstrates the great difference between free market societies that leverage the will, creativity, initiative, and ability to calculate risk by placing the authority for decisionmaking in the hands of their people, and those centralized planned economies that do not. The incontestable disparity of wealth produced by the free market system compared to any centralized planned competitor is ample evidence of what occurs when people are empowered with the authority to make decisions pertaining to their fields of responsibility.

The typical socialist, centralized, planned economy is logical, linear, hierarchical, and scientific. If human nature and activity conformed to Newtonian principles of cause and effect, socialism might merit great accolades for bringing the complexity of economics under rational, organized and predictive control. Assuming near perfect knowledge of resources, means of production, workforce, and population, *via* statistics the state itself collected, the equitable distribution of the fruits of national labor would seem assured.[11] The mystery for the logical, linear thinker, who often views reality through the narrow lens of a Newtonian paradigm, is that such a rational and "scientific" process can fail so badly. Attempts by centralized government to impose order on an essentially chaotic environment and to substitute the control of the few for the will of the many, utterly failed in contrast to the competition oriented free market system. Although centralized, planned economies were obvious failures from the start, their creators and their successors persisted in maintaining the system because it promised control of individuals, even if they could not control the economy. In the socialist state, hierarchical order and control was valued over both efficiency and effectiveness.

In contrast, the free market system creates opportunities for vast wealth, as individuals freely choose, create, interact, and decide across a wide variety of human activities. Since there is no central coordinating authority to synchronize the activity, this decentralization of control should, by any linear cause and effect theory, produce massive social incoherence and chaos. Yet the very opposite occurs. Bottom-up interactions between individuals generate self-organizing, cooperative relationships that optimize or mutually suffice to promote self-interest with maximum efficiency. By accepting distributed responsibility, and ensuring commensurate decisionmaking authority, the free market economy engages a naturally chaotic environment and responds with a flexible, adaptive economic order that generates opportunity, wealth, and social coherence.

The primary difference between the free market and the central planned economy is in whom the system trusts and empowers to make decisions. The central planned economy trusts the intellectual or experiential elite—a few very smart or experienced individuals who "know" what to do. The decisions are so vital, and the results so critical, that the leadership cannot allow the uninitiated to dabble in the complex details.

The market economy, on the other hand, finds the entire system far too difficult for even the most intelligent individual or group of individuals to comprehend in detail. Knowing the decisions are complex and the consequences dear, a free market opts to make the decision base as wide as possible. By empowering a larger number of interested, but not necessarily professional, decisionmakers, the market economy engages chaos and develops a broad pool of individuals experienced in performing within its complexity. These individuals learn from and adapt to the market environment; capture fleeting opportunities as they occur; act on their own initiative; cooperate with their neighbors to overcome common problems; take calculated risks; and produce synergistic efficiencies in their self-interest and quest for wealth. The collective intelligence and energy of the many has proven to be far greater than the refined knowledge of the few. Some individuals will risk and fail, but because the hierarchical pyramid has been flattened, fewer will be effected. Examples of both the failed and the successful contribute to the learning curve and adaptive response of all. Since so many are engaged, the overall "system" learns and adapts with remarkable speed. Multiple entrepreneurs, alert with initiative, are quick to discern and exploit fleeting opportunity.

Despite America's almost 200 years experience with a nonlinear, free market economy, its military services persist in seeking battlefield advantage by refining their institutions modeled on centralized, linear, hierarchical, Newtonian principles. As in the army of Frederick the Great, these principles have served our forces well over the years; but like Frederick's Prussian descendants, we might soon find ourselves studying how we lost our advantage. Similarities between our conventional military organization for war and a centralized planned economy are direct and obvious. Both are top down hierarchies relying upon the centralized planning of a few to direct the energy of the many. Execution is decentralized, to some extent, but initiative outside the established plan is largely suspect. Focus is disproportionately directed on generating internal order and establishing control, rather than on engaging the enemy, generating a faster and more continuous operational tempo and seizing fleeting opportunity. Organizational communications are constructed to pass information up and send direction down.

Conventional economics provides insight on the importance of proliferating decisionmakers to leverage human nature; the so-called "new economics" provide examples of a decentralized decision process leveraging the new communications technologies. Kevin Kelly, executive editor of *Wired* magazine and author of *New Rules For the New Economy*, combines the experience of cutting edge businesses with wisdom emerging from the biological sciences and chaos and complexity theory. He presents numerous examples of decentralized decisionmaking profoundly improving productivity. A particularly apt example is from Mexico:

> Any process, even the bulkiest, most physical process, can be tackled by bottom-up swarm thinking. Take, for example, the delivery of wet cement in the less-than-digital economy of rural northern Mexico. Here Cemex (Cementos Mexicanos) runs a ready-mix cement business that is overwhelming its competitors and attracting worldwide interest. It used to be that getting a load of cement delivered on time to a construction site in the Guadalajara region was close to a miracle. Traffic delays, poor roads, contractors who weren't ready when they said they would be, all added up to an on-time delivery rate of less than 35%. In response, cement companies tried to enforce rigid advance reservations, which, when things went wrong (as they always did), only made matters worse ('Sorry, we can't reschedule you until next week.'). Cemex transformed the cement business by promising to deliver concrete faster than pizza. Using extensive networking technology—GPS real-time location signals from every truck, massive telecommunications throughout the company, and full information available to drivers and dispatchers, *with the authority to act on* it—the company was able to promise that if your load was more than 10 minutes late, you got a 20% discount.
>
> Instead of rigidly trying to schedule everything ahead of time in an environment of chaos, Cemex let the drivers themselves schedule deliveries ad hoc and in real time. The drivers formed a flock of trucks crisscrossing the town. If 3 contractors called

> in an order for 12 yards of mix, the available truck closest to the site at that time would make the delivery. Dispatchers would ensure customer creditworthiness and guard against omissions, but the agents in the field had permission and the information they needed to schedule orders on the fly. Result: On-time delivery rates reached about 98%, with less wastage of hardened cement, and much happier customers.[12]

How a Mexican company decentralized decisionmaking and solved its problems of "just in time delivery" contrasts sharply with how Joint doctrine centralizes the delivery of air ordnance, and speaks volumes about institutional habits and proclivities. The Cemex example provides important insights on the growing inverse relationship between control and effectiveness. Kelly does not denigrate the important role of leadership in institutions, but he makes it clear that:

> At present, there is far more to be gained by pushing the boundaries of what can be done at the bottom than by focusing on what can be done at the top . . . The great benefits reaped by the new economies in the coming decades will be due in large part to exploring the power of decentralized and autonomous networks.[13]

Despite the vast differences between economic and martial enterprises, war and economics share the same driving common denominator—human nature. Theories of war and economics are both designed to explain and maximize human dynamics in a complex endeavor. What we learn about allocating decision authority from business models may not be directly applicable to a battlefield environment, but the consiliance approach compels us to examine how extraordinary success in one field can influence another.

THEORY AND NATURE OF WAR

Our current military organization for battle fails to exploit the most obvious advantages of our national character at the operational and tactical levels of war. Military organizations expend considerable effort to promote institutional conformity that inadvertently suppresses initiative by narrowly allocating decision authority along functional lines, and then establishes and enforces procedures to keep everyone in their designated lane. Holistic solutions and perspectives are precluded by administrative compartmentalization. Coordination is rarely done between adjacent or supporting units without the intervention—and associated friction—of a designated coordinating authority. This can lead to economy of centralized management, but often at the expense of timely support. Bottom-up associations and solutions are stifled by top-down administration.

The current system, however, is not without its merits, and ultimately some form of linear process does help organizational functioning. Some aspects of our world, particularly the physical dimension, are fairly well represented by the linear Newtonian paradigm. However, as our glimpse of comparative economics suggests, many human interactions, such as commerce and war, are not well replicated in the Newtonian model. The genius of Clausewitz was that he comprehended the nonlinear nature of war in an age that was energetically learning and gratuitously applying the emerging theories of Newtonian physics across a wide variety of disciplines. A student of the physical sciences in his own right, Clausewitz discerned the critical incongruities between the interactions of warfare and the cause and effect relationships of the physical sciences. He strongly resisted the proclivity of his age to submit the study of war to reductionist theories. His own study and experience suggested that scientific determinism was incompatible with the unpredictable nature of war. Linearity could not account for his observation that combat power accrued synergistically from both physical and intangible forces, and morale factors were disproportionately significant when compared to the physical means. Most significantly, Clausewitz understood that war was a dynamic process between two competing wills that interacted in real time within an environment of fear, friction, and uncertainty. The reactive nature of the enemy precluded predictability and certainty for Clausewitz, causing him to eschew any attempts to reduce war to an action-reaction concept, such as a chess match. He understood that in warfare, moves are not necessarily sequential, but can become simultaneous.

Nevertheless, Clausewitz was a captive of his age, and much of his writing is laced with metaphors heavily laden with terminology taken from the physical sciences. In an age enamored with science and Newton's principles, Clausewitz lacked an overarching set of scientific principles or explanations that would provide the terminology and perspective needed to describe those aspects of war that remained outside of Newtonian bounds. The complimentary and emerging sciences of chaos and complexity theory provide us with the tools and terminology that, to some degree, quantify Clausewitz's qualitative insights.

CHAOS AND COMPLEXITY

Incorporating chaos and complexity theory into a consilience of RMA disciplines provides both an alternative conceptual paradigm and a more robust lexicon to describe the nature of war. The essential difference between the linear and the nonlinear approach to warfare is the contrasting ways they deal with war's chaos and uncertainty.

The linear approach seeks to *impose* order on a chaotic environment by simplifying complexity through breaking problems into component parts. A great deal of attention is focused internally on organizational doctrine, control measures, coordination techniques, and procedures. Nonlinearity accepts chaos as inherent to warfare and seeks to better adapt to that environment than the adversary. The enemy is understood not only to be "reactive" as Clausewitz noted, but potentially interactive. The relative decision-action speed of adversaries engaged in conflict determines the ability to generate operational tempo and gain the initiative, i.e., reduce the enemy decision cycle to a reaction mode. To achieve this decision cycle dominance, chaos and complexity theorists advocate a proliferation of “complex adaptive systems” generating multiple decisions, that can be deliberately “out of phase” with each other, to provide constant stimulus to fatigue the centralized enemy decision process. *Speed of adaptation* will form another cycle similar to the traditional observation, orientation, decision, action loop (OODA loop). Focus is on the adversary; discerning his intentions and interacting advantageously.

Nonlinear approaches seek to enhance chaos and uncertainty if advantage can be gained, relative to the adversary, by faster decision and adaptation cycles. Complex organizational attempts to control chaos are eschewed in favor of developing resilient organizational structures that can accommodate changing combat circumstances and enemy innovation. Similarly, the enemy is considered as a dynamic, adaptive, and resourceful opponent, who himself is capable of generating surprise and chaos.

Both linear and nonlinear models can be useful in describing, interpreting, and conceptualizing the nature of war and its contemporary character. Arguably, in the day of massed, on-line formations, the linear model was not only suitable, but optimized. However, the growing complexity of war, and knowledge of the inherent truths of the new sciences will shift the paradigm by which we understand how the world works. More to the point, we will come to better understand how complex adaptive systems, like mankind, work in a world that still responds to the linear principles of Newtonian physics. Today, the nonlinear principles of chaos and complexity have begun to be viewed as a competing paradigm with linearity. This perception of competition will transition to an understanding of how both linear and nonlinear models are compatible, and not mutually exclusive ideas. Eventually both perspectives will become complementary concepts that will enable those who can master and aptly employ both to produce synergistic wisdom, wealth, and national power.

The chaos and complexity model will surpass the Newtonian model as the dominant template for future military organization and innovation. Warfare will not be the first discipline to incorporate the principles of these emerging theories; war will follow science, economics, and business; where the natural truths of chaos and complexity theory are already having dramatic effect. Several factors will drive this paradigm of innovation.

First, warfare will grow in complexity. While it has always been a complicated undertaking, in past wars linear models were adequate to approximate the comparatively limited number of battlefield variables. During our own Civil War, for example, the adversaries were technologically mirrored, and attempts to gain technological advantage were often immediately thwarted, as occurred with the simultaneous fielding of the evenly matched Monitor and Virginia ironclads. With the opposing forces using identical weapons and tactics, the terrain became the primary battlefield inconsistency. Extensive effort went into understanding the nature of the terrain, with advantage often going to the commander who used it best. Today, the variables include a wide range of technological innovations that are employed not only on land and sea, but in the air and space as well. These many tangible uncertainties, aside from those introduced by human fog and friction, are sure to produce myriad asymmetries on the future battlefield.

Second, adaptive preparation for future war will also marginalize the utility of the centralized linear model of organizing armies and procuring equipment. The abundance of new technological innovations and "systems of systems" will open countless technological variables for the force developer to choose from. Process intense procedures for discerning requirements relative to rapidly mutating enemy system capabilities will be far too slow to adapt to dynamic battlefield conditions. The time lag resulting from procedural inertia will be further compounded by the need to select from a wider array of technological options. Even advocates of linear models attempting to surmount this problem acknowledge that the nonlinear introduction of emerging technologies will challenge formal tools like Assumption Based Planning (ABP) and that "Genuine intuition and experience judgment may prove just as valuable as formal decisionmaking tools, perhaps even more so."[14] Connecting the decisionmaking process for equipment selection and development down to the unit level will field a wider variety of systems for experimentation in the crucible of battle. With experience gained from battlefield interaction, adequate systems can be introduced until more optimized systems evolve. The innovation, experimentation, feedback process will be continuous throughout the war. This proliferation of innovators would be the biological equivalent of expanding the gene pool. Current procedures are "inbred" with commensurate results.

Third, the character of warfare will continue to grow less predictable, and the requirements to meet its rapidly mutating challenges will emerge directly from the battlefield. The relative advantages and disadvantages of new weapons and technologies will be largely undetermined until they interact on the field of battle with new and innovative enemy systems and concepts opposing them. The uncertain number of quantitative and qualitative beginning variables that precedes interaction with the enemy further complicates the existing challenge of battlefield predictability that linear planning formulas are designed to produce. Linear techniques are designed to identify tangible and quantifiable requirements that can be used to assure predictable success. Statistical information on our own organization is rigorously pursued to meet planning and development schedules. Eventually, a centralized process provides standardized equipment common to all. While some degree of centralized standardization is necessary for communications and interoperability, it can also inhibit rapid technological adaptation. Save for what soldiers have on hand from foraging, captured enemy supplies and their own expedients, neither the materials nor time are usually present on the battlefield to allow adaptation to take place forward. Nor, traditionally, are the contractors who habitually produce the weapons employed. The battlefield innovation of the "Rhino Tank" to bust the hedgerows in Normandy was a significant bottom-up technological innovation led by enlisted soldiers. Similarly, "the Petersburg crater" produced by the Union miners from Pennsylvania capitalized on unit unique "nitch knowledge" to potential advantage. These events are atypical examples of bottom-up initiative that sporadically punctuate the history of linear warfare. The limited availability of examples of such initiatives demonstrates how successfully linear military organizations can suppress the innovative capability of otherwise "highly complex adaptive systems." If we choose to build on the nonlinear model, we will capitalize on the innovative potential that is latent in our soldiers and make it commonplace on the future battlefield.

COMMAND AND CONTROL

Chaos and complexity theories are relevant to our inquiry into a potential revolution in military affairs not only because these theories provide us with an enhanced model to understand the dynamic nature of war, but because they also suggest more optimized models of command, based on realistic appraisals of human cognition and decisionmaking potential.

In his anthology of "Speculations on Nonlinearity in Military Affairs," entitled *Coping with the Bounds*, Thomas J. Czerwinski credits Martin Van Creveld for discerning three dominant methods of command and control—*direction, plan, and influence*. He notes that command systems are designed to address the "pervasive underlying commander's quandary—uncertainty and insufficient information," and asserts that a variant of each of the three methods of command can be found as dominant in a contemporary U.S. service's future force initiative.

> The system supporting command by direction is the Army's "Force XXI" and its digitized battlefield. The "System of Systems" advocated by the immediate past Vice Chairman of the Joint Staff is a command-by-plan approach. Finally, command by-influence is associated with maneuver warfare to which the Marine Corps is doctrinally committed.[15]

Command by direction is the oldest method of command and control and extends from the beginning of primitive formation battles until the mid-1800s. It was the preferred method of kings and generals who could have line of sight observation and control over most of their force on the battlefield. The problem of uncertainty was resolved for the king by keeping the forces tight and within visual signaling distance. The digitized force seeks to replicate this level of visual simplicity for the commander with thick band width and display screen icons.

