Command and Control at the Crossroads

THOMAS J. CZERWINSKI

From *Parameters*, Autumn 1996, pp. 121-132. .

> I shall be telling this with a sigh,
> Somewhere ages and ages hence:
> Two roads diverged in a wood, and I--
> I took the road less travelled by,
> And that has made all the difference.
>
> -- Robert Frost
> *The Road Not Taken*, st. 4.

This article elaborates on the methods of command developed by Martin van Creveld in his classic *Command in War* (1985), with extensions to both definitions and framework. It then projects for each method its analogue in contemporary command and control (C2) system developments. Each of these systems is then evaluated against Van Creveld's "iron rules" for increasing the performance of command.

The second test in this article explores each command method in terms of linear and nonlinear dynamics, both as art and technology. Finally, the command methods are evaluated in accordance with the principles of the field of safety engineering. These three tests together provide a framework that complements, reinforces, and extends Van Creveld's original theses.

American command practice is at a crossroads. Which path or emphasis it takes is of vital concern. These tests suggest that the method least considered and least formulated is, nevertheless, the most appropriate, most of the time.

Command Methodologies and their Information Age Equivalents

The function of command is carried out by direction, by plan, or by influence. While not mutually exclusive and often employed in combination, these methods, or archetypes, are dominant.[1] While technological advances have affected these methods incrementally over time, the effect of the Information Age is such that all three methods are for the first time embodied in contending automated information system developments. 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.

Each of these three methods offers a response to the pervasive underlying commander's quandary--uncertainty and insufficient information. By insufficient, however, Van Creveld does not mean lacking in quantity. Rather, he speaks to getting the necessary quality of information in the right form, at the right place, at the right time. He describes information that does not conform to that standard, including information overload, as an "information pathology," a graphic term which unfortunately has not conceptually been pursued further. As a penetrating RAND study noted in 1989, "Commanders' information needs are rarely specific pieces of data but are instead highly variable and human-intensive elements."[2] Thus, C2 requirements are not information-intensive, but information-sensitive. Checklist-generated data might also be called "cyber-junk."

Each method of command grapples with uncertainty in its own way. In the absence of uncertainty the act of command would be a simple one, if not irrelevant. But a commander's work is virtually always complicated by uncertainty, and the three styles of command address that uncertainty in different ways. Generally, the directing commander attempts to *prioritize* uncertainty, the command-by-plan commander seeks to *centralize* uncertainty, and the influencing commander prefers to *distribute* uncertainty.

Command-by-Direction

Command-by-direction is not only the oldest of methods, but virtually the sole method until the middle of the 18th century, and largely in disfavor since. The earliest commanders learned that even if they could find a vantage point from which they could see the entire battle, distances prevented them from playing any role other than observer. They were required accordingly to adopt one of two compromise approaches to command. In the first approach, they could attach themselves to one element of the force, judging it to be the decisive one. They thereby directed some of their forces all of the time, while depending on tenuous, if any, communications with other units. The other approach involved the commander moving from unit to unit as the situation seemed to warrant, thereby directing some or all of the forces some of the time. Both variants of command-by-direction, however, fell short of the commander's dream--to direct dynamically all of the forces all of the time. To do so has been--until recently, with the maturation of the Information Age--all but impossible.

In recognition of the difficulties of command-by-direction, the Army had been evolving toward a concept of command-by-plan--not, however, without reservations. The demand to lessen dependence on command-by-plan was recognized in the Gulf War: "Schwarzkopf intuitively rejected a battle by formula of the sort taught at the Army schools and practiced by US forces in NATO. He had seen how poorly the Army had performed in Grenada in trying to conduct operations from a checklist."[3]

The Army's digitized battlefield is intended to equip commanders with dynamic,

near real-time synchronization[4] capabilities. That battlefield requires massively increased information processing capabilities, described as "the most complex mobile router-based computerized network that the world has ever seen," and as "deploying a network larger than the one managed by AT&T." A reinforced brigade will field more than 1200 computers. Every tank and Bradley fighting vehicle would be so equipped, as well as a number of other vehicles and dismounted troops.[5]

