STRATEGY RESEARCH PROJECT

THE NEW MATH FOR LEADERS: USEFUL IDEAS FROM CHAOS THEORY

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THE NEW MATH FOR LEADERS:

Useful Ideas From Chaos Theory

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ABSTRACT

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This research project is a study of the implications of modern chaos theory on military management and leadership for the next century. The critical elements of chaos theory are presented in a non-mathematical treatment to reach the broadest audience. The theory is then applied to large organizations to illustrate the five major types of organizational behaviors and the three general chaotic behavior patterns. Implications for management and leadership of each type are discussed and the complex organizational pattern is identified as the most viable in a turbulent socioeconomic climate. Six recommendations for management emphasis are made in high impact areas for potential implementation by military leaders today.

TABLE OF CONTENTS

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 three hundred years ago, and common sense observations of life's everyday happenings reinforce that paradigm everyday[i]. 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?

This paper outlines some basic implications of chaos theory to illustrate the usefulness of these new concepts 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 Twentieth Century and for understanding its effects on the military of the next century.

This discussion of the actual 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 can then discuss the emerging concepts for management of the military of the future. Without this knowledge we will be facing a machine gun armed only with a musket.

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 be able 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 entire 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 for us 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 that 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 usual result of the game or exercise. In addition, they are very difficult to model mathematically. The world, however, is not constrained to fit the linear model; many situations do have non-linear models[ii]. In fact, wildcards occur quite frequently.

CRACKS IN NEWTON'S WORLD

What does *non-linear* 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 *non-linear* 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 effective fires within prescribed zones on the field. Elements of power were used at predictable times and places to maximize their effects. Today's supposedly non-linear battlefield uses friendly forces massing at the last minute, exerting their combat power simultaneously at several depths, disrupting the enemy's momentum and plans for maneuver.

In the context of mathematics, however, *non-linear* 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 non-linear model for a given situation often contains feedback loops. Operationally, it violates the simple notion of small changes in the value of various factors yielding small changes in the answer. Small changes in the inputs may make huge differences[iii].

So when the operations analyst talks of non-linear 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 simple 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 non-military 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 brilliant 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 plus multiple other conflicts. This approach gave the parties an opportunity to talk in a focused way about their two-way relationship. As we know, the Egyptian-Israeli dispute was settled by the Camp David Accords in 1978. The contribution to peace in the region was 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 been settled. 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 the 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 already. The real world is too complex for Newton's theory to apply to multidimensional situations.

And here is a hidden danger in real, non-linear situations. Linear approximations often work well enough in some circumstances. This success reinforces our confidence in the approach and allows us to think we understand a situation when we really do not. Approximation works when we are predicting the general positions of planets in our solar system next year even though Kepler's Laws and Newton's Laws are only approximations to General Relativity. Problems arise when you need to predict the 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; they must have a method for compensating for modeling errors or they will miss their mark[iv]. A military example is the aphorism 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 been a goal of mankind for a long time. Meteorologists developed theories of air mass interactions and seasonal patterns that gave us hope a working model would be available as affordable computers emerged. A scientist named Lorenz led the effort at the US Weather Bureau. He built an incredibly detailed program to simulate weather patterns. Using Newton's Laws and others developed from them, he wrote out the equations for how a weather system develops while interacting with terrestrial and atmospheric forces. He ran his program on a now-ancient computer that took its time analyzing the equations and printing out its 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 far downstream. Discussions of this phenomenon[v] gave rise to the famous Butterfly Effect which points out that a butterfly flapping its wings in the Brazilian rainforest today may cause a typhoon in the Pacific a few weeks from now.

At first glance, this appears ridiculous; but look again. Small changes in the initial conditions of the air masses all over the world caused by the butterfly can lead to a totally different solution of the nonlinear equations that govern the global weather. That Brazilian butterfly could be the critical energy push needed to create a typhoon.