The advent of modern weapons required dispersion well beyond visual range, so *Command by Plan* was developed by Frederick the Great. This methodology opts for "comprehensiveness over dynamism" and "inherently fights the disorderly nature of war as much as the adversary. It is a futile quest to will order upon chaos." Czerwinski characterizes the command by plan method as "trading flexibility for focus," and notes that it has become the highly centralized command method of choice for most modern forces. Today's variant of command by plan envisions a "system of systems" that provide "dominant battlespace awareness" to conduct "precision warfare." It drastically reduces information requirements by avoiding interaction with the adversary and simplistically focuses on compiling and prioritizing target lists to destroy a limited set of key targets related to centers of gravity. To the extent possible, the contemporary version of this system reduces the enemy to an inanimate set of targets. A finite number of enemy reactions are "planned for" as branches and sequels to a main plan, but for the most part, a truly interactive enemy is to be avoided *via* centrally controlled standoff technologies.

Command by Influence is designed to distribute uncertainty in a manner highly analogous to the free market economy. What the commander wishes to influence is articulated *via* mission type orders that effectively convey a general concept of operations and commanders intent. Influence replicates the function of Adam Smith's "invisible hand" as the uniting force behind a proliferation of decisionmakers. Command by influence interacts with, rather than avoids or simplistically reduces complex situations.

> . . . only the outline and minimum goals of an effort are established in advance, effectively influencing all of the forces all of the time. Unlike other command forms, this method takes disorder in stride as "inevitable and even insofar as it affected the enemy as well, desirable." Great reliance is placed on the initiative of subordinates based on local situational awareness, which translates to lowered decision thresholds. It relies on self-contained, joint, or combined arms units capable of semi-autonomous action. All of this activity occurs within the bounds established by the concept of operations derived from the commander's intent.[16]

Command by influence is the appropriate adaptation to the nonlinear, post-Newtonian realities of modern warfare. It is optimized for an environment of uncertainty, complexity, and unpredictability; where experienced intuition and pattern recognition are prized over transient knowledge; and self-organization at the "edge of chaos" is favored over slower, static, hierarchical, centralized systems. The ability of decentralized and "decision empowered" units to rapidly and advantageously interact with more intimate situational awareness is a tremendous advantage over centralized systems which, however well connected by electrons, respond slower. Modern communications technologies are useful to leverage the capabilities of command by influence, but not integral to it. Other technologies, such as "missiles in a box," which hold promise of providing small units integral ordnance for fires against armored, air, and personnel targets, will enhance self-reliance, reduce logistics, and enable greater autonomy on the battlefield (as did Stinger missiles in the hands of Afghan and Contra rebels). Since we Americans are accustomed to decentralized decisionmaking by virtue of our economic system, we have a strong cultural advantage over many potential centralized adversaries; a situation analogous to the advantage enjoyed by post-revolutionary France over the monarchies of Europe.

Properly, and of necessity, a nation's military institutions are a sub-culture of the dominant culture they are sworn to protect. Unless the nation is a militarist state, this sub-culture status is designed to provide opportunity for the military to promote those unique personal virtues and institutional qualities that are required during war, but otherwise divergent from more liberal social values. However, to the degree that the two cultures can share a common set of basic assumptions on how to maximize human potential, we can more readily leverage our national character to military advantage. Currently, the military sub-culture, intent on conformity and order, drills out many of the very qualities our wider culture intrinsically values and inculcates into its citizenry to achieve wealth. Yet there are strong indicators, from diverse sources, that these are the very qualities we will want to proliferate in the "Army After Next."

The essence of command by influence is the interaction of a clearly articulated commander's intent with highly autonomous, self-directing, decisionmakers. Focus is not on internal control, but on external result. Uncertainty is dealt with by intuitive comprehension based on pattern recognition and localized situational awareness, not by ever expanding and time consuming quests for information. Timely "sufficient" interactions are preferred over more optimized, but delayed "solutions." The organizational values of such a force are trust, initiative, intuition, risk, and adaptability. Some internal disorder is tolerated, even protected, as a necessary trade-off for enhanced velocity in the OODA loop and adaptation cycles. Higher operational tempo to gain and maintain the initiative is valued over slower more comprehensive efforts. Multiple OODA loops acting in concert, but not in phase, compound the confusion of the enemy and render his ability to discern operational patterns more difficult.

CONCILIANCE

The intersection of chaos and complexity theory, military history, contemporary conflict, theory and nature of war, and economics all point to a future where the dominant force on the battlefield will be the one that best proliferates competent, more autonomous decisionmakers, who freely interact among themselves and the enemy to exploit opportunity, within the bounds established by commanders' intent. These units will be led by trusted, intuitive thinkers and risk takers, who adapt quickly and innovatively to the rapidly mutating conditions of modern war. Of course, this consilience-derived hypothesis is itself an intuitive leap, based on broad pattern recognition, to grasp the character of future war. Our contemporary linear models and Newtonian thought patterns are self-perpetuating, and will not transition logically to this same recognition. Consequently, we may not construct the "Army After Next" until we have first encountered the enemy after next.

The popular Prayer of St. Francis asks for "the strength to change what may be changed, the perseverance to deal with what cannot change, and the wisdom to know the difference." Clausewitz and Sun Tsu articulate the essential and unchangeable nature of war. Specious arguments that new technologies and systems will redefine war, or make high-minded promises of a more humane form of warfare, are beyond the pale of credibility. The character of war is mutable, but its fundamental nature is as fixed as the nature of the men who wage it. Similarly, the "real world" represents a continuum of activity from the static to the dynamic and beyond to the chaotic. Chaos and complexity theory leads us to understand that as we move closer toward the edge of the chaotic abyss—without falling in—we maximize the dynamic properties of human nature. Still, many linear processes will remain part of the process of war. The successful force of the future will be that which can move seamlessly between both linear and nonlinear concepts, utilizing each in the most effective manner. Wisdom lies with the force that can make these distinctions.

Ever more important in future war will be those intangible factors that elevate the soldier to the status of warrior. The proliferation of authority and responsibility downward to small unit leaders will make strong demands on character and leadership. The lack of "elbow touching" that has traditionally provided solidarity on the battlefield must be accounted for by greater effort in training to develop cohesion. The moral and organizational values of the force will remain of primary importance, but they will be different, at least in emphasis. Responsibility will be more important than accountability, initiative more important than conformity, expectation more important than inspection, and innovation more important than procedure. Above all, trust will be the paramount institutional value. Trust will be complimented by the command quality of nerve. The battlefield challenge for the future large unit commander will be to exercise self-restraint. Once he has clearly articulated his intent and concept of operations, he will need nerve to allow independent subordinates to maximize opportunity. The commander will be the custodian of the vision, verbalized as intent, and constantly promulgated and updated by every communications means available.

Recent history demonstrates how our adversaries have leveraged our propensity for centralized, risk adverse, hierarchical command organization to defeat our capabilities. From dead Rangers in Somalia to wasteful and counterproductive bombing efforts in Yugoslavia, current history is rife with examples of how the linear paradigm of warfare is crumbling. Still, rigidly linear concepts linger on and serve to mark how impervious our thought process really is. The Afghan rebels, armed with Stinger missiles, prototyped how autonomous small units can vex a large centralized force. Regretfully, America's adversaries are adapting to counter traditional methods of national power projection faster than we are innovating them. Yet we persist in seeking greater technological, rather than organizational, innovation, and develop ever more expensive and centralized systems of systems. Mechanized decision aides are sought to better empower the same slender number of decisionmakers, rather than to distribute the decision process among those most directly involved.

In many ways, we find our plight similar to the French army between World War I and World War II. Eugenia C. Kiesling, in her book, *Arming Against Hitler: France and the Limits of Military Planning*, provides a historic parallel that helps explain our situation. The French generals, she concludes, did their best within the social values, military traditions, and resources allotted. They were confined by the bounds of the social system they supported and their own institutional values. The French army did what was feasible and produced a valid plan. However, it was designed to meet internal constraints and failed to adequately consider external enemy capabilities. The domestic feasibility of the plan did not ensure its relative effectiveness. The French had won the last war, so the previous formula was considered validated. Similarly, IBM's dominance and competence in the mainframe computer industry caused them to scoff at the introduction of the personal computer until the competition nearly drove them out of the market. By the same token, our evolved, complex, hierarchical military structure will cause us to neglect empowering the small unit decisionmaker until we meet him as an enemy on the battlefield. Like Scharnhorst and the German military reformers, we will be responding to the initiatives taken by innovative adversaries and attempting to educate ourselves to their methods. In short, we will fail to learn one of the most important lessons of the "new economics"—readiness to abandon success, before current methods are surpassed by more innovative competitors.

The consilience approach leads us to a better understanding of future war and its character. The same approach, however, focused on established, successful, hierarchical institutions reveals that it is unlikely they will have the foresight, incentive, or perspective to innovate to the extent required to capitalize early on the next RMA. This is an objective appraisal, not an excuse for failure to meet the responsibilities of leadership. Once again Scharnhorst can be invoked as a role model for the contemporary military reformer. His ability to influence the self-education process of the German officer corps was critical to the ultimate success of the Prussian army and the victory of the Allies over Napolean. We must find our Scharnhorsts and place them in positions from which they can prepare the minds of future leaders to first accept and then cultivate the values that will enable a proliferation of combat decisionmakers.

ENDNOTES - CHAPTER 3

1. Edward O. Wilson, *Consilience: The Unity of Knowledge*, New York: Alfred A Knopf, 1998, p. 8.

2. Charles Edward White, *The Enlightened Soldier: Scharnhorst and the Militarische Gesellschaft in Berlin, 1801-1805*, Westport, Connecticut: Praeger, 1989, p. 57.

3. *Ibid*.

4. *Ibid*., p. 61.

5. *Ibid*., p. 57.

6. *Ibid*., p. 59.

7. *Ibid*., p. 62.

8. *Ibid*., pp. 77-78.

9. *Ibid*., p. 60.

10. Timothy T. Lupfer, "The Dynamics of Doctrine: The Changes in German Tactical Doctrine During the First World War," *Leavenworth Papers*, July 1981, p. 28.

11. Ludwig Von Mises, *Human Action: A Treatise on Economics*, Chicago, Henry Regnery, 1963, pp. 676-682.

12. Kevin Kelly, *New Rules For the New Economy: 10 Radical Strategies for a Connected World*, New York, Viking Penguin, 1998, pp. 14-15.

13. *Ibid*., pp. 18-19.

14. Antulio J. Echevarria II, "Tomorrow's Army: The Challenge of Nonlinear Change," *Parameters*, Autumn 1998, p. 95.

15. Thomas J. Czerwinski, *Coping With the Bounds: Speculations on Nonlinerity in Military Affairs*, Washington, DC: National Defense University, 1998, p. 234.

16. *Ibid*., p. 240.

CHAPTER 4

THE NEW MATH FOR LEADERS: USEFUL IDEAS FROM CHAOS THEORY

Glenn W. Mitchell

INTRODUCTION

The workings of this universe, as seen through the eyes of most intelligent and educated leaders in the West today, are fairly straightforward. Sir Isaac Newton described the basic concept of cause and effect almost 300 years ago, and common sense observations of everyday life reinforce that paradigm.[1] To be sure, programs on educational television suggest unusual problems occur if you travel at the speed of light or near massive stars, but those events are unlikely for most of us. So why delve into seemingly esoteric subjects such as this one?

In this chapter we outline some basic implications of chaos theory to illustrate its usefulness to military leaders. Understanding predictable effects of this theory is fundamental to shaping and leading the Army After Next (and its sister services). First, we will take a brief—and hopefully painless—look at Newton's cause and effect universe and then step into somewhat deeper water. That done, we will have the basis for widening our understanding of science at the end of the 20th century and for its effects on the military of the next century.

Our discussion of the chaos theory is at exceptionally low resolution. We do not need knowledge of mathematical intricacies to comprehend its important effects; the phenomena it predicts are the relevant outcomes for us. Given this framework, we will then discuss emerging concepts for management of the military of the future.

NEWTON'S UNIVERSE

Two comforting ideas in the everyday world are that *cause precedes effect* and that *results are proportional to the forces applied.* These ideas are the essence of Newton's science. He developed the mathematical calculus to predict the future motions of all material bodies, given the forces applied and the initial states of their motion. If you know enough detail about everything—all the positions and velocities, etc.—then you can calculate the future. Physical systems are either in equilibrium—the forces are in balance—or they are near-equilibrium and become stable as soon as possible.

This worldview is called *determinism* since all of history can theoretically be known given perfect knowledge at one point in time. Accuracy of predictions depends on the level of detail known. This is similar to the notion of reducing the fog of war by increasing the amount of data displayed to soldiers on the battlefield.

Another important Newtonian concept is *linearity*. Forces cause change in direct proportion to their magnitude. If anything appears to contradict this idea, we usually say the system in question is either too complicated to model exactly or the processes are poorly understood at present. Fundamentally, we want to believe in incremental change without sudden surprises.

These ideas brought us the Industrial Age. Implicit in the equations is the working of machines: this is Newton's clockwork universe. A working knowledge of mathematics leads to familiar modeling theories and war gaming. Those things that do not fit the models' variables—from the brilliant insight and inspiration of a great commander to panic among poorly led troops—are viewed as "wildcards." These uncontrolled factors can radically and unpredictably alter the anticipated result of the exercise. Additionally, they are very difficult to model mathematically. The world, however, is not constrained to fit the linear model; many situations have nonlinear models.[2]

CRACKS IN NEWTON'S WORLD

What does *nonlinear* mean in the context of chaos theory? There is danger in assuming you know what a word means because you use it frequently in another context. In the military, the terms *linear* and *nonlinear* commonly refer to the geometry of the battlefield. The linear battlefield is evocative of Napoleonic times with lines of troops standing shoulder-to-shoulder, delivering fires within prescribed zones on the field. Elements of power were used at predictable times and places to maximize their effects. Today's supposedly nonlinear battlefield uses dispersed friendly forces, massing at the last minute, exerting their combat power simultaneously at several depths to disrupt the enemy's momentum and plans for maneuver.

In the context of mathematics, however, *nonlinear* has a different definition. It means having equations with terms or parameters raised to powers other than one, and variables whose future values depend on their past values. A nonlinear model for a given situation often contains feedback loops. Operationally, it violates the notion of small changes in the value of various factors yielding small changes in the answer. Small changes in input may make huge differences in the output.[3]

Therefore, when the operations analyst talks of nonlinear situations, the modeler is thinking of equations with terms that are squared, cubed, or even worse. Variables are multiplied together rather than appearing separately in the equations. The output is not just lines with slopes and intercepts. There are no simple tables relating inputs and outputs, like gunnery tables, or even nests of smooth curves like those describing the maximum glide distance for each altitude and airspeed after engine failure in an aircraft.

An Example of Failed Linear Strategy.

A nonmilitary example may help clarify the concept. The modern Arab-Israeli conflict has been a Gordian knot for over 50 years. The current peace process owes its origin in great part to the strategic insight by Dr. Henry Kissinger. He separated the conflict into individual two-party conflicts so each could be addressed in turn. This philosophical approach is called *reductionism*. Thus, the conflict was seen to be the sum of the Syrian-Israeli border conflict plus the Egyptian-Israeli border conflict in addition to multiple other conflicts. Kissinger's approach provided the parties an opportunity to talk in a focused way about their two-way relationship. Consequently, the Egyptian-Israeli dispute was settled with the Camp David Accords in 1978. The contribution to peace in the region has been dramatic, since it is difficult for the adjoining states to wage war against Israel without Egypt.

Reductionism also facilitated solution of several areas in the Jordanian-Israeli conflict. Yet, overall, peace between Israel and its neighbors has not materialized. Why not?

The answer lies in the original assumption that the conflict was, in fact, the sum of the various two-party conflicts. This was too much of a simplification to be effective overall. The real interactions had effects that were dependent upon relationships among several parties. For example, the Syrian-Israeli situation depended not only on the two parties, but also on groups in Lebanon, the Jordanians and their resident Palestinians, the relationship between Jordan and Iraq, the current politics in Israel, and other factors.