The basic technological tenets of the Army's Force XXI concept are conducive to returning command-by-direction to the repertoire of the US Army commander after an absence of 250 years. In simulations, the information processing capabilities of Force XXI have "demonstrated that modernized information operations improve the commander's ability to synchronize operations in his battlespace . . . . [The] commander's situational awareness and the staff's shared picture of the battle [have] allowed the commander to make more accurate and rapid decisions than nondigitized counterparts."[6]

Force XXI embodies the first of the "iron rules" for improving the performance of command formulated by Van Creveld: "Confronted with a task and having less information than is needed to perform the task [a military] organization may . . . increase its information processing capability . . . [which] will lead to the multiplication of communications channels and to an increase in the size and complexity of the central directing organ." Van Creveld's study of command convinces him "that this approach is inadequate and stand[s] in danger of being self-defeating."[7] At another level of analysis, the Army's approach implies that command forms which attempt to *prioritize* uncertainty do not lend themselves to success.

Force XXI is an effort to offset command-by-plan with the more proactive and interventionist element of Information Age command-by-direction. Most Army commanders seeing the opportunity to be a boxer, as well as an architect, cannot refuse the opening offered by the promise of modern information technology.

Command-by-Plan

Two hundred and fifty years ago, Frederick the Great tried to break out of the limitations imposed in commanding by direction. He resorted to command-by-plan, thereby opting for comprehensiveness over dynamism. His efforts consisted of "trying to plan every move in advance, relying on highly trained troops and strict discipline to carry out the scheme as ordered."[8] Frederick's use of a plan to command all of the forces all of the time met with mixed success.

Nevertheless, the highly centralized command-by-plan formula evolved into the norm for the command of modern military forces. This has been accompanied by much experimentation and adaptation in doctrine and systems to support the method, and in training, equipping, and organizing the force to operate according

to plan. However, as with all plan regimes, increased complexity has kept pace with heightened competency. The reason is that command-by-plan inherently fights the disorderly nature of war as much as the adversary. It is a futile quest to will order upon chaos. The contemporary C2 equivalents for this method are the various forms of plan regimes under the broad designation of precision warfare. Foremost among these is the "System of Systems" concept based upon achievement of dominant battlespace awareness, or knowledge,[9] and the Air Force's air campaign methods and supporting systems.

The method is characterized by trading flexibility for focus in order to concentrate on identifying and neutralizing centers of gravity, or target sets, in a campaign context. Operating exclusively at the strategic and operational levels of war, it reduces information requirements by focusing on perceived centers of gravity and by honing the associated target lists into prioritized and--increasingly--synchronized and simultaneous operations. Essentially, both the organization and tasks are designed to operate with less information in total, notwithstanding the considerable complexities in achieving targeted expectations.

The argument is made that the second of Van Creveld's iron rules for increasing the performance of command applies to command-by-plan: "drastic simplification of the organization so as to enable it to operate with less information." As with the first rule's applicability to command-by-direction, this second rule tends to make command-by-plan "inadequate and . . . in danger of being self-defeating." In other words, command forms that *centralize* uncertainty do not lend themselves to success.[10]

Command-by-Influence

A hallmark of command-by-influence is the use of *auftragstaktik*, or "mission-type orders," especially as developed by the Germans in the latter stages of World War I and refined in World War II. In this method of command 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, considering it as "inevitable and even, insofar as it affect[s] the enemy as well, desirable."[11] 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.

Confronted with insufficient information to carry out a task, Van Creveld's third rule states that a military organization

> may react by designing the organization, or indeed the task itself, to operate on the basis of less information, relying on the division of the

> task into various parts and to the establishment of forces capable of dealing with each of the parts separately on a semi-independent basis. It is a central theme . . . through every change . . . [and] technological development that the third one will remain superior . . . in virtually every case.

This suggests that only command forms which *distribute* uncertainty are likely to be more or less consistently successful.