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 with a less professional and prepared foe. Or it may be the brilliant success of units or individuals that were mediocre at best 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[vi]. The complex mathematical equations that truly model combat success are most certainly non-linear. 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 under some circumstances will 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 predict the performance of a unit reliably from their training behavior. 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's momentum on 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 to inject 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. Desert Storm was one of those cases. Coalition forces were so superior that the enemy was not able to generate large-scale chaotic conditions during any engagement, and thus the nonlinear terms in the model never became strategically or even operationally significant. 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. In essence, the Gulf War's complex equations were functionally simplified to linear terms by the imbalance in combat power and leadership. 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 everyday situations are still effectively modeled by familiar, predictable, linear equations. Linear equation 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[vii]. 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 the 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 be working at finding 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, efforts at modeling these problems have tremendous potential for future applications. We should be exploring both the critical values and the range of potential outcomes to understand the bounds of our possible futures.

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 best 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[viii]. From this viewpoint, there are five types of organizations that are 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 behavior states characterize most states of organizations. Each has a specific pattern of behavior, and the states differ mostly in terms of the mix of linearity and nonlinearity. The names given to these states 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 state to another will take place. Unfortunately, so far no one has yet proposed a way to do this in organizations.

The first two states 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 be easily predicted.

These two types are typical of physical and mechanical systems, and they are seldom found in individual or organizational behavior. They may be found in organizations where people are treated as if they are machines. There have been attempts to create an exact science of management that describes perfectly behavior and makes sure predictions and total control based on the assumption that people's behavior follows these orderly patterns. 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 the Limit Cycle, there is only similar behavior. In organizations, this behavior follows norms, customs, regulations, rules, prescriptions, or laws. This type of behavior 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 and a few deviants will digress and go beyond the norm. For example, you can be relatively sure of the average number of workers who will be absent from work at different times of the year. It is possible to use statistical methods to predict what will happen and prepare for what is likely to 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 that 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 today's turbulent environment: loss of ability to change; lack of resilience; and uniform procedures unsuitable to people who are very different from each other. The problem a Torus leader faces in turbulent times is not how to maintain order and enforce the regulations, but how to create the conditions that nourish the growth of change, innovation, enterprise and creativity. Encouraging renewal and positive change should be the organizational goal.

The fourth state, 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 completely differently.

This system often behaves like multiple Torus systems joined together. People acting within one group are behaving similarly to one another, but differently than people in other groups. For example, people 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.

But a problem arises 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 work and responsibility or between those who are honest and those that steal time or property from the organization.

Behavior in different groups can be radically changed by a small change in a critical organizational parameter, such as differences in wage increases or in the way people 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 the 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 and gently guide our 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 state 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 the old 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. The disturbances move the system to a point where its only alternatives are total change or disintegration. The former Soviet Union illustrates this condition well.

In organizations deep chaos 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 predicted exactly.

THE THREE 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*. The ordered pattern coincides with the two linear states: the Point and the Limit Cycle. The chaotic pattern coincides with the state of Deep Chaos, where randomness reigns. The complex pattern combines features of Torus and Butterfly states. 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 a Point and Limit Cycle state? Applying this pattern to human beings is problematic. Attempts to do so can be found in prisons, in a conscript army and in the assembly line in industry. It is possible to use this pattern with people when industry employs workers with little education and no alternative employment possibilities. In these circumstances people can be controlled and regimented to work like machines and robots.

The managerial style of this pattern is of one way control, from top to bottom. The pattern is maintained by the threat of punishment or of 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 last too long.

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, maintaining what is, loyalty to the past, etc. This stifles the energy and creativity of the organization. On the other side, there is the danger of falling into too much disorder and ineffectiveness resulting from irregularity, uncertainty and instability. An organization can fall into this state when it forfeits its vision, and its identity and people are lost in uncertainty concerning the future. Deep Chaos is a transition state, where what worked in the past is relevant no more and yet there still is no new way of escaping from the maze.

AVOIDING DEEP CHAOS

How can 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 different organizations, but basically they are of two kinds.