These interactions make a linear model for the peace process too simplistic. The easy, mostly linear terms—such as the Israeli-Egyptian border dispute over the Sinai—in the true model have been solved. However, the real world is too complex for Newton's theory to apply to the multidimensional situations.

This is the hidden danger in real, nonlinear situations. Linear approximations work well enough in some circumstances, and that reinforces our confidence in the approach; allowing us to think we understand a situation when we really do not. Approximation works when predicting the general positions of planets in our solar system next year. Problems arise when you need to predict future positions of distant galaxies or even the exact position of the planets. Remember, there is a mid-course correction for astronauts traveling in space because they must compensate for modeling errors, or they will miss their mark.[4] A military example is the adage that a tactical plan no longer applies after the battle starts; the linear models we use do not apply to complex interactions among combatants.

With this overview in mind, we have arrived at the point where we can appreciate how chaos theory was discovered and why it is being developed.

THE DISCOVERY OF CHAOS THEORY

Predicting the weather has long been a goal of mankind. Meteorologists developed theories of air mass interactions and seasonal patterns that gave us hope a working model would be available as more sophisticated computers emerged. A scientist named Lorenz at the U.S. Weather Bureau built an incredibly detailed program to simulate weather patterns. Using Newton's Laws and others developed from them, he wrote the equations for how a weather system develops while interacting with terrestrial and atmospheric forces. He ran his program on a computer that analyzed the equations and printed out predictions for future weather. The output appeared promising, but he repeated his calculations as a precaution against errors. He entered the same starting data, only rounding off a few decimal places to save time. The second answer was completely different from the first!

Dr. Lorenz had stumbled upon a basic characteristic of complex, nonlinear equations: *the results are very sensitive to the exact initial conditions*. Seemingly minor changes in initial data lead to tremendous effects downstream. Discussions of this phenomenon[5] gave rise to the famous Butterfly Effect; which postulates that a butterfly flapping its wings in the Brazilian rainforest today may cause a typhoon in the Pacific a few weeks from now.

But what does this aspect of chaos theory mean—in useful terms—to those of us in the military?

CHAOS AND THE MILITARY

The occurrence of unexpected results is bewildering to most of us. The surprise may be the loss of an outstanding unit in combat against a less professional and prepared foe. Or it may be the brilliant success of units or individuals that were mediocre in training. After action reports try to explain the outcomes, but causes often are ascribed to phenomena such as bad luck or miracles. This is actually an effect of chaos[6]. The complex mathematical equations that truly model combat success are most certainly nonlinear. Complex interactions among factors such as motivation and leadership, commitment and endurance are not simple terms. The situation is just right for chaos to enter. No matter how many times a scenario is run during training, the results will always be different; sometimes only in small ways, sometimes strikingly so. Under the right circumstances, slight changes in the starting conditions result in vastly different results. Anyone who has tried to repeat a maneuver against the opposing force at the National Training Center knows it is impossible to reproduce conditions exactly. The difference between success and failure in some circumstances may be as small as the flap of butterfly wings.

The military importance is in the need to abandon the simple determinism that makes us comfortable. We like to think we can reliably predict the performance of a unit from its training record. Most times we are right. However, small, almost imperceptible changes can occur under stressful conditions that result in dramatic differences in individual and group performance. A lackluster company makes a bold attack that carries the battalion to victory; a slow and quiet soldier earns the Medal of Honor. We can only assign a probability to the success or failure of a given unit for a specific mission. We use our own accumulated assessments—a strategy of repeated trials to see the range and distribution of possible results during training—or we judge a unit by seeing it perform once or twice. Of course, the second choice is potentially dangerous and prejudiced. The practical lesson is to always try injecting positive factors into any unit's starting conditions—a motherhood-and-apple-pie talk, a hot meal, resupply of personal necessities, a pre-combat visit from the commander—and to exercise repeatedly under stressful conditions to explore the entire range of outcomes. Yes, there is actually a mathematical theory behind what good leaders have been doing empirically all these years.

There is one other important aspect to chaos theory to be explored. We need to understand the circumstances in which the chaos phenomenon is likely to happen.

In some cases, the linear approach alone is sufficient. Operation DESERT STORM was an example. Coalition forces were so superior that the enemy was unable to generate large-scale chaotic conditions during any engagement. Therefore, the nonlinear terms in the model never became strategically or operationally significant. In essence, the Gulf War's complex equations were functionally simplified to linear terms by the imbalance in combat power and leadership. The area in which Iraq was most able to threaten chaos was in information warfare where random SCUD missile attacks and efforts to portray innocent civilian casualties could have destabilized public opinion. Terms in the equation for use of weapons of mass destruction never had to be determined, but could have led to a quite different outcome. How do we account for these kinds of effects in a chaos model?

THE BORDERS OF CHAOS

Many daily situations are effectively modeled by familiar, predictable, linear equations. These models give only one answer for each combination of variables. Equations exhibiting chaotic behavior, however, may give two very different answers at one time. On a graph of the chaotic equations, there is a discontinuity in the graph line instead of the familiar continuous line. The possibility of two very different answers for one combination of variables is the hallmark of chaos. We do not know reliably which result the system will have at the end.[7] In complex systems, such as units in combat, there may be a cascade of these discontinuities; the result is lack of predictability for the whole system.

This lack of predictability should not be confused with random outcomes. A characteristic of chaos, arising from complex interactions modeling real world behavior, is that potential outcomes have predictable limits. Which exact state the system will end up in is uncertain, but the range and the probabilities of possible outcomes are constrained. This is called *deterministic chaos*, and it applies to most situations of interest to us.

Military operations research should attempt to find the critical values leading to discontinuities in equations modeling phenomena of interest. What were the critical factors leading to political collapse of the former Soviet Union? What are the critical values leading to possible use of weapons of mass destruction by terrorist groups or rogue states? The full equations are incredibly complex, and our knowledge of all variables is incomplete. However, the payoff for successfully modeling these issues has tremendous potential for future applications.

We have now identified a few things needed to maximize our military success under chaotic conditions. What else does the organization need to do? What does a nonlinear organization look like? How should its leaders manage in a chaotic environment?

THE NONLINEAR MILITARY ORGANIZATION

To best understand the impact of chaos theory on the military, we can look at the emerging paradigm of nonlinear organizations. We will borrow heavily from recent concepts of the Santa Fe Institute and of Dr. Uri Merry concerning nonlinear organizational dynamics.[8] From this viewpoint, there are five types of organizations categorized into three general types of behavior patterns. They will be discussed in terms of practical implications for military management.

THE FIVE BEHAVIOR TYPES OF ORGANIZATIONS

A series of five behavioral types characterize most forms of organizations. While each has a specific pattern of behavior, the forms differ, mostly in terms of the mix of linearity and nonlinearity. The names they are given are not important to our discussion, but indicate underlying mathematical behavior to those who study chaos theory more rigorously. In systems of many different kinds—physical, physiological, etc.—it is possible to calculate when the transition from one type to another will take place. Unfortunately, no one has yet proposed a way to do this in organizations.

The first two types, Point and Limit Cycle, have behaviors that repeat themselves exactly. In the Point, behavior repeats itself like a free-swinging pendulum that always comes to rest at the same point. In the Limit Cycle, behavior repeats itself like a thermostat which maintains the temperature between two points, or a street lamp that goes on and off according to the amount of daylight. Systems that display such orderly behavior are generally simple, linear, close-to-equilibrium systems fully described using Newton's theories. They allow very exact calculations, and their behavior can easily be predicted.

Point and Limit Cycle are typical physical and mechanical systems and are seldom found in individual or organizational behavior. If found in an organization, it will probably be one in which people are treated as if they are machines. In an effort to create an exact science of management based on the ssumption that human behavior follows orderly patterns, attempts have been made to perfectly describe behavior and make accurate predictions on what will happen in any given circumstance. Robots mimic this behavior.

In the third state, the Torus, each behavior more or less repeats itself, but in a slightly different way each time. Instead of identical repetition as in the Point and Limit Cycle, there is only similar behavior. In organizations, this behavior follows norms, customs, regulations, rules, prescriptions, or laws. This type is common in the behavior of individuals, groups, teams and other entities. Just as you tie your shoelaces in a similar way each morning, you behave in a similar way, *but not exactly*, each time.

Most people will behave as the norm prescribes, but a few deviants will digress and go beyond the norm. For example, we can be relatively sure of an average number of employees who will be absent from work at different times of the year. Likewise, we can use statistical methods to predict what will happen and prepare for what may take place in the future.

In a Torus organization rules, regulations and codes of behavior will maintain order and discipline. In this system linear order is preserved, and continuity is ensured. Uniform regulations apply to everyone without favoritism. Management is kept busy issuing new rules and regulations and ensuring they are observed. Most regulations are in written form, and arrangements of supervision and control ensure enforcement.

This type of organization functions best in a stable environment where little change takes place, such as during the Cold War. Weaknesses become apparent in a turbulent environment: lack of ability to change; lack of resilience; and uniform procedures unsuitable to people who are very different from each other. The challenge a Torus leader faces in turbulent times is not how to maintain order and enforce the regulations, but how to create conditions that nourish the growth of change, innovation, enterprise, and creativity. Encouraging renewal and positive change should be the organizational goal.

The fourth behavioral type, the Butterfly, is characterized by even less regularity and diminishing control. The change is from similar behavior to a range of behaviors. Instead of one norm, there is division into dissimilar patterns. This means that under the same set of conditions people in the organization will divide into populations that may react in completely different ways.

This system often behaves like multiple Torus systems joined together. People acting within one group are behaving similarly to one another, but differently than those in other groups. For example, employees may choose (albeit from a limited range of possibilities) what clothes they wear at work, during what hours they work, whether they carry umbrellas, etc. Instead of the constraints of unchanging rules and regulations, freedom opens choice of roles and the way the roles are performed. This variety in choice of behavior holds not only for individuals, but also for departments and teams.

Problems arise when the chosen behaviors are not functional or supported by the organization. There are unacceptable divisions among groups, for example, between those who are committed to, and identify with, the organization, and those who are alienated from it. The workforce can diverge between effective workers with high output and those who shirk their responsibility, or between those who are honest and those that steal time or property from the organization.

Behavior in different groups may be radically changed by a small shift in a critical organizational parameter, such as differences in wage increases or in the way employees are treated. When such a parameter reaches a critical point, it can lead to chaotic change. In other words, not every change in organizational parameters leads to division; changes may take place without a ripple in the pond. It is only when a change reaches a critical point—like the last straw and the camel—that dramatic divisions occur. A change in retirement eligibility policy may have no effect at all, but under certain conditions, it may be seen as a crucial factor in decreasing job security and lead to organizational instability.

Allowing choices for a range of behaviors may appear to be the opposite of desirable military behavior, but organizations functioning in a turbulent environment need variety, creativity, and change. Survival is not possible in a climate of turbulence if an organization clings rigidly or irrationally to its old and trusted ways of functioning. Flexibility and adaptability become more and more essential as the environment changes at an increasing rate. This will be the environment of the next century. The challenge for leaders is to consistently demonstrate appropriate behaviors while guiding workers to make choices that are consistent with the organization's vision. Versatility enhances our survival: A butterfly on an unchanging flight path soon falls prey to predators.

The fifth and last behavioral type is called Deep Chaos. In this state, constraints on behavior disappear, and there are no limitations imposed by order and regularity. Randomness reigns and allows no place for order. It is never a desirable state for a military organization.

Deep chaos is a transition period where order has broken down, and a new order has not yet emerged to replace the old. Complex systems reach this state after internal divisions turn into deep cleavages and external factors push beyond a critical point. Disturbances move the system to a point where its only alternative is total change or disintegration. The former Soviet Union illustrates this condition well.

Deep chaos in organizations may follow acute organizational crises involving major factors such as budget, mission, or human resources. The organization faces either transforming itself into a new order or disintegrating. From deep chaos a complex system transforms itself into a different state which cannot be accurately predicted.

Organizational Behavioral Patterns.

The Santa Fe Institute's research on complex adaptive systems indicates the existence of three basic patterns of behavior: *ordered, chaotic and complex*.[9] The ordered pattern coincides with the two linear states: Point and Limit Cycle. The chaotic pattern coincides with the Deep Chaos, where randomness reigns. The complex pattern combines features of Torus and Butterfly. Systems that adapt best to changing environmental conditions function mainly in the complex pattern.

Management in the Orderly Patterns.

What managerial style fits organizations that function within the orderly pattern of Point and Limit Cycle? Applying this pattern to human beings is problematic. Attempts to do so can be found in prisons, in a conscript army, and on the assembly line in industry. It is possible to use this pattern in industries employing workers with little education and no alternative employment possibilities. In these circumstances employees can be controlled and regimented to work like machines and robots.

The managerial style of this pattern is one of top-down control. The pattern is maintained by the threat of punishment or being fired, combined with financial rewards for performing regularly in a repetitive manner according to managerial instructions. Close follow up and regulation of all actions and interactions maintain tight control. In a world of mass communication and the global highway, this pattern cannot survive.

Management in the Complex Pattern.

How should a leader behave in an organization that is functioning in the complex pattern, which combines order and disorder, certainty and uncertainty, continuity and variety? It is a difficult path to follow. On one side lies the danger of too much order, continuity, similarity, loyalty to the past, etc. This stifles organizational energy and creativity. Conversely, there is the danger of falling into too much disorder and ineffectiveness, resulting from irregularity, uncertainty, and instability. An organization may reach this state when it forfeits its vision, and its identity and members are lost in uncertainty concerning the future. This is a transition state of Deep Chaos, where what worked in the past is no longer relevant and there is yet no new way of escaping from the maze.

Avoiding Deep Chaos.

How may Deep Chaos be avoided? Insights from the New Math suggest that leaders should try to identify and shape critical forces whose continued growth might pull the organization to a critical division. These parameters vary between organizations, but basically they are of two kinds.

The first is *internal division*, such as widening the gap between the needs and wants of people and the possibilities of satisfying them. This may cause major behavioral differences in the degree of members' identification with their organization, their devotion to work, and their readiness to do anything beyond regular work demands. There will always be differences and gaps, the problem lies in how wide and extreme they are. If the breaches deepen beyond a critical threshold, the population tends to breakup into sections. For example, there will be those who will continue to behave honestly even when there is a negative change in their work conditions. Others may attempt to solve their problems through deviations such as absence, destruction or neglect of organizational property, low outputs, theft, embezzlement, etc. Criminal acts by senior leaders, for example, may be seen as a warning of impending Deep Chaos.

The second kind is *external division*, which is linked to the organization's ability to adapt to its environment. For example, an unanticipated change in government policy on base housing or commissary availability can lead to critical divisions. Leaders must strive to minimize these negative outside forces and mitigate the effects of those that are necessary.

Management of Deep Chaos.

All accepted methods of control loose their value in a state of Deep Chaos. Means such as education, training, and rewards do not work. New directions are necessary. Studies reveal that only chaos can cope with chaos. Research is being conducted in areas such as controlling chaos in lasers, in electrical circuits, in heart tissues, and in brainwaves. As yet, these directions have not been translated into controlling chaos in human systems.

We do know that a state of deep chaos is a transition period that may lead to either transformation or disintegration of the system. The leader's role is to prevent disintegration and to assist the organization in its transformation and renewal.

There is little chance of accomplishing this with a linear approach. Attempts to motivate people by preaching, pressure, rewards, and punishments generally lead to failure. The problem is not one of applying pressure to change the existing state, but how to free the organization from the binds it itself has created. These are often mental models of personnel in the organization. The models are the filters through which organizations perceive reality and give meaning to incoming information. The leader's role is to create conditions through feedback, support of new initiatives, and other means, that undermine prior maladaptive models, so employees can concentrate on positive change. Of course, the best strategy is to avoid this state.

Managing at the Edge of Chaos.

An adaptive system attempts to steer itself to the edge of chaos by regulating the level of mutual dependence among its components and between itself and other systems in the environment. In other words, it can be guided by increasing or decreasing the level of autonomy of its components, teams, and individuals, while simultaneously increasing or decreasing the level of integration with outside systems such as suppliers, sub-contractors, and sister services. Strategic planning applies, but only for limited time periods into the future.[10]

Since many organizations want to move from the edge of chaos into the orderly pattern, the problem generally is one of too much continuity and order maintained by hierarchic, centralized control.[11] This necessitates increasing the level of autonomy of organizational components; decreasing tight central control of units; and increasing their authority and control of resources, creating semi-autonomous work teams, building teams on the basis of competencies of members, etc.