The third rule is embodied in command-by-influence. Yet despite the promise of this form of command, the dim outlines of its information system equivalent are only now starting to take shape, and then largely on a theoretical plane. Inexplicably, the most promising method for future command (as evaluated by Van Creveld) has fallen behind competing command forms that exhibit no superior characteristics in terms of realization and resources.

How the Command Methods Relate to the Tofflers' Third Wave

Command-by-direction and command-by-plan are supported by the capabilities of the technologies at the surface of the Third Wave, the so-called Information Age. Command-by-influence, however, has its source at the deepest level of the Third Wave: post-Newtonian science, or nonlinear dynamics, exemplified by theories of chaos and complexity. Most readers will be familiar with the concept of the Information Age, with Silicon Valley, the Internet, and the writings of Peter Drucker and of Heidi and Alvin Toffler. The Revolution in Military Affairs debate has largely been shaped by the technology of this age, by the pervasive rush of chip advances, computer utilities, and an increasingly internetted world. In fact, the Information Age and the Third Wave are generally synonymous to both the public and the military.

Nothing could be farther from the truth. The Third Wave is a complex, contentious place.

Awareness that nonlinear dynamics is at the base of the Third Wave is low in comparison to the broad general understanding of the omnipresent technology that otherwise helps to define it. This science is in its infancy, and it is more about biology than about physics. It is only some 20 years old, and required the computer revolution for its discovery. Nonlinear dynamics has its own jargon: phase states, bifurcations, fractals, periodic and strange attractors, emergence, criticality, and path-dependence.[12] Its message, however, is post-Newtonian.

By Newtonian, we mean the arrangement of nature--life and its complications--to be a linear phenomenon: where inputs are proportional to outputs; prediction is facilitated by careful planning; success is pursued by detailed monitoring and control; and a premium is placed upon reductionism, rewarding those who excel in reductionist processes. Reductionist analysis consists of taking large, complex

problems, and reducing them to manageable chunks. Reductionism still works where effective linearity holds sway, such as in some areas of engineering and technology.

By post-Newtonian, we mean that the arrangement of nature--life and its complications, such as warfare--is nonlinear. It defines activities in which inputs and outputs are not proportional; where phenomena are *unpredictable, but within bounds, self-organizing*; where unpredictability frustrates planning; where solution as self-organization defeats control; and where a premium is placed on holistic, intuitive processes. It rewards those who excel in the calculus of bounds[13] as the variable of management and command.

By denying the efficacy of prediction and control, post-Newtonian science ratifies command-by-influence and its principles. In command-by- direction and command-by-plan, the emphasis is placed upon technology insertion, innovation, and training the force to take advantage of increased capabilities. In command-by-influence, the emphasis is on training and educating the force to exercise initiative to exploit opportunities, guided by the commander's intent, only secondarily dependent on technology. The difference involves a difficult transition from the ingrained habit of deductive, reductionist thought to more holistic, inductive processes, in which intuition is elevated and powers of pattern recognition are prized. Intuition in this sense means not so much instinct as experiential training and education and firsthand experience. It offers the opportunity to infuse lower echelons with both the confidence and competence to engage in semi-autonomous action.

What a Command-by-Influence System Might Look Like

The outline of a command-by-influence system retains its historic characteristics, foremost of which are "mission-type orders" and self-contained units capable of semiautonomous action, complemented by the following four traits:

- *Recognition that the native mode of command is an image, or mental model, not voice or text.* Further, "the meaning of any information gained by the commander is driven by the image that frames it, and the value of that information is determined by the manner in which it fits into the image . . . . [Therefore] a major purpose of communications in the command-and-control process lies in the sharing of images."[14]
- *Advances in synthetic environment technology, especially thin panel imagery displays, to transmit the intent of the commander as a symbolic representation of the mental image.* This symbology, in the form of standard and personalized icons, requires extensive investigation and experimentation. This may lead us into the field of semiotics, a "science which analyzes signs and symbols and puts them in correspondence with a particular meaning."[15]
- *The provision of subtle "directed telescopes."* This technique employs the

selective and careful use of trusted and attuned subordinates to act as the commander's eyes and ears, to observe and report directly, by-passing channels. This technique is especially useful for determining intangibles, such as morale.[16] Sadly, this historic practice no longer is found even as an option in current doctrine.

