

# *CAS in War, Bureaucratic Machine in Peace: The US Air Force Example*

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**T**he operational art of air power, as articulated by its earliest pioneers (Douhet, Mitchell, and Trenchard) as well as by recent air power theorists (Col. John Warden III, Lt. Col. Stephen McNamara, and others), has increasingly been seen as innately flexible, nonlinear, and adaptive. From the reconnaissance, air supremacy, and strategic bombardment lessons of the First and Second World Wars to recent experiences in the Gulf War and Operation Allied Force with stand-off precision engagement and parallel system-wide attacks on enemy leverage points, the US Air Force has learned to minimize force-on-force encounters by first removing an enemy's ability to resist. In essence, the enemy and the Air Force are thought of as "complex adaptive systems." Complex adaptive systems (CAS) are defined here as nonlinear systems made up of multiple interacting agents that are sufficiently different from each other that their behavior will not be exactly the same in all conditions (Brown & Eisenhardt, 1998: 18).

Many of the characteristics of CAS can be found in military writings from over 2,500 years ago by the famous Chinese General Sun-tzu (1963). According to Sun-tzu, "to win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill" (Sun-tzu, 1963: 77). He described warfare as a process of "ceaseless change" and warned that his principles should be used fluidly in response to actual confrontation with the enemy.

Even western philosophies on warfare recognize its inherent fluidity and dynamical nature. Early nineteenth-century Prussian general and philosopher Karl von Clausewitz stated, “War is an activity of the will, not—like the mechanical arts—exerted upon dead matter, but upon a living and reacting force” (Clausewitz, 1965: 111–12). Yet, with all of the US Air Force’s confirming evidence that societies, economies, forces, and warfare itself are all nonlinear complex adaptive systems, it has not yet fully embraced these lessons in the peacetime complex adaptive system: organizational structures and relationships, referred to here as the “organizational method.”

The US Air Force, as an independent organization, was “born” with the passage of the National Security Act of 1947. At that time, organizations all over America were striving to perfect the clockwork of their classic bureaucracies. The Air Force was no exception. It was divided up into an intricate hierarchy of commands with clearly defined roles and responsibilities. Over the years, countless required regulations, instructions, standardized procedures, forms, policy letters, manuals, and pamphlets at every major level of command have been generated to control every aspect of daily work flow. In lockstep with American private industry and the rest of the Department of Defense, the US Air Force followed the conventional wisdom of traditional organizational science and built a veritable fortress in the never-ending struggle for order, control, predictability, and equilibrium. Its machine-like organizational paradigm was clearly evident from the words of the first Commander of the US Air Force’s Strategic Air Command (SAC), General Curtis E. LeMay, who said, “Whether we venture into the realms of Space in our latest vehicles, or whether we are concerned principally with overhauling our engines and loading our ordinance here on the ground, we will still be a part of a vast proud mechanism which must function cleanly if it is to function at all ... Crank her up. Let’s go” (US Air Force, 1995).

This dichotomy between operational art and organizational method has become increasingly pronounced over the short history of the US Air Force. Its operational art has rapidly evolved and adapted in response to subtle environmental factors, changing technology, training exercises, and successes and failures in actual warfare, while rigid organizational structures and policies seem to change only in painful and forceful fits and starts when no other alternative exists in response to radical environmental changes. Rinaldi (1997) postulates that the operational art of air power has shifted over time from its early beginnings to a completely new paradigm that is best defined by complexity science, a “discipline

that has self-organized to examine the question of how coherent and purposive wholes emerge from the interactions of simple and sometimes non-purposive components” (Lissack, 1999: 112). This nascent field is also “an approach to research, study, and perspective which makes the philosophical assumptions of the emerging worldview” (Dent, 1999b) including holism and mutual causality.

Rinaldi (1997) challenges the US Air Force to “complete the shift and employ the new framework in [AF] operational thinking. For it is only in incorporating insights from complexity in practical applications that we fully exploit the power the new paradigm has to offer” (Rinaldi, 1997: 249–50). It appears that the Air Force is taking heed of this sage advice for twenty-first-century aerospace power. However, the current paradigm for organizational method is still firmly entrenched in its mechanistic beginnings. As the US Air Force continues to be challenged by a lack of resources, coupled with a steady increase in global operational requirements without the benefit of forward basing, Air Force operations will become increasingly dependent on organizational responsiveness.