Regulating internal interdependence alone is not sufficient to reliably guide the organization near the edge of chaos. External interdependence must also be guided to increase or decrease the level of integration with outside bodies. Increasing interdependence may take many forms such as partnership, joint venture, sub-contracting, information sharing, joint development, strategic partnerships, etc. Decreasing these relationships may also take different forms, such as spreading the sources of materiel, maintaining parallel forces, building internal capabilities, etc.

Why does regulating interdependence influence the ability of organizations to function at the edge of chaos? Organizations with no outside ties do not influence each other. If the ties are very close, every act may adversely influence the relationship because of repercussions. Just as in a good marriage, there needs to be the right balance between interdependence and autonomy. The relationship needs to be tuned to allow both close relations and long-term stability.

RECOMMENDATIONS AND CONCLUSION

This basic examination of chaos theory provides a minimum amount of knowledge for comprehension and application of its principles. We examined the management of organizations using chaos principles and discovered potential changes in philosophy that may cope with these turbulent times.

Recommendations.

Several positive steps to ensure the military survives and to prepare it for future success in the field emerge from chaos theory:

1. Diversity can allow us to adapt more efficiently to changing times.[12] Only with a full array of culturally diverse viewpoints and mindsets can we get to the optimum solutions. This principle applies to individuals, to units, and to the services themselves. A purple-suited fighting force

may stultify military diversity and ultimately interfere with operational effectiveness. When the tension among various groups is channeled into *creative tension,* it is good for generating ideas and new approaches. The diversity we have today among services, combat formations, and individuals should not be diminished. Celebration of diversity is not homogenization of the underlying culture.

2. War games, battle labs, and training maneuvers are vital to defining a range of outcomes for new approaches to battle. An individual exercise, however, is not predictive of future success or failure. It is simply the outcome of a particular event, given its unique starting point and resources. We need to document each exercise and analyze multiple iterations to gain insight into the desirability of outcomes and the probabilities of obtaining success with new configurations. Only with repetitive similar outcomes can we gain confidence in a specific doctrinal approach.

3. Current planning cycles and systems are mostly linear in concept and execution. In the operations area, even the set sequence of briefers suggests compartmentalization and insufficient creativity and cross talk. The mission statement and commander's intent, however, indicate that some principles consistent with chaos theory have made it into our thought process, but we should go farther. We need to revise the process to optimize staff interactions and feedback loops. This will get us closer to the edge of chaos so optimal solutions may emerge more easily. In the planning, budgeting, and execution cycle, we need to redesign a cumbersome and poorly responsive Cold War process to allow innovation and adaptability to our present environment. Otherwise we consign ourselves to mediocrity and perhaps failure against a more unconstrained and agile future adversary.

4. Quality of life issues are extremely important to the functioning of the entire military organization. Inequities among individuals, groups, or even services promote divisiveness and push the system towards the possibility of

deep chaos. Even a seemingly trivial issue such as umbrella use in the Army sets males against females and the Army against the other services. Perceived inequities in deployment taskings or promotion opportunities are also destabilizing. Leaders must continually exert significant effort to maintain the highest quality of life possible for service members. We must balance individualism with the need for discipline and consistently demonstrate the caring and respect that will maintain and maximize cohesiveness.

5. Values and vision have a profound effect on organizations. Our values drive behaviors on the battlefield during chaotic situations. If soldiers believe in the system, they will sacrifice all to accomplish the mission. However, if the conduct of leaders does not seem to follow the values publicly espoused[13] or if the organization's vision for the future is not clear and resonant, soldiers may not be as motivated to perform beyond their limits. Then chaos will not steer units to the creative edge. Soldiers will, at best, follow traditional linear patterns at less than their full potential or, at worst, they will lose their cohesion and fail. Whether or not leaders live up to the personal commitment and responsibility demanded by the organization's values and vision truly effects the outcome of battles.[14]

6. With emerging technology allowing near-perfect knowledge of the battlefield, there will be a temptation to give senior commanders too much detailed information about their subordinate units. The ability to know such things as the physical (or even mental) condition of individual soldiers is not necessarily a good thing for battalion commanders and higher.[15] The chaos inherent in combat is best dealt with at the lowest level where individual factors can be more clearly recognized and compensated for.[16] Filters will be required to give summary information to higher echelons without superfluous data to encourage micro-management. Historical situations such as President Johnson's personal selection of bombing targets in North Vietnam support this approach.

Conclusion.

That too much chaos is a problem is intuitive. But we may not understand why an ordered pattern also is problematic. Managing is often seen as creating order to insure the sequential flow of planned events. Problems arise when an organization attempts to be so orderly that it excludes the necessary elements of variety, discontinuous change, innovation, experimentation, development, and creativity.[17] Too much order is counterproductive when the organization needs to adapt quickly and effectively under chaos-producing conditions.[18]

Should a leader manage so that the organization functions in the complex pattern? Generally yes, but that may not be optimal. The organization should function as closely as possible to the edge of chaos. This is where life has enough stability to maintain itself and enough creativity to be called life; it is where the system's components do not degenerate into stability and do not disintegrate into deep chaos. The challenge for today's military leader is to find the closest approach to this edge, consistent with mission requirements during training and everyday operations, and to maintain a balance there during actual combat.

We need to become comfortable with these new concepts and exploit their combat multiplier effects to the fullest. The success of the Army After Next depends as much on leader development as on technological advances.[19]

ENDNOTES - CHAPTER 4

1. Newton's impact on our innate sense of order is thoroughly discussed in L. Douglas Kiel, *Managing Chaos and Complexity in Government: A New Paradigm for Managing Change, Innovation, and Organizational Renewal*, San Francisco: Jossey-Bass Publishers, 1994, pp. 4-6. He goes on to develop the need for dynamic change and to point out why the usual government bureaucracies will not adapt well in a complex and socio-economically turbulent world.

2. There is a clear physical example in James Gleick, *Chaos: Making a New Science*, New York: Penguin, 1988, p. 24:

> Nonlinearity means that the act of playing the game has a way of changing the rules. You cannot assign a constant importance to friction because it depends on speed. Speed, in turn, depends on friction. That twisted changeability makes nonlinearity hard to calculate, but it also creates rich kinds of behavior that never occur in linear systems.

3. Margaret J. Wheatley, *Leadership and the New Science: Learning About Organization from an Orderly Universe*, San Francisco, CA: Berrett-Koehler Publishers, 1992, pp. 125-127.

4. Edgar E. Peters, *Chaos and Order in the Capital Markets*, New York: Wiley & Sons, 1991, p. 135.

5. This discovery and its military implications are discussed quite succinctly in Robert R. Logan, *A Complex Dragon in a Chaotic Sea: New Science for USMC Information Age Decisionmakers*, CARLISLE, PA: U.S. ARMY WAR COLLEGE, 1996, PP. 5-8.

6. An enlightening and creative discussion of chaos theory in terms of Clausewitzian theory and the overlap of both with the Vietnam War is contained in Scott E. Womack, *Chaos, Clausewitz, and Combat: A Critical Analysis of Operational Planning in the Vietnam War*, 1966-1971, Fort Belvoir, VA: Defense Technical Information Center, Document Number ADA306112, 1995, p. 151.

7. This branching of pathways is framed in terms of symmetry breaking by Kiel, p. 37. The process of branching is discussed more rigorously in Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature,* New York: Bantam Books, 1984, p. 177.

8. Uri Merry, *Coping with Uncertainty: Insights from the New Sciences of Chaos, Self-Organization, and Complexity*, Westport, CT: Praeger, 1995, is a treasure trove of reasonably clear discussions of the effects of chaos on organizations. His more recent work, along with that of the current staff at the Santa Fe Institute is available on the Santa Fe website at *http://santafe.edu/sfi/publications* and on Dr. Merry's website at *http://pw2.netcom.com/~nmerry/art2.htm*.

9. *Ibid*.

10. Steven E. Phelan, "From Chaos to Complexity in Strategic Planning;" available from *http://comsp.com.latrobe.edu.au/ papers/ chaos.html*; accessed November 21, 1997, details the relatively limited applicability of long range strategic planning

11. This point is made clearly by Kiel, p. 140.

12. A strong argument is made for the positive effects of diversity by *ibid*., p. 162.

13. That leaders should be risk takers, strongly reinforce actions that have positive outcomes for the organization, and have a long-term outlook, not simply a response to everyday crises is discussed by *Ibid., pp. 175-194.*

14. Peter M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization*, New York: Doubleday, 1994, p. 214, gives an excellent discussion of the requirements for executing an organizational vision. He points out that everyone, not just the leaders themselves, must believe the vision, and everyone should contribute to its development to facilitate buy-in.

15. This is even consistent with current writings from the Training and Doctrine Command itself. See John L. Romjue, *American Army Doctrine for the Post-Cold War*, Fort Monroe, VA: United States Army Training and Doctrine Command, 1997, pp. 28-29.

16. The fact that the fog of war will persist in the face of technology is presented clearly in Douglas A. Macgregor, *Breaking The Phalanx: A New Design for Landpower in the 21st Century*, Westport, CT: Praeger, 1997, pp. 50, 161. He also makes the point that local initiative by lower level leaders make critical differences in outcome in *Ibid*., p. 160.

17. The necessity of seeing reality for any adaptive organization as seething with change and not simply a mechanical system is emphasized in Prigogine and Stengers, p. xv.

18. "The linear approximation is usually worst when things are about to fail." Nina Hall, *Exploring Chaos: A Guide to the New Science of Disorder*, New York: Norton, 1991, p. 151.

19. John G. Sifonis and Beverly Goldberg, *Corporation on a Tightrope: Balancing Leadership, Governance, and Technology in an Age of Complexity*, New York: Oxford University Press, 1996, p. 34, points out that:

> leadership on one level sets the logic, the vision, the direction of an organization; on another it enables processes. Technology enables and facilitates leadership and governance, but how much technology an organization uses is driven by leadership and governance.

This feedback is a basic phenomenon of nonlinear interaction.

CHAPTER 5

EDUCATING JUNIOR MILITARY OFFICERS FOR THE INFORMATION AGE

Andre H. Sayles

INTRODUCTION

> Future military leaders need to learn about cutting-edge technology that may change how wars are fought, but they also need a historical underpinning to their professional education.
>
> Rep. Ike Skelton[1]

As the Armed Forces transition to the 21st century, senior leaders will face the challenges of the information age. At an unprecedented pace, new technologies are changing the way the services plan for future military operations. During the first two decades of the 21st century, nearly every service member will feel the impact of the Information Revolution. A paradigm shift in the professional military education (PME) of junior officers is on the horizon. Simultaneously, this new approach to education must continue to provide for the historical underpinnings in the current education system.

In May 1996, the chairman of the Joint Chiefs of Staff published *Joint Vision 2010* as "the conceptual template for how America's Armed Forces will channel the vitality and innovation of our people and leverage technological opportunities to achieve new levels of effectiveness in joint warfighting."[2] This framework for joint operations in 2010 lays the foundation for visionary programs in the individual services.

The Army outlook for the first 25 years of the 21st century is captured by the continuum of *Force XXI, Army Vision 2010, and Army After Next.*[3] *Transitions for the Navy and Marine Corps will be guided by the strategic concept of*

Forward . . . From the Sea.[4] The Air Force strategic vision is captured by Global Engagement: *A Vision for the 21st Century and Air Force 2025*.[5]

Joint operations are common threads that run throughout the collective vision of the Chairman of the Joint Chiefs of Staff and the service chiefs. As a driving force behind future joint, combined, and ultimately integrated operations, the Information Revolution will lead to new education requirements for junior leaders. Soldiers , sailors, airmen, and marines will continue to win wars as they have done in the past; new technologies will not displace the human dimension. However, leaders will have to understand new tools of the trade in the future as they have in past wars. These new information age tools have already begun a historic revolution in military affairs (RMA).[6]

This chapter will address issues related to junior military officer education in the information age. After a discussion of information operations (IO), a future scenario provides a basis for proposed junior officer education. This report suggests that education of military leaders be factored into the force planning process. The services should not assume that education requirements for the information age will be a natural product of the times. Unless direct action becomes a priority, the human factor may slow progress towards the 2010 force.

INFORMATION OPERATIONS

> All planning, particularly strategic planning, must pay attention to the character of contemporary warfare.
>
> Carl von Clausewitz[7]

In 1996, Winn Schwartau defined information warfare (IW) as "those actions intended to protect, exploit, corrupt, deny, or destroy information or information resources in order to achieve a significant advantage, objective, or victory over an adversary."[8] He developed this definition by combining elements of three existing taxonomies associated with the Department of Defense (DoD), national security, and economic infrastructure. Although the DoD focus was on actual conflict, the broader definition offered by Schwartau extended to peacetime activities that ranged from recreational hacking to computer terrorism.

In *Field Manual (FM) 100-6,* published in August 1996, the Army used information operations to describe the full range of information issues from peace through global war.[9] Information operations became the Army's implementation of the DoD version of information warfare, but in a much broader sense.

Although information warfare was becoming a universal term by the mid-1990s, a resistance to the use of "warfare" in the private sector ultimately led to a preference for information assurance (IA). This term described the range of nonmilitary activities related to what previously had been described as information warfare. The President's Commission on Critical Infrastructure Protection described information assurance as:

> Preparatory and reactive risk management actions intended to increase confidence that a critical infrastructure's performance level will continue to meet customer expectations despite incurring threat inflicted damage. For instance, incident mitigation, incident response, and service restoration.[10]

Assurance includes protection of information systems, detection of intrusions, and restoration of operations after an attack. In 1998, the new *Joint Publication* (Joint Pub) 3-13 brought closure to the concept of military information operations from a Joint Staff perspective.[11] As shown in Figure 1, *Joint Pub* 3-13 describes relationships between information operations, information warfare, and information assurance in peace and war.

Information operations are supported by command, control, communications, computers, and intelligence (C4I) across the full spectrum of military activities. Such

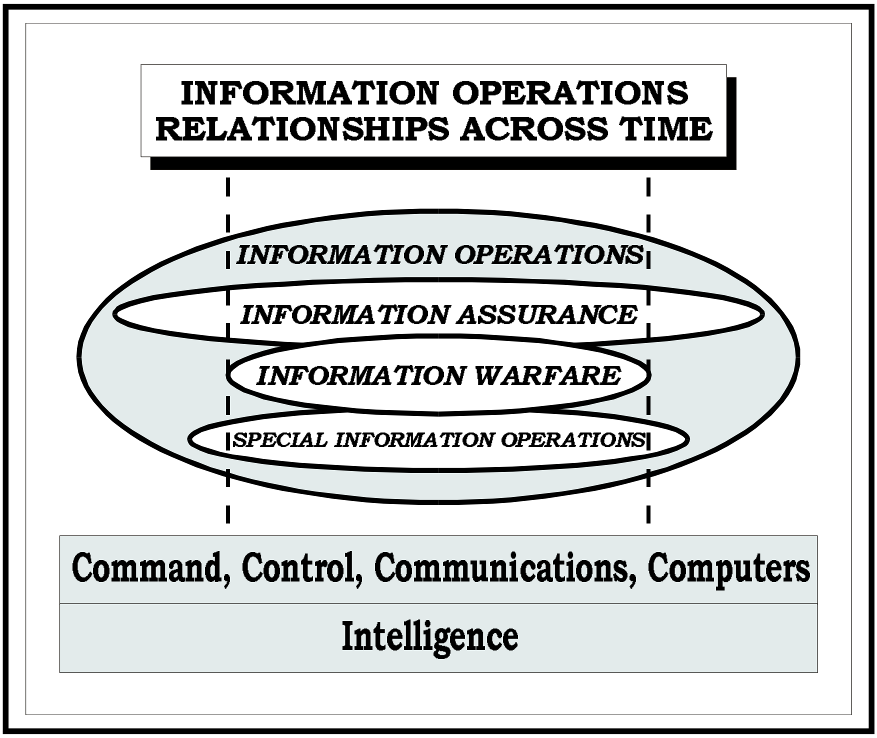

Figure 1. Information Operations Relationships Across Time.

operations include "actions taken to affect adversary information and information systems, while defending one's own information and information systems."[12] Information warfare is a subset of information operations during time of crisis or war. Like information operations, information assurance is a full-time activity. In *Joint Pub 3-13,* information assurance is defined as "IO that protect and defend information systems by ensuring their availability, integrity, authentication, confidentiality, and nonrepudiation."[13] In DoD, as well as the private sector, information assurance implies protection of systems, detection of infringement, and recovery or reaction.