- *The introduction of the principles of post-Newtonian science, and reducing the use of voice and text in the battlespace.* This characteristic can be waived as necessary to raise alarms should circumstances require it.

The display of mental images, the native mode of command, through synthetic environment technology produces a decision loop bordering on the instantaneous. A combination of standard and personalized icons and frames displayed on thin-panel screens, representing the commander's intent, results in a superior decision cycle, both in elapsed time and integrity. One is virtually reading the commander's mind (with imagery feedback loops provided). In the command and control process:

> Control is provided by feedback--the continuous flow of information about the unfolding situation [or better, the changed situation based on subordinate initiative] returning to the commander--which allows the commander to adjust and modify command action as needed." Importantly, "control is not strictly something which seniors impose on subordinates; rather, the entire system gains control . . . based on feedback about the changing situation. The result is a mutually supporting system of give and take in which complementary commanding and controlling forces interact to ensure that the force as a whole can adapt continuously to changing requirements.[17]

This description is consistent with the behavior of any complex adaptive system, the nonlinear form of post-Newtonian science.

The introduction of nonlinearity is justified by, consistent with, and compelled by the fact that seemingly random turbulence, such as the chaos inherent to the battlespace, or in white water rapids, has been shown to be *unpredictable, but within bounds, self-organizing*. The commander's mental images, representing his intent, or concept of operations, and captured in synthetic environments, constitute (a) those bounds and (b) the means by which deliberately stimulated but controlled chaos is inserted to achieve command-by-influence. The subordinate, freed from the prescriptive qualities of voice and text, is cast in the role of interpreter of the image, which together with his local situational awareness, provides the latitude for slightly chaotic but self-organizing effects to take hold. The result is the breaking up of Western man's acculturated Newtonian pattern of linear cause-and-effect processes, and their predictability. While our adversaries in Vietnam lacked mobility, they enhanced their agility by reading our linear responses. As a result, they were the ambushers more often than the ambushees. Despite Delta Force's effort to mask procedures in Somalia, patterns

were detected by discerning opponents. The mechanistic intrusion of slightly chaotic effects, bounded by the commander's intent imbedded in symbolic imagery, promises to allow us "to do mountains, jungles, and cities." It will even the odds in low-intensity conflicts.

Further, limitations on the use of voice and text are not only necessary in order to achieve a slightly chaotic condition, but are vital to survivability on the battlefield. Electromagnetic signatures invite corruption, disruption, and destruction by the adversary and need to be minimized to protect both C2 and the force. Finally, this command environment acts as a barrier, or at least an obstacle, to the ever-present potential for micromanagement. The dysfunctional conduct of the in-theater operational, and even tactical, levels of war as practiced in Vietnam would be rendered difficult, if not impossible, by breaking the prescriptive qualities of command dependent upon voice and text.

The Technology and Implications of Chaos

Laboratory experiments have demonstrated practical ways to synchronize conventional message traffic with chaotic signals. This appears to have potential for battlefield C2 radio applications where data is perishable, or transient, due to the speed and fluidity of conditions. The technology of chaos has the virtues of being light, compact, cheap, and simple. The technology is not based on expensive and intricate software and computers, but on relatively simple electronic circuits--resistors, inductors, diodes, and so on.[18] For example, a message signal can have chaos added to it at the point of transmission. At the receiving end, the chaos can be stripped away, leaving the original message. Along the transmission path the signal is ostensibly nothing but random noise. The application of this technique, with low probability of intercept and unscrambling, has potential down to the smallest unit level, especially for dismounted troops. Chaos can also be controlled. On the battlefield, this capability allows chaotic signals to form messages. This can be accomplished by having each pattern of chaos represent an alphanumeric value or more global representations, such as alarms.