### *THE FIVE ASSUMPTIONS OF ORGANIZATIONAL ART*

One of the key figures of the European Renaissance between the fourteenth and seventeenth centuries was Leonardo Da Vinci. Da Vinci had an insatiable love of learning. Although he is most famous for his accomplishments as a painter, he was also an excellent sculptor, architect, musician, engineer, and scientist. He was a dreamer and a perfectionist at the same time. His work blurred the lines between artistic creativity and scientific precision. The US Air Force needs senior leaders who share Da Vinci’s love of learning. These leaders need to be able to blur the lines between operational art and organizational method. We call this synthesis the practice of “organizational art.”

The new discoveries of complexity science have caused a reexamination of the underlying assumptions of what are now recognized to be non-linear complex adaptive systems and the connections between and within systems that were previously assumed to be severable. Just as complexity science offers a highly instructive framework for the employment of air power within the complex adaptive system of warfare, we propose the use of a similar framework to inform our view of the leadership and design of the complex adaptive system of the US Air Force as an organization. As we move into the twenty-first century, organizations of all types may find that they must learn to embrace the new paradigm of complexity science

if they are to continue to thrive in the information age. Consequently, we offer five key assumptions to frame thinking about successful organizations of the future. Such organizations will be increasingly nonlinear, holistic, interdependent, perspectival, and self-organizing. These traits should not be considered “steps” or “checklist items.” They are all descriptions of complex adaptive systems from distinct but instructive perspectives that introduce a new worldview (Dent, 1999b). Since all of these traits describe the same pattern of phenomena, they are themselves connected in important ways that could be the subject of further contemplation.

It is interesting to note that people are beginning to see the role of the military in society differently as they peer through these five lenses. For example, a holistic perspective would suggest that the military should not be primarily a war-fighting force. In fact, “military operations other than war” (MOOTW) consume more and more of the military’s efforts as it focuses on peacekeeping, providing aid, maintaining borders, and restricting the flow of illicit drugs, among other duties. A second example is the perspectival assumption. The media increasingly report about and debate the military’s function, including not only the list above but also how much of it is to provide entry-level job skills for citizens, how much is a backbone of a community in terms of an employer; how much is a primary R&D source for the country, how much is a polluter to be watched, how much is an inculcator of values (such as patriotism, honor, and duty), and so forth.

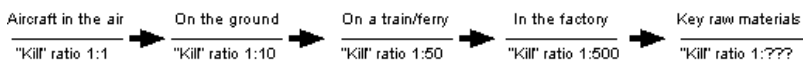
### *NONLINEAR*

Nonlinearity is a fundamental characteristic of all complex adaptive systems. It is this very characteristic that caused Sun-tzu to place such importance on assessing the initial conditions of warfare before engaging in it. Warden (1989) formed a conceptual basis for an air campaign that was essentially used against Iraq during the Gulf War. He emphasizes the importance of identifying the enemy’s leverage points, “point[s] against which a level of effort could accomplish more than that same level of effort could accomplish if applied elsewhere” (Warden, 1989: 7). Understanding the initial leverage points of both opposing forces is critical to the employment of effective offensive and defensive strategies that will yield favorable synergistic results. The wise strategist knows that the intricate cause-and-effect relationships of CAS mean that the leverage points are not easily located and that they will change over time.

Another characteristic of nonlinear systems is that they tend to be highly sensitive to the nature of the relationships between their elements

or subsystems. Moreover, small perturbations can lead not only to quantitative change, but also to fundamental transformation. Likewise, large efforts at change may have little or no actual impact. Systems thinker Donella Meadows (1982) quotes an ancient Sufi teaching that shifts focus away from “things” to the “relationship between things” in nonlinear systems: “You think because you understand one you must understand two, because one and one makes two. But you must also understand and” (Meadows, 1982: 23). Recently, organizational researchers have discovered that leaders (particularly at the senior levels) should concentrate as much or more on the flow of information between departments as on the activities within departments (Rummler & Brache, 1995: xvi).