Defensive and offensive IO are relevant across the peace and war spectrum. Defensive IO is particularly important in protecting information systems on a daily basis.

Information assurance is one of many defensive measures available. As attacks on information systems increase, offensive information operations may also be used as defensive measures. Currently, the number of attacks on military information systems may be as high as 500,000 annually.[14] Many of these attacks are not detected by current defensive measures.

INFORMATION AGE TECHNOLOGIES

> The world has changed and there is great risk in standing still.
>
> General Gordon R. Sullivan[15]

Information operations are a conduit for integration of information age technologies into future battlespace. The projections in *Joint Vision* 2010 include global communications and intelligence networks, precision weapons, digitized platforms, direct links between sensors and shooters, advanced soldier systems, full enemy and friendly force identification, and situational awareness.

Many rapidly advancing technologies are driven by new innovations in semiconductors, electronics, and optics. In 1965, Gordon Moore predicted that the number of transistors on an integrated circuit would double every year. In 1975, he revised his prediction to what is now called Moore's Law; the number of transistors will double every 18 months. Remarkably, this prediction has remained accurate for the past 20 years, except for recent advances that are about 1 year early.[16]

Success in the semiconductor industry has underpinned advancement for many other technologies. Specifically, miniaturization of high speed processors has opened doors for computers, communication systems, sensors, displays, and numerous other capabilities that have both commercial and military applications. Coupled with advanced materials, signal processing, and developments in software engineering, microelectronics has led to dramatic improvements in command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR). Technology is affecting force structure, military operations, and the way the services manage information on a daily basis.

FUTURE MILITARY SCENARIO

> Generally, operations of war require one thousand fast four-horse chariots, one thousand four-horse wagons covered in leather, and one hundred thousand mailed troops.
>
> Sun Tzu[17]

A significant number of futurists have offered scenarios describing the evolution of economic, political, social, and military conditions over the next 30 years. Likewise, each of the services has published a vision from the present to 2025. Due to the conjectural nature of scenarios, an exhaustive review of military futures would offer no more certainty than a single brief scenario. Thus, a concise futurist statement is adequate to stimulate thoughts about junior officer education requirements in the information age. The following paragraphs offer a brief future scenario based on the notion that the advanced land warrior will be the primary focus.

Currents of Change.

Steven Metz describes the most important overarching currents of change as interconnectedness, compression of time, and demassification.[18] At the strategic level, these three broad categories are applicable to many published military futures. Interconnectedness is already underway at all levels within the Armed Forces, including individual, organizational, service, and interservice systems. The increased focus on information operations supported by C4ISR is but one indication that interconnectedness is a way of the future.

In both peace and war, the compression of time is becoming reality through a variety of communications and information systems. Data can be sent or retrieved in near real time from virtually any location on earth. Future transportation systems will likely compress both time and space as travel times are reduced or the need to travel long distances to accomplish the mission will no longer be necessary.

The application of demassification to military organizations will lead to smaller units across the services. The smaller units will be able to conduct an operation anywhere in the world while moving quickly and maintaining global communications. A full range of information operations resources will be at their disposal.

Land Warrior Futures.

Over the next 30 years, the land warrior will develop into an individual fighting machine. Outfitted in climate-controlled individual armor, the land warrior will be protected by an integrated defense against chemical agents, small arms fires, and adverse environmental conditions. Global communications via satellite will complement regional communications via wireless or cellular systems enhanced by unmanned aerial vehicles. Along with these communications assets, advanced global positioning concepts will be integrated into a specially designed helmet.

At the touch of a button or perhaps in response to an inconspicuous mental or physical gesture, the head-worn display will provide the positions of enemy and friendly forces, targeting information, mission status, and environmental conditions. The individual weapon will be able to identify and target the enemy while offering a range of responses from stun to kill. The land warrior will have no concerns about temporary environmental conditions such as day and night. Likewise, the ability to be extracted or resupplied at just the right time is taken for granted.

Land Warrior Supporting Forces.

The remainder of the military force structure will be designed to support the individual land warrior as well as operate independently. A wide range of small units will be combined at practically any level or size in order to provide the necessary firepower and logistical support. Heavier weapons will be made available in case of a rare conflict which may be thought of as conventional. Supporting aviation platforms will range from close support to strategic. Space and naval assets will be available to the land warrior upon request. When the mission dictates a larger force, land, air, and sea elements will be integrated into a single unit that communicates and operates much like the smaller land warrior component.

Land Warrior Technology.

The land warrior is a creation of the Information Revolution. From a technology point of view, only the land warrior assets matter in the transition to the future. Capabilities that will have been miniaturized and powered for the land warrior in 2030 or the robot replacement in 2050 will easily be duplicated on larger platforms. Global communications, situational awareness, precision weapons, and climate-control are easily accomplished on vehicles, ships, and aviation assets where power, size, and weight restrictions are of less importance.

In some cases, existing larger platform technology will be miniaturized for land warrior use. In other cases, technology developed for the land warrior will be magnified for space, air, naval, and vehicular applications. The greatest challenge will be developing resources for the land warrior. Integrating those capabilities into the other forces will be a secondary task.

Cyber tools will underpin nearly every land warrior asset. Addition of the land warrior support forces will generate an integrated battlespace that provides real-time

C4ISR, logistics, and medical support. The battlespace will be supported by a national cyber infrastructure, linked to an international infrastructure and a space infrastructure. Within this framework, wars will be fought—sometimes from space, sometimes silently through the global cyber infrastructure, sometimes by the warrior support forces, and sometimes by the warrior on the ground.

SCENARIO INTERPRETATION

> Technology, one of the principal driving forces of the future, is transforming our lives and shaping our future at rates unprecedented in history, with profound implications that we can't even begin to understand.
>
> John L. Petersen[19]

The scenario in the previous section is just one of many ways of looking at the future. Complete credibility of such a projection into the future is not essential to an argument for or against a paradigm shift in junior officer education. In fact, when funding constraints are considered, the probability of a full set of advanced land warrior and support forces appearing in 2025 is relatively low. The most likely scenario is one that projects a mixture of forces at various stages of modernization.

By 2025, the Armed Forces may have a percentage of advanced forces with a corresponding advanced support structure. The remainder of the force may be grouped into two or three categories according to the level modernization. Extension of modernization to reserve forces is yet another consideration. Some of the more expensive platforms may continue to exist essentially as they do today, except for selected sub-system improvements.

Argument for a new look at junior officer education can be supported by any segment of the scenario, including projections for the next few years. The Information Revolution has already created a need for change, with a key step being acknowledgment by DoD that information operations must be brought to the forefront. The implied education needs of the land warrior are already clear.

As outlined in *Joint Vision 2010*, "we must have information superiority: the ability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying and adversary's ability to do the same."[20] In time of conflict, offensive information warfare will reduce or eliminate enemy capabilities, while defensive information warfare will protect military operations as well as the supporting infrastructures.

Challenges associated with information assurance must be addressed on a full-time basis. Protection of national and space infrastructures is vital to the safety and economic prosperity of America. Today most attacks are recreational in nature. In time of conflict, however, it is likely the infrastructures will receive more serious attacks as the adversary attempts to use space and cyberspace to further his war aims.

For the land warrior, information superiority is the key to success, whether in the year 2000 or 2025. In an adverse environment, the land warrior must understand the technology that provides his tactical and operational advantage. This understanding must include how to use the technology effectively, how to make it work under adverse conditions, how to recognize when it is not functioning properly, and how to operate when the technology fails.

FUTURE LEADERSHIP CHALLENGES

> In no other profession are the penalties for employing untrained personnel so appalling or so irrevocable as in the military.
>
> General Douglas MacArthur[21]

The impact of the Information Revolution on the Armed Forces has often been compared to the development of motorized armored vehicles and the effective use of technology in the Blitzkrieg of World War II. A parallel can be drawn between information age technologies and the internal combustion engine. Similarly, *Blitzkrieg* can be likened to information operations and other methods of employing information age capabilities.

Perhaps a better analogy for pending revolutionary trends in military affairs is the impact of rifled and repeating weapons in the 19th century. The killing zone increased from approximately 150 meters to a thousand meters or more by the end of the American Civil War.[22] Many military leaders did not accept the larger killing zone brought on by technology and continued to charge across open spaces while facing a rainstorm of bullets. Those who failed to respond to new weapons caused the loss of many lives; from Pickett's Charge at Gettysburg to the slaughters of World War I.

Like rifled and repeating weapons, information technologies will directly affect every person in uniform. At some point, C4ISR tools will be at the finger tips of all service members, including the land warrior. Those who fail to respond to the Information Revolution will join General Pickett at Gettysburg or the Allied Forces at the beginning of World War II. The services must face the need to bring warfighters into the information age. The most imminent challenge is the necessary paradigm shift in education of the officer corps. This change will be an even greater task for the services that have not emphasized technical degrees in the past.

A 1997 Army After Next Wargame demonstrated that tactical success greatly depends on the ability to execute decentralized operations.[23] Junior leaders must be prepared to accomplish their mission without the luxury of calling upon support elements or contractors when equipment fails to operate properly. They also must understand the underlying principles in order to use information age technologies to maximum effectiveness under a variety of conditions.

In the 21st century, small unit leaders will be expected to use the same communications and intelligence resources that digital technology will make available to higher commands. Education requirements will go well beyond the understanding of information technologies. Integration of systems or "systems of systems" will require a general understanding of science and engineering, along with a certain level of comfort with technical equipment. Training will not be able to accommodate the pace of change and the breadth of technological advances. The only solution will be through technical education for the officer corps.[24] This process must start with the undergraduate education of junior officers and continue through their military career.

While education must focus on science, engineering, and the requisite historical perspective, both training and education must also address the need for leaders to make correct decisions in a timespan decreased by the fast pace of future operations. Leaders will have to be decisive under conditions of too much information, just enough information, and too little information. Quick and positive development of innovative solutions to a wide-range of multidimensional problems will be a standard for good leadership. The information age will bring an overwhelming amount of information, but when systems have temporary failures the flood of information may become a drought.

OFFICER EDUCATION

> Wars may be fought with weapons, but they are won by men.
>
> General George S. Patton, Jr.

The Armed Forces need "leaders who have a deep understanding of warfare in the context of the information age."[25] Such knowledgeable leaders must have had the opportunity to internalize the significant capabilities and vulnerabilities associated with the current and future role of information (from both the technological and human perspectives).[26]

Although a variety of technologies will have an impact on future warfare, we will focus on the information age. The Information Revolution is clearly driving the revolution in military affairs (RMA) and the need for a paradigm shift in junior officer education. When the services have an adequate number of information knowledgeable leaders, a likely by-product will be that the overall shortfall in science and engineering education will become manageable. The result will be an environment in which technology is readily accepted.

The new approach to junior officer education must specifically address the 4-year undergraduate program and the first 6 months of service after commissioning. The topics listed in Table 1 are suggested for three categories of officer education by the end of the first year of service. Many of the topics can be covered in undergraduate programs if appropriate requirements are placed on commissioning sources. Remaining topics can be provided through joint or service distance learning programs and military branch or specialty schools upon entry on active or reserve duty.

The Depth of Knowledge categories are represented by three tiers. Tier 1 represents the minimum requirements for all junior officers. At this level of knowledge, all officers will have the tools to operate effectively and train subordinates in information age or land warrior scenarios. Tier 2 represents the knowledge requirements for officers in branches or specialties that include operational level responsibilities in communications, intelligence or information. Tier 3 is the depth of knowledge required of officers who have strategic level responsibilities or work as scientists, engineers, or system administrators. Tier 3 officers should have an undergraduate or graduate degree in science or engineering.

TOPIC	Depth of Knowledge TIER 1	TIER 2	TIER 3
Computers and Information Technology	B	I	A
Software Applications	B	I	I
Programming Languages	F	B	A
Software Development	N	F	I
Networks and Telecommunications	F	I	A
Information System Intruder Tactics	F	B	A
Information Security	F	I	A
Computer System and Network Security	F	B	A
Information Assurance	N	F	I
Human-Computer Interaction	F	B	B
Satellite Communications Systems	F	I	I
Global Positioning Systems (GPS)	F	B	B
Wireless Communications	F	B	I
Communications Fundamentals	B	I	I
Electrical Engineering Fundamentals	F	B	B
Electronic Vulnerabilities	F	B	I
Strategic and Operational Intelligence	B	A	A
Information Operations Principles	B	I	I

Levels: N-None F-Familiarization B-Basic I-Intermediate A-Advanced

Table 1. Education Requirements for Military Officers.

The topics in Table 1 do not imply separate academic courses. Single undergraduate courses that cover several of the topics already exist. An explanation of each topic follows:

• Computers and Information Technology: This is a typical introductory or CS1 level computer course that provides the basics of computer operation, types of computers, and computer hardware. Completion of the course should enable the officer to be comfortable working with computers and displays at the required level.

• Software Applications: Often included in introductory courses, software applications provide additional experience with computers and the opportunity to learn fundamentals applicable to commercial and military software.

• Programming Languages: This course provides an understanding of how software interfaces with hardware in computer systems, microprocessor-based systems, and military applications.

• Software Development: Provides knowledge and experience to Tiers 2 and 3 officers, enabling them to develop software, troubleshoot systems, or supervise contractors or military subordinates performing those functions. Software is critical to system integration.

• Networks and Telecommunications: Connectivity and communications between systems will be a primary component of future information warfare. Officers should have a basic understanding of strengths and weaknesses in this area.

• Information System Intruder Tactics: A first step in defense against attacks on information systems is the recognition of adversary techniques and capabilities. An understanding of the hacker will also lead to higher sensitivity to, and better identification of, intrusions.

• Information Security: Junior leaders will be expected to ensure proper security measures are in place for electronic information. Decentralization will place this responsibility at the lowest levels.

• Computer System and Network Security: The information warrior needs to understand security mechanisms and the associated vulnerabilities and reliability.

• Information Assurance: Information assurance is a more advanced topic that focuses on maintaining robust systems that will resist attack, detect intrusions, and continue to operate while under attack. The technology for assured performance will evolve as infrastructure protection becomes a higher priority.

• Human-Computer Interaction: Although not well defined, this topic will take on more importance as warfighters learn how to sort information from the global communications and intelligence network. Subjects of interest include cognitive psychology and human decisionmaking.

• Satellite Communications, Global Positioning Systems, and Wireless Communications: Leaders must be familiar with these three subjects since they will underpin future information operations. System level familiarization should be combined with a clear understanding of vulnerabilities to the environment as well as the adversary.

• Communications Fundamentals: Every leader in the information age will be a communications officer. Computers will become so common that the user will also be a system administrator. The organizational system administrators will have to concentrate on architecture and security and will no longer be able to make desk calls. The individual land warrior will have to know the communications business in this same manner.

• Electrical Engineering Fundamentals: The information age would not exist without electronics. Future hardware will be based on advanced applications of electrical engineering principles. A basic understanding of electronics will raise the confidence of users of numerous systems.

• Electronic Vulnerabilities: Electronic vulnerability is a sub-topic of several of the other subjects, but is listed separately because this will be the adversary's primary counter measure in a theater of operations. Satellites, GPS, and many other information age technologies will be susceptible to degradation by electronic countermeasures.

• Strategic and Operational Intelligence: Situational awareness will be critical to warfighting in the next century. Intelligence information will be important at all levels from the individual land warrior to the carrier battle group. The information knowledgeable leader will need to know the sources of intelligence, the integration schemes, and how to interpret information in real time.

• Information Operations Principles: Information operations are not confined to DoD. Many of the issues and concerns are common to the private sector. The importance of IO dictates that the principles be taught in an academic as well as in a training environment.