When compared to the other command forms, an inherent weakness in command-by-influence is its potential for incurring friendly casualties. In contrast, the Army's Force XXI command-by-direction proposes to incorporate the "knowledge of where everyone is on the battlefield, which will prevent fratricide."[19] This weakness of command-by-influence could be offset by the provision of strong Identification-Friend or Foe (IFF) capabilities. Perhaps the greatest potential of chaotic signal technology lies in preventing friendly casualties by breaking the barriers to affordable and portable electronic protection from "blue on blue" engagement. Troops and vehicles emanating a unique chaotic signal generated by simple circuitry may be able to operate with less fear of friendly fire or detection by the adversary than has ever been possible.

Chaos-based technology is still in its infancy. Closely allied to the technology of chaos are certain analytical computer tools derived from the science of complexity, which deal with the calculus of bounds. These include genetic algorithms, cellular automata, and simulated annealing programs.[20] These contributions may be universally useful, regardless of the command method, but appear to be especially pertinent to command-by-influence, where the behavioral, analytical, and technological attributes of nonlinearity intersect.

The Command Methods Through the Lens of Safety Engineering

Another way to view the command forms, suggested by Charles Perrow, is from the perspective of the principles of safety engineering. Fundamental to this discipline is the classification of systems by certain properties, and the assigning of risk values and risk management measures according to the characteristics of the properties. We can, in any system, classify the parts and their linkages as tight or loose. "Tight coupling refers to agents that are strongly dependent upon one another. Disturbances in the system may be highly correlated to each other when the system is tightly coupled. Time- dependent processes, with little give or slack, characterize tightly coupled systems. Additionally, disturbances tend to propagate throughout a tightly coupled system."[21] Obviously, in the case of loosely coupled agents or parts of the system, these attributes are reversed, or perhaps relaxed.

In addition to the coupling characteristics of the parts of a system, the parts can be distinguished by whether their interactions are linear or complex. "Linear interactions are those in expected and familiar production or maintenance sequences, and those that are quite visible even if unplanned. Complex interactions are those of unfamiliar sequences or unplanned and unexpected sequences, and either not visible or immediately comprehensible."[22] The result is that systems can be classified as one of four combinations: tightly linear, tightly complex, loosely linear, or loosely complex.

<table>
<tr><td></td><td></td><td colspan="2">Coupling Characteristics</td></tr>
<tr><td></td><td></td><td>Tight</td><td>Loose</td></tr>
<tr><td rowspan="2">Interactions of Parts</td><td>Linear</td><td>Command by Plan
Centralized control
. System of Systems
. Air Tasking Order</td><td>Either centralized
or decentralized
. Some combat support functions</td></tr>
<tr><td>Complex</td><td>Command by Direction
Neither centralized
nor decentralized
(These systems are at risk.)</td><td>Command by Influence
Decentralized</td></tr>
</table>

		. Force XXI?	

Figure 1. Consolidated Analysis of Safety Engineering of Proposed Concepts.

It seems clear that command-by-plan, exemplified by the "System of Systems" and the Air Tasking Order, is tightly linear. "Tight linearity" is at the core of plan regimes, where actions are designed to be separated, yet related enough to detect attributed outcomes, and where the outcomes are normally expected to be proportional. It also seems clear that command-by-influence is inherently a system exhibiting loosely complex characteristics. With respect to command-by-direction, however, the case is less clear. It appears that the form may fall into the category of tightly complex systems. These systems are, in safety engineering terms, those containing the highest risk.

According to Perrow, "complex but loosely coupled systems are best decentralized [*influence*]; linear and tightly coupled systems are best centralized [*plan*]; linear and loosely coupled systems can be either [*certain combat support functions*]; but complex and tightly coupled systems [*direction*?] can be neither--the requirements for handling failures in these systems are contradictory." Again, "the organizations at risk are the complexly interactive, tightly coupled ones."[23]

If Force XXI's digitized battlefield is, indeed, a tightly complex system, it would exhibit system characteristics similar to those found in "nuclear plants, nuclear weapon systems, chemical plants, space missions, and DNA," and,

> For the interactively complex and tightly coupled system the demands are inconsistent. Because of the complexity, they are best decentralized; because of the tight coupling, they are best centralized. While some mix may be possible, and is sometimes tried (handle small duties on your own, but execute orders from on high for serious matters), this appears to be difficult for systems that are reasonably complex and tightly coupled, and perhaps impossible for those that are highly complex and tightly coupled.[24]

Whether these conditions exist, and their extent, can be verified only through modeling, simulations, and exercises. Nevertheless, there is the possibility that even with the capabilities of Information Age technologies, the return of full-fledged command-by-direction to the battlefield may be beyond our reach.