The first kind 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 people's identification with their organization, their devotion to work and their readiness to take initiative and do anything beyond regular work demands. There will always be differences and gaps, the problem lies in how wide and extreme these are. If the breaches deepen beyond a critical threshold, the population tends to breakup into sections. For example, there will be people who will continue to behave honestly even when there is a negative change in their work conditions. Others may attempt to solve their problems by deviations such as absence, destruction of organization property, low outputs, neglect of property, theft, embezzlement etc. Criminal acts by senior leaders, for example, may be seen as non-conventional behavior that disrupt existing patterns and warn 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 the government's 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, rewards and training do not work. New directions are necessary. Research reveals that only chaos can cope with chaos. Research is being carried out in areas such as controlling chaos in lasers, in electrical circuits, in heart tissues and 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 time that can lead either to transformation or to 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 putting on pressure to change the existing state but how to free the organization from the binds it itself has created, often mental models of people in the organization. These models are the filters through which the organization perceives 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 people 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 components, teams and individuals and simultaneously increasing or decreasing the level of relatedness with outside systems such as suppliers, sub-contractors, sister services, etc. Strategic planning applies, but for limited time periods into the future[ix].

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[x]. 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 guide the organization reliably near the edge of chaos. External interdependence must also be guided to increase or decrease the level of interdependence with outside bodies. Increasing interdependence can take many forms such as partnership, joint venture, sub-contracting, information exchange, joint development, strategic partnerships, etc. Decreasing interdependence can 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 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 low-level 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 can cope with these turbulent times.

RECOMMENDATIONS

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

1. Diversity can allow us to adapt more efficiently to changing times[xi]. 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 mostly 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. We need to employ our differences constructively to create needed new solutions. Celebration of diversity is not homogenization of the underlying culture.

2. War games, battle labs, and training maneuvers are vital to defining the 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 the particular exercise given its unique starting point and resources. We need to document each exercise and analyze multiple iterations to gain insight into the desirability of the set of outcomes and the probabilities of obtaining failures with new configurations. Only with repetitive similar outcomes can we gain confidence in a particular doctrinal approach.
3. Our 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 do show that some principles consistent with chaos theory have made it into our thinking, but we can and should go farther. We need to revise this process to optimize staff interactions and

feedback loops. This will get us closer to the edge of chaos so optimal solutions can 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 are consigning ourselves to mediocrity and possible future failure against a more unconstrained and agile foe.

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 servicemembers. 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[xii] or if the organization's vision for the future is not clear and resonant, soldiers will 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 values and vision truly effects the outcome of battles[xiii].

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[xiv]. The chaos inherent in combat is best dealt with at the lowest level where individual factors can be most clearly recognized and compensated for[xv]. Filters will be required to give summary information to higher echelons without enough 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 vital elements of variety, discontinuous change, innovation, experimentation, development, and creativity[xvi]. Too much order is counterproductive when the organization needs to adapt quickly and effectively under chaos-producing conditions[xvii].

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; it is the battlefield between degeneration and anarchy. The challenge for today's military leaders is to find the closest approach to this edge consistent with mission requirements during training and everyday operations and to balance on the edge 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[xviii].

Word count = 5988

ENDNOTES

[i] 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), 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.

[ii] There is a clear physical example in James Gleick. Chaos: Making a New Science. (New York: Penguin, 1988), 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."

[iii] Margaret J. Wheatley. Leadership and the New Science: Learning About Organization from an Orderly Universe. (San Francisco, CA: Berrett-Koehler Publishers, 1992), 125-7.

[iv] Edgar E. Peters. Chaos and Order in the Capital Markets. (New York: Wiley & Sons, 1991), 135.

[v] 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: US Army War College, 1996), 5-8.

[vi] 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 Belvior, VA: Defense Technical Information Center, Document Number ADA306112, 1995), 151.

[vii] 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), 177.

[viii] 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> on the Internet.

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

[x] This point is made clearly by Kiel, 140.

[xi] A strong argument is made for the positive effects of diversity by Kiel, 162.

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

[xiii] Peter M. Senge. The Fifth Discipline: The Art and Practice of the Learning Organization. (New York: Doubleday, 1994), 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.

[xiv] This is even consistent with current writings from the Training and Doctrine Command (TRADOC) itself. See John L. Romjue. American Army Doctrine for the Post-Cold War. (Fort Monroe, VA: United States Army Training and Doctrine Command, 1997), 28-9.

[xv] 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), 50 and ibid., 161. He also makes the point that local initiative by lower level leaders make critical differences in outcome on ibid., 160.

[xvi] 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, xv.

[xvii] "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), 151.

[xviii] 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), 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.

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