The arguments presented here are by no means exhaustive. Implementation of such an education program for military leaders demands further study. Topics in Table 1 are repeated in Table 2, along with suggestions as to how the required education can be provided. The services may have to place more requirements on commissioning sources and restrict the number of new officers who do not have a degree in mathematics, science, or engineering. Joint distance learning programs may be more efficient than programs generated by individual services. It is important to note again that competency objectives can no longer be accomplished through training alone. Education must play a much greater role in providing a background that offers

TOPIC	Under-graduate Course	Distance Learning	Military Course
Computers and Information Technology	X		
Software Applications	X		
Programming Languages	X		
Software Development	X		
Networks and Telecommunications	X		X
Information System Intruder Tactics	X	X	X
Information Security	X		X
Computer System and Network Security	X		X
Information assurance			X
Human-Computer Interaction	X		X
Satellite Communications Systems		X	X
Global Positioning Systems		X	X
Wireless Communications		X	X
Communications Fundamentals	X	X	X
Electrical Engineering Fundamentals	X	X	
Electronic Vulnerabilities		X	X
Strategic and Operational Intelligence		X	X
Information Operations Principles		X	X

Table 2. Education Opportunities for New Officers.

versatility and an acceptable level of comfort across a wide range of technologies.

The "military course" category in the right column of Table 2 would likely be the basic course or specialty training that a new officer receives upon entrance on active or reserve duty. Because of the importance of information age technologies, it is conceivable that most basic officer courses will have an information operations component in the 21st century.

The table may appear to suggest a large number of sub-courses under military education; however, the suggested Tier 1 familiarization will often be a by-product of an undergraduate program. For example, satellite communications, GPS, and wireless technology may turn out to be survey topics in a communications course. On the other hand, the requisite depth at Tier 3 may dictate a special sub-course if an officer's undergraduate program did not meet requirements.

Information operations need not challenge warfighters in the 21st century as *Blitzkrieg* did in World War II. The American Army responded to German armored divisions by carefully identifying officers to lead the newly formed armored units. Since these units had not existed before, the Army could not look to training alone for the solution. Instead, versatile officers were identified from their education background. Education offers the same versatility necessary in the information age. As suggested by Alvin and Heidi Toffler, the new military must place massive emphasis on training and education at every level.[27]

WORK IN PROGRESS

> New technologies and processes can frighten those who are comfortable with the routines established to accommodate the old technologies. Furthermore, vested interests within the organization and within its bureaucracy—usually for what to

them are good and logical reasons—will resist ideas that threaten status quo.

General Gordon R. Sullivan, and
Lieutenant Colonel Anthony M. Coroalles[28]

DoD is leading the way in bringing information operations into focus. The establishment of a Deputy Assistant Secretary for Information Operations and the pending publication of *Joint Pub 3-13* will lead to increased emphasis on policy and doctrine. New technologies will eventually stimulate new ideas on force structure and staff organizations. As history has proven, the human dimension is of critical importance and must not be left out.

In August 1996, the Army published *FM 100-6* (Information Operations). Although the release of *Joint Pub 3-13* (Doctrine for Information Operations) will require significant revisions, *FM 100-6* was a good start. In 1995, the Naval Postgraduate School (NPS) introduced an Information Warfare degree within the Systems Engineering Program. With the help of the Deputy Director of Operations, J39 (Information Operations), on the Joint Staff, the Navy has made a strong statement that officer education requirements have changed. An outline of the curriculum is available on the NPS web site and summarized in Figure 2. In addition to programs at the Naval Postgraduate School, the Navy established the Navy Information Warfare Activity in 1994 and the Fleet Information Warfare Center in 1995. Navy doctrinal publications will be published shortly after release of *Joint Pub 3-13*.

The Air Force established the Air Force Information Warfare Center in 1993 and created the 609th Information Warfare Squadron in 1996. In March 1997, the Air Force activated the Information Warfare Battlelab at the Air Intelligence Agency, Kelly Air Force Base, Texas. The Army's Land Information Warfare Activity has taken on a

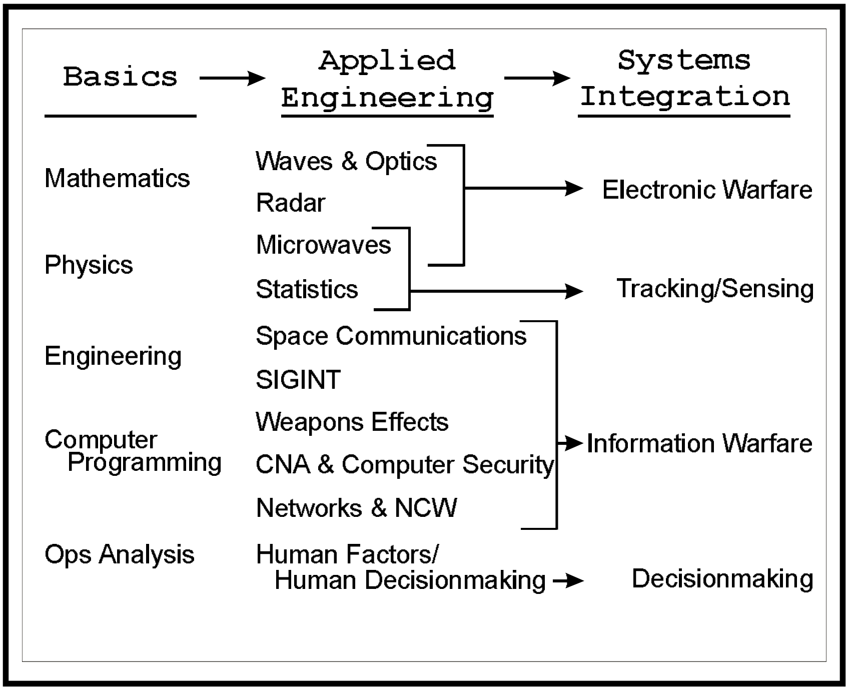

Figure 2. Information Warfare Systems Engineering at NPS.[29]

leadership role in establishing security measures for the information infrastructure and responding to attacks.

These are but a few examples of current DoD investments in the information age. The new Defense Information Assurance Program will add to ongoing efforts to secure the defense and national information infrastructure. Other initiatives will continue to address the full spectrum of offensive and defensive operations.

CONCLUSION

> We face no imminent threat, but we do have an enemy—the enemy of our time is inaction.
>
> President William J. Clinton[30]

The next 10 years will be a critical time for American Armed Forces. Each of the services has charted a path to 2010 and beyond with technology being a primary driving force. The manner in which leaders will be educated for *Joint Vision 2010* has not been adequately spelled out. Since the services will not reap the benefits of any new education policy until approximately 5 years after the effective date, immediate action is necessary.

Over the next 9 years the New York Times estimates that one million new computer science jobs will be created in the United States. Up to 400,000 jobs may be vacant in 1998.[31] With colleges and universities graduating less than 40,000 candidates for those jobs on an annual basis, the salaries offered to experienced programmers are sometimes exceeding six figures.

After the Cold War, the services lost a large number of officers with technical degrees. Promotion policies have also been costly as officers who took time to get advanced technical degrees were no longer competitive for promotion. Although some of those officers have reserve commitments, many will not have a role in the next military force.

The demands of the Information Revolution are leading the services—some more than others—to the idea of contracting technical jobs to private companies. This idea has at least three major drawbacks. Due to competition in the private sector, the cost of private contracting and consulting to the military will be much more than the cost of requiring officers to come into the service with a technical degree. The services simply will not be able to afford the contracts. Today, a contract for a single civilian programmer costs up to $150,000 per year.[32]

The second shortcoming is that contractors may not be willing to follow the warfighters into battle when so many jobs are available across the private sector. The third consideration is the evidence presented in this report that the need for technical competency will extend down to the small unit leader. We simply will not be able to hire a contractor to be the land warrior or land warrior leader.

In conclusion, the Armed Forces must actively consider initiating programs that will develop information knowledgeable leaders. These programs must provide many more technically qualified officers than actually needed because of the expected losses to the private sector after service obligations are fulfilled. Junior officers will have to be educated through a combination of undergraduate course requirements, distance learning, and military schooling.

ENDNOTES - CHAPTER 5

1. Rick Maze, "Officer Schooling Concerns Buyer, Skelton," *Army Times*, February 16, 1998, p. 6.

2. John M. Shalikashvilli, *Joint Vision 2010*, Washington, DC: Chairman of the Joint Chiefs of Staff, p. 1.

3. Dennis J. Reimer, *Army Vision 2010*, Washington, DC: Department of the Army, 1996, p. 2.

4. Department of Defense, *Defense 97*, Alexandria, VA: American Forces Information Service, No. 6, 1997, p. 19.

5. *Ibid*., p. 19.

6. Steven Metz and James Kievit, *Strategy and the Revolution in Military Affairs: From Theory to Policy*, Carlisle Barracks, PA: U.S. Army War College, Strategic Studies Institute, June 27, 1995), p. v.

7. Carl von Clausewitz, *On War*, Michael Howard and Peter Paret, trans., Princeton, NJ: Princeton University Press, 1976, p. 220.

8. Winn Schwartau, *Information Warfare*, New York: Thunder's Mouth Press, 2nd ed., 1996, p. 12.

9. Department of the Army, *FM 100-6, Information Operations*, Washington, DC: U.S. Department of the Army, August 27, 1996, p. 2-2.

10. President's Commission on Critical Infrastructure Protection, *Critical Foundations: Protecting America's Infrastructure*, Washington,

DC: President's Commission on Critical Infrastructure Protection, October 13, 1997, p. B-2.

11. Department of Defense Joint Staff, *Joint Publication 3-13, Joint Doctrine for Information Operations*, Draft, Washington, DC: U.S. Department of Defense, January 28, 1998, p. I-4.

12. *Ibid*., p. I-19.

13. *Ibid*., p. I-18.

14. John T. Correll, "War in Cyberspace," *Air Force Magazine*, January 1998, p. 34.

15. Gordon R. Sullivan and Anthony Coroalles, *The Army in the Information Age*, Carlisle Barracks, PA: U.S. Army War College, Strategic Studies Institute, March 31, 1995, p. 21.

16. Linda Geppert and William Sweet, "Technology 1998," *Spectrum*, January 1998, 20.

17. Sun Tzu, *The Art of War*, Samuel B. Griffith, trans., Oxford, England: Oxford University Press, 1963, p. 72.

18. Steven Metz, *Strategic Horizons: The Military Implications of Alternative Futures*, Carlisle Barracks, PA: U.S. Army War College, Strategic Studies Institute, March 7, 1997, pp. 2-3.

19. John L. Petersen, *The Road to 2015*, Corte Madera, CA: Waite Group Press, 1994, p. 27.

20. Shalikashvili, p. 16.

21. Department of Defense Joint Staff, *Joint Publication 3-13, Joint Doctrine for Information Operations*, Draft, Washington, DC: U.S. Department of Defense, July 2, 1997, p. VI-9.

22. Department of the Army, *The Annual Report on The Army After Next Project*, Washington, DC: U.S. Department of the Army, July 1997, p. A-1.

23. *Ibid*., p. 21.

24. U.S. Air Force Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century*, Washington, DC: U.S. Department of the Air Force, January 30, 1996, p. 50.

25. Philip A. La Perla, *Creating Information Knowledgeable Leaders Through Information Operations Education*, Carlisle Barracks, PA: U.S. Army War College, July 1997, p. 1.

26. *Ibid*.

27. Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century*, New York: Little, Brown and Company, 1993, p. 146.

28. Sullivan and Coroalles, p. 18.

29. Naval Postgraduate School, "Information Warfare & Information Operations," available from *http://www.nps.navy.mil/~iwag*; accessed 13 March 1998.

30. President William J. Clinton, "State of the Union Address," January 1997.

31. Amy Harmon, "Software Jobs Go Begging, Threatening Technology Boom," *New York Times*, January 13, 1998, sec. A, p. 1.

32. *Ibid*.

CHAPTER 6

A PROPOSAL FOR DESIGNING COGNITIVE AIDS FOR COMMANDERS IN THE 21st CENTURY

Lawrence G. Shattuck

Army commanders at all levels will face new and unprecedented challenges on 21st century battlefields. The challenges will result, in part, from the infusion of technology into the command and control (C2) process. Our doctrine states that commanders have two primary tasks: leading and deciding. *FM 100-5* describes decisionmaking as "*knowing if* to decide, then *when* and *what* to decide."[1] Commanders at all levels—tactical through strategic—are decisionmakers. As we digitize the military, the decisionmaking process is quickly becoming more complex, more difficult, and more taxing on cognitive resources. Digitization provides decisionmakers with unlimited access to data. However, decisionmakers do not make decisions based on data. Data must be amplified, interpreted, or integrated, within the situational context. This data analysis is performed by humans who are, in most cases, unaided by technology. With more data available than ever before, decisionmakers easily can become overwhelmed. They need an aid that will assist them with contextually based data analysis. This aid will free them to reason at higher cognitive levels and, as a result, make them better decisionmakers. This chapter investigates the decisionmaking challenges induced by digitizing the force; discusses the cognitive processes that contribute to decisionmaking; proposes methods to study the processes that precede decisionmaking; and offers a soldier-centered solution.

Impact of Digitization on Decisionmaking: An Illustration of the Problem.

During the period June through November 1997, the Army prepared for and conducted the Division Advanced Warfighting Experiment (DAWE) with the 4th Infantry Division. The division was possibly the most technologically sophisticated ground maneuver force in the world. Yet, in many ways, it was a model of inefficiency. Observations from that experiment reveal three problems that may be attributed to the digitized technology. All observations were made at a brigade tactical operations center (TOC).

Observation #1 (Data Flow and Analysis).

Research conducted by Shattuck, *et al*., investigated how data flowed within a brigade TOC and the types of analyses staff personnel performed on the data.[2] They found that one of the most sophisticated brigade TOCs in the world still transmitted approximately 89 percent of its data using traditional means (radio, telephone, paper, and face-to-face conversations). Additionally, the type of processing that occurred on data flowing within the TOC was also categorized. Types of processing ranged from transduction (i.e., changing the data from an incoming radio message to an entry in a paper log) to interpretation (i.e., applying higher order knowledge and cognitive skills to reason about the data). The results revealed that less than 30 percent of the data was processed beyond the level of transduction.[3]

Researchers attributed the results to two phenomena. First, as more data flowed into and around the TOC, the staff had less time to devote to any one item. Therefore, the cognitive processing performed on the data was relatively shallow. Second, clumsy automation impeded data flow and analysis. It was easier to write an incoming message on a piece of paper and take it to the other side of the TOC than it was to move it electronically.

Observation #2 (Centralized C2 Structure).

Military organizations are hierarchical. At the tactical level, a senior decisionmaker—the commander—receives data, reviews what he knows about the battlefield, and makes a decision. He has assistance in gathering and analyzing the data, but the final decision rests with him. During Simulation Exercise (SIMEX) 1, a training exercise prior to the DAWE, staff officers frequently handed the brigade commander slips of paper or briefed him face to face. On other occasions, the commander roamed around the TOC, looking at various Army Tactical Command and Control System (ATCCS) computer screens (see Figure 1). In most instances, what was brought to him (or what he observed as he walked around) was low-level, unfiltered data.

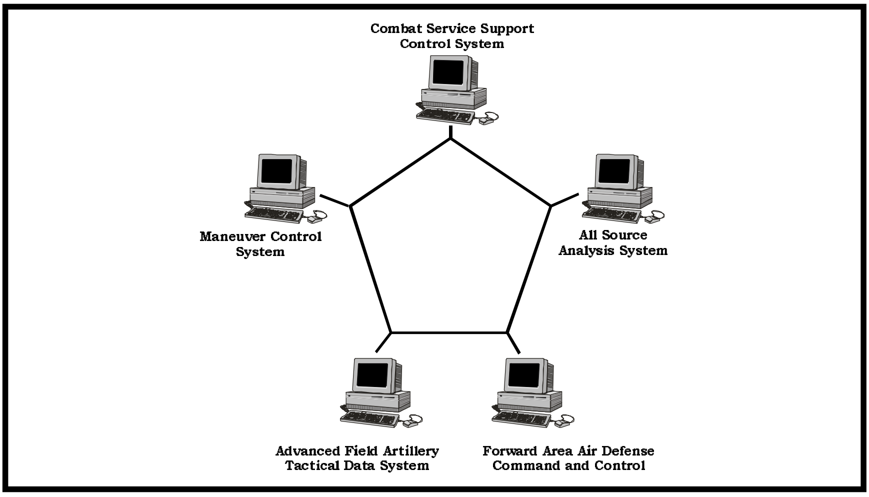

Figure 1. Major Components of the Army Tactical Command and Control System (ATCCS) Architecture.