Other Issues Related to the Methods of Command

While they are beyond the scope of this paper, at least two other areas deserve further examination. The first is the specific relationships between Information Warfare and each of the command methods. The Information Warfare component on the battlefield is designated as Command and Control Warfare (C2W). C2W provides for the protection of command and control, as well as for

attacking the opponent's C2. C2W is defined as "the integrated use of operations security, military deception, psychological operations, electronic warfare and physical destruction, mutually supported by intelligence, to deny information to, influence, degrade or destroy adversary C2 capabilities, while protecting friendly C2 capabilities against such actions."[25] It is likely that with each of the three command methods analyzed above, the interaction between C2W and C2 will differ in emphasis, challenge, and perhaps utility.

The other area deserving of consideration is the relationship between each method of command and joint doctrine. Joint doctrine tends to be written for the context of command-by-plan which has, after all, dominated warfare for 250 years. It therefore presumes, for example, the existence of linear and tightly coupled systems, and other conditions of the command-by-plan environment. This represents perhaps an unintended, yet effective bias. Joint doctrine will somehow have to strike a delicate balance--on the one hand, authoritative enough to promote interservice synergy, while on the other, remaining contingent enough to encourage continual innovation.

Conclusion

The timelessness of Clausewitz will inevitably be revitalized by the incorporation of post-Newtonian scientific terminology, replacing that of the prevailing science of Clausewitz's own era--the branch of physics known as statics. It will be more biological. "Centers of gravity," "friction," and "mass" will give way to nonlinear concepts, including those rooted in thermodynamics. The commanders of tomorrow will wrestle with "entropy" and "phase states," while grasping "periodic and strange attractors" as they search for "fractals" and "emergence."[26]

To use whitewater rapids as a metaphor for the chaotic battlespace, the *directing* commander applies his skills and sources to traverse the turbulence through a pragmatic mix of direct address and portage. The *plan* commander builds a dam to elevate the water level to submerge the rocks. The *influencing*, nonlinear commander, like the kayaker, conquers whitewater by "reading" the turbulence, immersing himself in it, and combining technology, organization, and concept to exploit it. If turbulent times await us, which method of command will best prepare us to cope with them?

NOTES

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1. Much of the material in this section is based upon chapters 2-5 of Martin van Creveld's *Command in War* (Cambridge, Mass.: Harvard Univ. Press, 1985).

2. James P. Kahan, D. Robert Worley, and Cathleen Stasz, *Understanding Commander's Information Needs* (Santa Monica, Calif.: RAND, June 1989), p. v.

3. Bernard E. Trainor, "Schwarzkopf the General," *Proceedings*, May 1994, p. 110.

4. "Synchronization is arranging activities in time and space to mass at the decisive point." US Army, Field Manual 100-5, *Fighting Future Wars* (Washington: HQDA, 14 June 1993), p. 2-8.

5. "Largest computer network to power Task Force XXI," *Pentagram*, 15 March 1996, p. 3.

6. US Army, Office of the Chief of Staff, *Force XXI: America's Army of the 21st Century* (Ft. Monroe, Va.: Louisiana Maneuvers Task Force, 15 January 1995).

7. Van Creveld, p. 269.

8. Van Creveld, p. 53.

9. William A. Owens, "The Emerging System of Systems," *Proceedings*, May 1995, pp. 35-39.

10. This formulation by no means is meant to denigrate planning, or to relegate it to some subordinate status. The relationship between planning and command-by-plan was furnished by Dwight Eisenhower: "In preparing for battle I have always found that plans are useless, but planning is indispensable." (Quoted by Richard Nixon in "Khrushchev," *Six Crises* [Garden City, N.J.: Doubleday, 1962].) Planning is required in order to accommodate surprise. Planning is a means for coping. Planning is essential to such basically linear elements of warfare as certain combat support activities. However, the process of devising a plan should always be recognized as a provisional exercise. The object is not to devise a script, but to ensure that processes exist through which commanders and their staffs can respond to unanticipated opportunities or setbacks during a campaign, battle, or skirmish.