Just prior to the actual DAWE, the commander directed that a wooden cabinet be built that could house six TV monitors.[4] On the screens, he wanted to view the ATCCS data. During the DAWE, the commander spent much of his time studying the monitors, as well, as a large paper map.

The commander no longer had to roam around the TOC, but there was still a problem. The TV monitors displayed data, not information. Additionally, by bypassing the staff that was supposed to filter and analyze the data for him, the commander now had to perform that task himself. The array of TV monitors actually increased the cognitive workload, even though he no longer had to physically move around the TOC.

Observation #3 (Creating Situational Awareness).

During SIMEX 1, not everyone in the TOC appeared to understand what was happening or what the commander was trying to accomplish in the tactical scenario. The staff did not have situational awareness. To correct the situation, before the DAWE, the commander procured and installed a high quality sound system that could drown out all other noise in the TOC.[5] During the DAWE, a few times a day, he explained to everyone in the TOC what was happening and what he was planning to do next. Although innovative, his solution bypassed not only his senior staff officers, but also all the technology in the TOC.

One might draw the conclusion from these three observations that the commander lacked the skill necessary to command a brigade equipped with the latest technology. On the other hand, the actions of the commander can be interpreted as providing creative solutions to problems that arose when the brigade was given technology that was less than optimal in its design. We presume the latter explanation, but do not view the adaptations implemented by the commander as suitable.

The large amount of data, coupled with insufficient technological tools to process it, resulted in staff officers delivering raw data to the commander. The commander's response was to attempt streamlining the process by centralizing the data. By doing so, the commander made his decisionmaking process more difficult because he was then required to perform both analytical and reasoning tasks.

(Additionally, the cumbersome displays tethered the commander to the TOC and made its displacement problematic.) The technology was poorly designed because it was not compatible with our doctrine, our organizational procedures, or the way that humans process data and make decisions. The following section provides results of a review of the literature on decisionmaking and the processes that lead up to it.

DECISIONMAKING AND CONTRIBUTING PSYCHOLOGICAL PROCESSES

Decisionmaking. There are three general theoretical approaches to decisionmaking that relate well to the methods found in Army doctrine. The first approach is based on *rational models* of *decisionmaking.* These models describe how we ought to make decisions. Researchers eventually learned that most people didn't follow rational models in decisionmaking tasks. Instead, it became clear that subjects were systematically influenced to make decisions that were less than optimal. As a result, researchers developed *descriptive* models of decisionmaking. These models describe how subjects were influenced by *heuristics* and *biases* to make decisions.

Decisionmaking research that led to the normative and descriptive models often was conducted in laboratory settings. Laboratory subjects were not confronted with the dynamics of the real world, nor would they have to implement and live with the decisions they made. Many researchers began to investigate how decisions were made outside the laboratory by practitioners engaged in meaningful activities. These studies led to the naturalistic models of decisionmaking. We will now discuss the three models in greater detail and then relate them to current doctrinal descriptions of decisionmaking.

Rational Models of Decisionmaking. Two roles are attributed to rational models: *normative* and *prescriptive.*[6] Normative models describe the choices of a hypothetical, ideal decisionmaker. Such a decisionmaker would be both omniscient and omnipotent. Prescriptive means that there is only one true rational choice. By systematically applying the rational model, a decisionmaker will be able to identify the correct choice.

Howard Raiffa discusses decisionmaking tasks by using the language of decision analysis. According to him, there are several steps in identifying the best outcome.[7] Figure 2 depicts a simple decision tree illustrating the decision analysis method. Assume a commander must select a course of action for an upcoming mission. The staff has developed three options. The commander realizes that the best course of action is dependent upon what the enemy decides to do. According to decision analysis, there are four steps that should be followed.

First, *list the events that you expect to occur*.[8] Events are of two types: *choices and chances*. A choice event, depicted as a square, represents a decision that must be made between two or more alternatives. A chance event, depicted as a

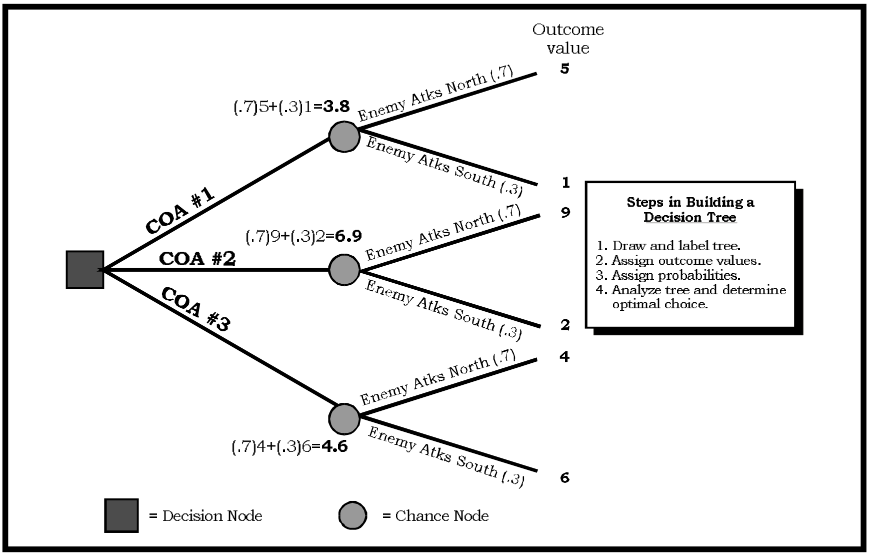

Figure 2. Decision Tree Depicting the Rational Decisionmaking Model for a Commander prior to the Onset of Hostilities.

circle, describes all possible alternatives in an uncertain environment. A chance event differs from a choice event in that the decisionmaker has no control over the outcome. In Figure 2, enemy activity illustrates a chance event. The enemy may decide to press the attack to the north or to the south.

Second, *list the value of the possible outcomes*.[9] The criteria for assigning values are at the discretion of the decisionmaker. The commander might use criteria such as speed, accuracy, number of lives lost, or amount of equipment damaged. Outcomes can be actual figures (i.e., 35 soldiers killed in action (KIA)) or based on a relative scale (i.e., 10 = most desirable outcome; 1 = least desirable outcome).

Third, *list the probabilities of chance events*.[10] Total probability for all the branches originating from a node must total to 1.0. Determining the probabilities of how the enemy will attack into the sector can be a difficult task. The difficulty stems from the inherent uncertainty of the battlefield. Commanders may be able to reduce uncertainty but they will not be able to eliminate it.

Fourth, *analyze the tree and determine the optimal choice*.[11] Beginning at the right side of the tree, the outcome value of each branch is multiplied by the probability of that outcome. These figures are summed for each Chance Node. In Figure 2, the Chance Nodes have values of 3.8, 6.9, and 4.6. At the Decision Node, the decisionmaker should select the COA that has yielded the highest value—in this case, COA #2.

As previously stated, the prescriptive nature of the Rational Decisionmaking Model suggests that there is only one possible correct solution to the problem. Techniques such as decision analysis are designed to lead the decisionmaker to the “right” answer. However, even in the simple example depicted, it should be obvious that there are several sources of error that could lead to an erroneous decision. Researchers realized that decisionmakers functioning in operational settings and, faced with non-trivial problems, often did not make the "right" decision. In operational environments, one may be unable to list all possible outcomes or to make definitive assessments of values or probabilities of outcomes. Consequently, researchers began to look at how decisions are *actually* made rather than how they *ought* to be made. This led to descriptive models of decisionmaking.

Descriptive Models of Decisionmaking. At approximately 9:12 PM (local time) on May 17, 1987, an Iraqi Mirage F-1 fired two Exocet missiles at the *USS Stark* while it was operating in the Persian Gulf.[12] Prior to the attack, the *Stark's* commander initiated action to track and establish contact with the aircraft. However, he never gave the order to bring the ship's weapon systems to bear on the aircraft. As a result, 37 sailors were lost, and the ship was severely damaged.

Fourteen months later, on July 3, 1988, an Iranian A-300 Airbus carrying 298 people climbed into the sky and turned to enter a commercial air corridor. The *USS Vincennes*, operating in the Persian Gulf, detected the aircraft and mistook it for a hostile warplane. The *Vincennes* fired on the Airbus, killing everyone on board.[13] During the ensuing investigation, the commander of the *Vincennes* indicated that the attack on the *Stark* had played a part in his decisionmaking process. His statement supports the idea that, in operational settings, decisions are not discrete events, and decisionmakers do not rely solely on rational models. The outcome of one decision will influence or bias subsequent decisions.

A. Tversky and D. Kahneman conducted extensive research into influences that lead decisionmakers to deviate from "*optimal*" outcomes.[14] These consistent deviations are actually patterns of error known as biases. The researchers demonstrated that biases arise when decisionmakers attempt to employ rules of thumb known as *heuristics*.

Heuristics are valuable because they help us conserve limited cognitive resources. While these cognitive shortcuts require fewer resources, they may rely on assumptions that ultimately prove to be invalid. The research of Tversky and Kahneman identified several heuristics and biases. Three of them are described below.

Availability Heuristic.[15] Decisionmakers may be influenced by their ability to recall or imagine events that are similar to the situation in which they now find themselves. The availability heuristic predicts that the recency or salience of their experiences will influence their assessment. The trend is to over-estimate the frequency of events and, therefore, ascribe inordinately high probabilities to these events.

Representativeness Heuristic.[16] Decisionmakers often rely on the extent to which the characteristics of a given situation *S* are prototypical of a parent population *P1*. If there is a close match, the decisionmaker is likely to decide situation *S* is an instance of population *P1*. This process seems reasonable until the base rates are considered. (A base rate tells us how often an event is likely to occur.[17] So, although the characteristics of situation S closely match population *P1*, this population is rarely present in the environment. Populations *P2* and *P3* contain only a few of the characteristics of *S* but they occur much more frequently than *P1*. The representativeness heuristic predicts that the decisionmaker would ignore the base rates and consider *S* to be an instance of *P1* because the characteristics are a close match.

Confirmation Bias.[18] Decisionmakers who have selected a course of action will interpret subsequent information in light of their decision. Therefore, new evidence that ought to disprove their decision is interpreted as supporting their decision.

Descriptive models explain how and why we deviate systematically from rational decisionmaking strategies.

Stated another way, descriptive models explain the consistent irrationality of decisionmakers. Like the descriptive models, naturalistic models also strive to accurately describe the decisionmaking process. However, naturalistic models stress that decisionmakers are rational. According to naturalistic models, decisions are grounded in, and influenced by, the operational setting in which they occur.

Naturalistic Models of Decisionmaking. Naturalistic models are recent additions to the decisionmaking domain. More accurately, perhaps, they represent a paradigm shift that led researchers out of the laboratory and into operational settings. In the laboratory, decisions tend to be studied as singular events. In operational settings, decisions are embedded in a complex process and are influenced by the events that precede the decisions, the organizational structure, and the environment. Researchers have identified eight characteristics of naturalistic decision settings.[19]

- Ill-Structured Problems.
- Uncertain, Dynamic Environments.
- Shifting, Ill-Defined, Competing Goals.
- Action/Feedback Loops.
- Time Stress.
- High Stakes.
- Multiple Players.
- Organizational Goals and Norms.

Several naturalistic decisionmaking models have been proposed in recent years. While all of them are based on the eight characteristics listed above, they vary in their approach to explaining how decisions are made in operational settings. One model that has been popular with military researchers is Gary Klein's Recognition Primed

Decision (RPD) Model.[20] Klein has used his model to explain decisionmaking in a number of diverse domains. He has studied, among others, fireground commanders, army tank commanders, critical care nurses, and tournament chess players.[21]

RPD emphasizes situation assessment and values expertise. Rather than searching for the optimal solution, RPD asserts that decisionmakers in naturalistic setting engage in “satisficing.” That is, they look for the first option that works rather than the best option. Decisionmakers consider alternatives serially. They engage in mental simulation to determine whether the alternative has merit. If the alternative does not fit the situation and cannot be tailored to fit, it is discarded and a new alternative is considered. There are four major steps in the RPD Model.

- *Experience the Situation*.[22] Is the situation familiar based on previous experiences? If not, the decisionmaker may need to gather more information or reassess the situation. (A platoon leader in Desert Storm observes an Iraqi armor formation.)

- *Recognition*.[23] The decisionmaker recognizes the situation as similar to one previously experienced. The match between the current and recalled situations can range from exact to only vaguely similar. In addition to recalling the situation, the decisionmaker also recalls the solution that was implemented. (The platoon leader recognizes the Iraqi armor formation as similar to an enemy formation he encountered at the National Training Center. He recalls that he used an arrowhead formation to penetrate the defensive position.)

- *Mental Simulation.*[24] The decisionmaker mentally simulates implementing the recalled solution in the current situation. If the decisionmaker cannot visualize any problems, the solution is implemented. However, if the decisionmaker visualizes problems in implementing the solution, the solution is modified. If, after modification, the mental simulation still reveals problems, the decisionmaker must recall the next closest match (step 2 above) and again mentally simulate implementing the solution. (The platoon leader mentally simulates his tanks attacking in an arrowhead formation. However, unlike the National Training Center (NTC), these positions are more dispersed and better fortified. He will have to request indirect fire to soften the enemy's defenses and direct his tank commanders to spread out the formation. He mentally walks through the attack with these modifications and is satisfied with the plan.)

- *Implementation*.[25] The feedback the decisionmaker receives from implementing the plan serves as input to the next decision that must be made.

Decisionmaking in Doctrine. FM 101-5 describes the seven-step military decisionmaking process (MDMP).[26] These steps include developing and comparing multiple courses of action. The commander then reviews each, evaluating their strengths and weaknesses, then selects the best one. This is the same process described in the Rational Decisionmaking section. The commander's decisions may be affected by heuristics and biases, depending on his experiences and expertise. The process applies most to the decisionmaking that occurs prior to implementing the plan.

After the plan is implemented, the commander must continue to make decisions because inevitably, unexpected events occur. In these instances, commanders are more likely to use naturalistic decisionmaking methods, such as Klein's RPD. Army doctrine (FM 101-5), however, does not acknowledge the fundamental differences between decisionmaking that occurs during the deliberate planning process and that which occurs after the plan is implemented. Instead, it suggests that time is the only factor that impacts on the process. It further states that, under time constraints, the same steps should be followed, but they should be modified. Command and General Staff College Student Text 100-9, while not doctrine, describes three decision processes under constrained conditions: combat decisionmaking; quick decisionmaking; and immediate action drills.[27] The latter two are performed exclusively by the commander and employ naturalistic methods.

Research literature indicates that decisionmakers in operational environments, described by the eight characteristics listed above (i.e., ill-structured problems; uncertain, dynamic environments; etc.), utilize naturalistic decision methods. In developing aids to assist commanders in their decision process, methods embedded in these aids should parallel methods used by actual decisionmakers. In this case, aids developed to assist commanders, in those decisions that must be made after the plan is implemented, should be based on naturalistic decisionmaking. Essential to naturalistic decisionmaking is having situational awareness.

Situational Awareness.

Anyone who has been exposed to the Army's modernization program is familiar with the term "situational awareness." Junior enlisted soldiers in digitized TOCs refer to it as "SA." Soldiers describe it as knowing where they are in relation to other friendly and enemy forces. Most researchers agree that better decisions are made if the decisionmaker has situational awareness. Stated differently, situational awareness is a precursor to good decisionmaking. Perhaps more important than determining *if* one has situational awareness is to determine how to get it.

Understanding *how* situational awareness is achieved is essential to building automated decision aids. Prior to building the aids, however, we must identify and understand the cognitive process that underlies or precedes the attainment of situational awareness. A well-designed aid should work in parallel with the cognitive process that leads to situational awareness. Therefore, the next section will discuss some of that process.

Cognitive Processes Requisite for Situational Awareness.

Our memory systems are generally thought to consist of three components: sensory memory, short term (or, working) memory, and long term memory.[28] Only a portion of the data sensed by our eyes and ears (as well as our other senses) is transferred to our working memory. We must focus on a data element for it to be transferred. All other data fades from our memory system within a few seconds. Data are transformed and reasoned about in our working memory. Relevant elements of long term memory (rules, procedures, schema, etc.) are transferred to working memory to help process the data. Unfortunately, the capacity of working memory is very limited (7 +/- 2 elements).[29] This capacity is even more restricted during periods of stress. These three memory components are integral to the processes that lead to decisionmaking.

Before commanders or staff officers can make appropriate decisions about events unfolding on the battlefield, they should have accurate situational awareness. They achieve this accurate view by analyzing information they have received and structuring it in meaningful ways. Before they can reason, the data must be transformed into information. Before it can be transformed, data must be detected. This process—reasoning, transformation, and detection—is affected by individual and environmental factors. Each are essential considerations in designing a system to assist decisionmakers on the battlefield.

Detection. Military decisionmakers work in a complex, dynamic, and data-rich environment. A data element will only be transferred from sensory memory to working memory if we focus on it.[30] What we focus on is a function of the characteristics of the stimulus (or data element), the environment, and the individual. How salient is the data element? Is it an auditory or visual stimulus? Is it sufficiently different (i.e., louder, brighter, etc.) from the surrounding environment to warrant our attention? Have we been primed by our long term memory to look for a particular data element? Are we tired, sick, or afraid? Well-designed decision aid displays must discriminate between important and unimportant data. Data deemed important must be presented in a manner that will facilitate detection.

Transformation. After data is detected and transferred to working memory, it must be transformed into meaningful information. Micah Endsley, a situational awareness researcher, refers to this process, where disjointed data elements are combined, as comprehension.[31] Perhaps a better term is *cognitive integration*. This latter term suggests that combining the data is not an amorphous process but a function of both situational context and the experience level of the decisionmaker. An experienced commander, whose subordinate units are about to engage the enemy in a frontal assault, will more than likely integrate different data elements (or integrate the same elements in different ways) compared to a novice commander whose subordinates are in a terrain-oriented defense. As described at the beginning of this chapter, battlefield automation systems display overwhelming amounts of data and provide little, if any, assistance to commanders in integrating the data. Decision aids should assist commanders in context-based integration so that they can free up limited information processing capacity to reason about the newly created information.

Reasoning. Fundamental to decisionmaking is the ability to reason about that which we perceive and that which we know. Much of this reasoning involves pattern matching. In his RPD model, Klein indicates that decisionmakers match patterns that have been constructed in working memory from what they have perceived with stored patterns.[32] Daniel Serfaty, *et al*., support Klein. “The expert’s memory consists of an array of ‘patterns,’ with information items grouped and indexed by their relevance for problem solving in the domain of expertise.”[33]

The literature reviewed indicates that we use rational, descriptive or naturalistic models when making decisions. Military decisionmakers, during battlefield operations, are more likely to use naturalistic models (i.e., Klein’s RPD Model). Many of these models stress that the decisionmakers should have situational awareness prior to making decisions. Situational awareness is constructed in our memory system by employing processes that include perception, integration, and pattern matching. Of these, there is little research on how military decisionmakers integrate low-level data in meaningful ways to form information that may be used in pattern matching.

Investigating Cognitive Integration.

The most reliable research methods are those that employ converging methods. A single type of research may lead to an answer, but not necessarily the truth. Sound research should be both valid and reliable. Findings will be even more robust if a variety of methods are used to surround—or converge on—the truth.[34] At least three methods may be used to converge on the role of cognitive integration in decisionmaking.

Single Scenario Simulations.

Many researchers make a distinction between expert and novice decisionmakers. Identifying those differences is useful in training novices and for developing aids to assist commanders in decisionmaking. Using a single scenario simulation is one method to discern these differences. The expert group might consist of former brigade commanders who have excelled in combat or at the NTC. The novice group might consist of combat arms officers of similar grades with no command experience. Each officer would be given an operations order, maps, overlays, and other products to embed themselves in the tactical scenario (i.e., movement to contact). The officers would then be presented with a series of situation reports. Each report would alter the situation in such a way as to require a decision. Presented with an array of low level data, they would be forced to select a subset of the data, integrate it, and use the newly constructed information to match patterns and make decisions. Measurements might include identifying which data were selected and why; how they were integrated; and what patterns the integrated data formed. We would expect the integration patterns of experts and novices would be significantly different.

Multiple Scenario Simulations.

Commanders are faced with a multitude of tactical scenarios—attack, defend, envelop, delay, etc. The set of low level data that is integrated in a movement to contact may differ from that in another tactical situation. It is important, therefore, to explore multiple scenarios to determine if there is a data set that is particularly relevant for a given scenario. In these simulations, expert commanders would be run through protocols similar to the one described above. However, each commander would be asked to participate in a variety of mission types. The data sets they use and the integration they performed would be compared across mission types.

Cross Domain Observations.

Researchers often make the mistake of concentrating on a single domain. Much can be learned from studying other domains. While other domains may appear to have little in common with military C2 on the surface, at theoretical or abstract levels they may be remarkably similar. The observations made and the lessons learned from other areas may be used to develop solutions to problems identified in the military domain. It is essential to identify characteristics of the cognitive integration task that define the domain and those that are merely present. For example, when defining characteristics in the tactical military arena, commanders might include data overload and virtually exclusive use of visual and auditory modalities. A less important characteristic might include the environment (tent or track versus office building). Once the defining characteristics are determined, other relevant domains can be identified and studied.

Results from these three studies will yield converging evidence that will surround the truth about cognitive integration and the role it plays in building situational awareness prior to decisionmaking. The next step is to apply the empirical results to the design of a soldier-centered decision aid. The final section of this paper describes some characteristics essential to such a system.

Considerations in Designing an Aid to Assist Commanders with Cognitive Integration.

Engineers or computer programmers who have no military experience develop most of the military's technological systems. The result is systems that are technology- or machine-centered. Donald Norman states,

> Today much of science and engineering takes a machine-centered view of the design of machines and, for that matter, the understanding of people. As a result, the technology that is intended to aid human cognition and enjoyment more often interferes and confuses than aids and clarifies.[35]

Technology-centered solutions often result in clumsy systems. These systems aid humans during periods of routine activity when the cognitive demand is minimal. However, when the system is stressed, due to increased demands or failure, the cognitive demands on the human escalate and the technology provides little relief.[36] The alternative to a technology-centered system is one that is soldier-centered. The focus is the soldier (including the physical and cognitive capabilities and limitations), the system in which he/she operates, the task to be performed, and the environment in which it is performed. The system is then built around the soldier (rather than building the system and then selecting and training soldiers to operate it).

This chapter described the methods and processes involved in decisionmaking. It also described the role of situational awareness and the cognitive processes that contribute to situational awareness, including cognitive integration. Finally, converging methods to study cognitive integration were described. These theories and the results of the proposed research should form the foundation of the system developed to aid commanders in cognitive integration. The system should be based on a naturalistic decisionmaking model; it should integrate low level data into patterns consistent with the context; and, it should facilitate the commander's ability to match the pattern of integrated information with patterns they have stored in memory. There are two approaches in the field of artificial intelligence (AI)that would be useful in developing this aid.

Intelligent Agents.

Most TOCs operate on a data-push system. Commanders, sitting at the top of the organizational hierarchy, are fed a continuous stream of data by staff officers. Most of the data is sent to the commander not because it is wanted or needed, but because staff officers feel obliged to keep their boss informed. The result is a commander overwhelmed with low-level data that he is unable to process or reason about. An alternative would be a pull system. System designers should develop intelligent agents or knowbots to search computer systems for low level data elements needed to build informational patterns the commander might use within the context of his mission.[37] When located, the data would be pulled up and integrated for the commander.

Case-Based Reasoning.

A veteran observer-controller (OC) at the NTC may have seen as many as 40 brigades rotate through the maneuver box. His experience affords him the opportunity to build a robust schema with respect to movement to contact operations. He has the ability to look at patterns of data and immediately discern what is happening because he can relate the current situation to a previous rotation in which a similar pattern emerged. When this type of cognitive processing is built into an AI system, it is known as case-based reasoning.[38] Such a tool may be used in comparing the patterns identified and confirmed by the commander, with previous patterns for similar scenarios stored in memory. The key to developing a successful aid is to build it to complement and support the cognitive activities of the decisionmaker.

Conclusion.

The Department of the Army continues to invest heavily in technologically-laden systems for the battlefields of the 21st century. The systems will increase the range of weapons, increase the speed at which soldiers and logistics move around the battlefield, and improve the ability to communicate with one another. Concomitant with these changes is a dramatic increase in the amount of raw data available to the commander. Current C2 systems are impressive in their ability to move data, but the tasks of analysis, synthesis, and integration are still left to humans. Commanders will not be able to intrude upon the enemy's decision cycle unless they have assistance. It is time for the Army to begin developing soldier-centered systems that complement human cognitive activity.[39] Such systems must be intuitive to operate.[40] The goal of developing soldier-centered systems begins with the deliberate, empirical investigation of human cognitive activity as it occurs in operational settings.[41] This may slow development and fielding of these systems, but ultimately it will result in increasingly effective commanders who make decisions in a more timely manner.

ENDNOTES - CHAPTER 6

1. Department of the Army, *Field Manual 100-5, Operations*, Washington, DC: U.S. Department of the Army, June 14, 1993, pp. 2-14.

2. Lawrence Shattuck, Douglas Mulbury, Justin Rueb, and Sehchang Hah, "The Impact of Technology on Tactical Decisionmaking: A Cognitive Evaluation," in *Proceedings of the Fifth Annual U.S. Army Research Laboratory/United States Military Academy Technical Symposium*, West Point, NY, 1997, p. 188.

3. *Ibid*., p. 189.

4. Lawrence Shattuck, Field observations made during the Division Advanced Warfighting Experiment, Fort Hood, TX, November 1997.

5. *Ibid*.

6. Lee Roy Beach and Raanan Lipshitz, "Why Classical Decision Theory is an Inappropriate Standard for Evaluating and Aiding Most Human Decisionmaking," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action: Models and Methods*, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 21.

7. Howard Raiffa, *Decision Analysis*, Random House: New York, 1968, p. x.

8. *Ibid*.

9. *Ibid*.

10. *Ibid*.

11. *Ibid*.

12. Gene I. Rochlin, *Trapped in the Net*, Princeton, NJ: Princeton University Press, 1997, p. 154.

13. Judith Orasanu and Eduardo Salas, "Team Decisionmaking in Compex Environments," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action:*

Models and Methods, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 327.

14. A. Tversky and D. Kahneman, "Judgement Under Uncertainty: Heuristics and Biases," *Science 185*, 1974, p. 1124.

15. Marvin S. Cohen, "Three Paradigms for Viewing Decision Biases," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action: Models and Methods*, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 37.

16. *Ibid*.

17. *Ibid*.

18. *Ibid*.

19. Judith Orasanu and Terry Connolly, "The Reinvention of Decisionmaking," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action: Models and Methods*, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 7.

20. Gary Klein, "The Recognition Primed Decision, RPD) Model: Looking Back, Looking Forward," in Caroline E. Zsambok and Gary Klein, eds., *Naturalistic Decisionmaking*, Mahwah, NJ: Lawrence Erlbaum Associates, 1997, p. 285.

21. Gary A. Klein, "A Recognition Primed Decision, RPD) Model of Rapid Decisionmaking," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action: Models and Methods*, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 144.

22. *Ibid*., 141.

23. *Ibid*.

24. *Ibid*.

25. *Ibid*.

26. Department of the Army, *Field Manual 101-5, Staff Organization and Operations*, Washington, DC: U.S. Department of the Army, May 31, 1997, p. 5-3.

27. U.S. Army Command and General Staff College, *The Tactical Decisionmaking Process*, Student Text 100-9, Fort Leavenworth, KS: U.S. Army Command and General Staff College, July 1993, pp. 1-4.

28. Rochlin, p. 109.

29. Mica R. Endsley, "Toward a Theory of Situation Awareness in Dynamic Systems," *Human Factors*, Vol. 37, No. 1, March 1995, p. 36.

30. Gary Klein, "Re: Another question," electronic mail message to Lawrence Shattuck, February 19, 1999.

31. Christopher D. Wickens, Sallie E. Gordon, and Yili Liu, *An Introduction to Human Factors Engineering*, New York: Addison Wesley Longman, Inc., 1998, p. 147.

32. G. A. Miller, "The Magic Number Seven Plus or Minus Two. Some Limits on Our Capacity for Processing Information," *Psychological Review*, Vol. 63, 1956, p. 81.

33. Endsley, p. 40.

34. *Ibid*., p. 37.

35. Gary A. Klein, "A Recognition Primed Decision (RPD) Model of Rapid Decisionmaking," in Gary A. Klein, Judith Orasanu, Roberta Calderwood, and Caroline Zsambok, eds., *Decisionmaking in Action: Models and Methods*, Norwood, NJ: Ablex Publishing Corporation, 1993, p. 141.

36. Daniel Serfaty, Jean MacMillan, Elliot E. Entin, and Eileen B. Entin, "The Decisionmaking Expertise of Battle Commanders," in Caroline E. Zsambok and Gary Klein, eds., *Naturalistic Decisionmaking*, Mahwah, NJ: Lawrence Erlbaum Associates, 1997, p. 235.

37. Elizabeth B.-N. Sanders and Susan Stuart, "The Role of User Research in Consumer Product Development," in Thomas G. O'Brien and Samuel G. Charlton, eds., *Handbook of Human Factors Testing and Evaluation*, Mahwah, NJ: Lawrence Erlbaum Associates, 1996, p. 270.

38. Donald A. Norman, *Things That Make Us Smart*, Reading, MA: Addison-Wesley Publishing Company, 1993, p. 9.

39. David D. Woods, Leila J. Johannesen, Richard I. Cook, and Nadine B. Sarter, *Behind Human Error: Cognitive Systems, Computers, and Hindsight*, Wright-Patterson Air Force Base, OH: Crew Systems Ergonomics Information Analysis Center, 1994, p. 114.

40. "Intelligent Software Agents," http://www.cs.umbc.edu/ agents/; Internet;accessed March 31, 1999.

41. "Case-Based Reasoning," http://www.ai-cbr.org/theindex.html; Internet.

ERRATA

Corrected Figure and Tables.

Page 12, Figure 4, Organizational Strata and Functional Domains.

Page 90, Table 1, Education Requirements for Military Officers.

Page 93, Table 2, Education Opportunities for New Officers.

ORGANIZATIONAL STRATA AND FUNCTIONAL DOMAINS

Stratum	Time span	Functional Domain
(vii) 4-star level	20 years	Systems (Strategic level) - unbounded environment, outward focus - create complex systems, envision future - build consensus, create culture
(vi) 3-star level	10 years	- oversee complex systems
(v) 2-star level	5 years	Organizational (Operational level) - exist within bounded open system - manage one complex system
(iv) Brigade CDR	2 years	- oversee operating sub-systems
(iii) Battalion CDR	1 year	Production (Tactical Level) - direct one operating sub-system - bounded within larger sub-system - face-to-face
(ii) Company CDR	3 months	- direct tasks
(i) Troops	<3 months	- perform tasks

Figure 4. Organizational Strata and Functional Domains.

TOPIC	Depth of Knowledge TIER 1	TIER 2	TIER 3
Computers and Information Technology	B	I	A
Software Applications	B	I	I
Programming Languages	F	B	A
Software Development	N	F	I
Networks and Telecommunications	F	I	A
Information System Intruder Tactics	F	B	A
Information Security	F	I	A
Computer System and Network Security	F	B	A
Information Assurance	N	F	I
Human-Computer Interaction	F	B	B
Satellite Communications Systems	F	I	I
Global Positioning Systems (GPS)	F	B	B
Wireless Communications	F	B	I
Communications Fundamentals	B	I	I
Electrical Engineering Fundamentals	F	B	B
Electronic Vulnerabilities	F	B	I
Strategic and Operational Intelligence	B	A	A
Information Operations Principles	B	I	I

Levels: N-None F-Familiarization B-Basic I-Intermediate A-Advanced

Table 1. Education Requirements for Military Officers.

TOPIC	Under-graduate Course	Distance Learning	Military Course
Computers and Information Technology	X		
Software Applications	X		
Programming Languages	X		
Software Development	X		
Networks and Telecommunications	X		X
Information System Intruder Tactics	X	X	X
Information Security	X		X
Computer System and Network Security	X		X
Information assurance			X
Human-Computer Interaction	X		X
Satellite Communications Systems		X	X
Global Positioning Systems		X	X
Wireless Communications		X	X
Communications Fundamentals	X	X	X
Electrical Engineering Fundamentals	X	X	
Electronic Vulnerabilities		X	X
Strategic and Operational Intelligence		X	X
Information Operations Principles		X	X

Table 2. Education Opportunities for New Officers.