11. Van Creveld, p. 188.

12. There are a number of useful introductions to nonlinear dynamics, the variable being the degree of mathematical literacy required. At the low end, see Uri Merry, *Coping with Uncertainty: Insights from the New Sciences of Chaos, Self-Organization, and Complexity* (Westport, Conn.: Praeger, 1995), and P. Coveney and R. Highfield, *Frontiers of Complexity: The Search for Order in a Chaotic World* (Fawcett Columbine, 1995). An exploration of chaos theory and its application to warfare is to be found in Glenn E. James, *Chaos Theory: The Essentials for Military Applications* (Newport, R.I.: Naval War College, 21 February 1995). An example of the application of complexity theory to warfare is found in Steven M. Rinaldi, *Beyond the Industrial Web: Economic Synergies and Targeting Methodologies*

(Maxwell AFB, Ala.: Air Univ. Press, April 1995), especially chapter 2.

13. By "calculus of bounds" is meant the unfinished business of how one exercises command, or management, in a nonlinear environment where planning and control mechanisms are considered marginalized, if not negative. This leaves the "bounds" as the major actionable variable. Several means and aids are suggested in this article. In the private sector, a measure of success has been realized through a calculus consisting of corporate vision statements (intent) and worker empowerment (lowered decision thresholds), thereby increasing productivity. Nevertheless, the definition and establishment of "bounds" may represent the 21st century's greatest challenge--from theology to ideology to paychecks, much less warfare.

14. Kahan et al., p. vi.

15. Alex Meystel, *Semiotic Modeling and Situation Analysis: An Introduction* (Bala Cynwyd, Pa.: AdRem, 1995), p. 45.

16. Napoleon, Montgomery, and Patton are cited as adept practitioners of the "directed telescope" by Gary B. Griffin, *The Directed Telescope: A Traditional Element of Effective Command* (Ft. Leavenworth, Kans.: US Army Command and General Staff College, Combat Studies Institute, 20 May 1985). For the misuse of telescopes in Vietnam, see Van Creveld, pp. 251-58.

17. Marine Corps Concept Paper (MCCP) 6, "Command and Control" (draft) (Washington: Headquarters, USMC, 12 December 1995), pp. 43-46.

18. William L. Ditto and Louis M. Pecora, "Mastering Chaos," *Scientific American*, August 1993, pp. 78-84.

19. *Pentagram,* p. 3.

20. Steven M. Rinaldi, *Beyond the Industrial Web: Economic Synergies and Targeting Methodologies* (Maxwell AFB, Ala.: School of Advanced Airpower Studies, April 1995).

21. Rinaldi, pp. 8-9.

22. Charles Perrow, *Normal Accidents: Living with High Risk Technologies* (New York: Basic Books, 1984), p. 78.

23. Ibid., p. 331.

24. Ibid., p. 334.

25. Memorandum of Policy No. 30. *Command and Control Warfare* (Washington: Chairman of the Joint Chiefs of Staff, 8 March 1993), p. 2.

26. "Clausewitz displays an intuition concerning war that we can better comprehend with terms and concepts newly available to us: *On War* is suffused with the understanding that every war is inherently a nonlinear phenomenon." Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security,* 17 (Winter 1992-93), 61.

Thomas J. Czerwinski is on the faculty of the School of Information Warfare and Strategy of the National Defense University, in Washington, D.C. A political scientist (M.A., Wisconsin), he has specialized in systems analysis. As an enlisted infantryman, he served in both the Marine Corps and the Army. His *Third Wave: What the Tofflers Never Told You,* was recently published by the National Defense University as a *Strategic Forum* paper.

Reviewed 21 August 1996. Please send comments or corrections to usarmy.carlisle.awc.mbx.parameters@mail.mil.