Understanding “relationships between things” is also critical to the employment of air power. Air superiority is always the first aim of any air campaign. Whoever controls the air generally controls the surface. During the Second World War, British Field Marshal Bernard Montgomery noted that “if we lose the war in the air we lose the war and we lose it quickly” (quoted in Meilinger, 1995: 3). The linear approach to achieving air superiority is force-on-force aerial combat. However, it is also the most inefficient (and potentially costly) means to the desired end. Warden estimates that “in the aggregate, one friendly plane can destroy one enemy plane.” Instead, Warden advocates seeking nonlinear effects by understanding the relationships in the enemy’s “aircraft system” so that we can trace the aircraft chain to a vulnerable link that can be easily broken or disrupted for maximum effect (Warden, 1989: 35–8). Consider the following simple illustration.



*Figure 1 Nonlinear relationships: Disrupting enemy aircraft*

In this example, the enemy’s air superiority leverage point is the “aircraft system.” If logistics were determined to be the enemy’s air superiority leverage point, a similar analysis could be conducted on the relationships in the enemy’s “fuel system” or perhaps its “transportation system.” In any situation the Air Force can use knowledge of the inherent non-linearity of complex adaptive systems to best determine strategy. It can also begin to strive toward the realization of Sun-tzu’s assertion about the “acme of skill,” in that it may become possible to subdue the enemy effectively without actually fighting a single air-to-air battle.

With a few important exceptions, the current organizational US Air

Force is managed according to an underlying assumption of linearity, yielding no better than linear results. The men and women who make up the US Air Force are working harder than ever, yet it never seems to be enough. Personnel are trying everything they know to get more efficient. Well-intentioned leaders perturb the organization according to their best intentions: They reduce personnel, they reengineer, they consolidate functions, they regionalize services, they use efficiency tools like competitive sourcing and privatization, and they try to “do more with less.” Yet, in many ways, the Air Force seems to get “less with less.”

One of the most prevalent trends over the past few years throughout the organizational Air Force is a greater reliance on the private sector to accomplish tasks previously performed by Air Force personnel. Competitive sourcing and privatization initiatives shift the responsibility for existing commercial-type functions to new public and private-sector organizations that demonstrate the potential to accomplish the functions more efficiently. Acquisition reform initiatives shift responsibility for the details of task performance to expert contractors, thus eliminating the need for an extensive Air Force acquisition workforce to give direction and provide oversight. Headquarters staffs are reduced under reengineering initiatives while the use of advisory and assistance service contractors proliferates.

None of these initiatives is necessarily a bad idea, but the true results cannot simply be measured by looking within the boundaries of the US Air Force’s organizational charts. Efficiency is a noble goal, but it is one best suited to a linear system. Is the organizational Air Force more effective? Are morale and loyalty and personal satisfaction higher? What is happening to retention and recruiting? Is the Air Force’s knowledge base growing? When you view the Air Force and its environment as a system, have they even achieved the overall efficiency so diligently pursued?

### *HOLISTIC*

Reductionism assumes that smaller and smaller pieces of work will be handled more efficiently and more effectively. Early organizational theorists and pioneers quickly latched on to this idea and pursued its implementation wholeheartedly. For example, the division of labor is “one of the central issues which bound otherwise disparate figures such as Adam Smith, Karl Marx, and Emile Durkheim in their various concerns and passions” (Clegg, 1990: 10). A key tenet of the management of modern organizations is managing differentiation. Central to contingency theory, for example, is the balancing of differentiation and integration in

the midst of a rapidly changing external environment.

The division of labor can be taken too far. It perhaps reached its nadir about 1960 when a large percentage of the industrial workforce had jobs in which they performed a simple task, or series of tasks, hundreds if not thousands of times each day. The situation has improved since then with the advent of job enrichment, which has shown that people will be more effective and produce higher-quality work if they see their task as a meaningful whole. Still, the US Air Force's current organizational art emphasizes analysis at the expense of synthesis. Analysis is the process of taking a work problem and breaking it down into parts. Synthesis is the process of taking a work problem and looking to see what larger system contains it, and how the problem gets generated in that system (Ackoff, 1981).

Many benchmarking efforts have fallen victim to this overemphasis on analysis. Benchmarking can be a great tool, but the benchmark must be of the whole, not just the parts of the whole. If one tried to replicate a top-notch flying squadron by copying the same number and type of aircraft, the same amount of aircrew training, the same number of exercise sorties, the same level of aircraft maintenance, and similar metrics, it is possible that nowhere near the same level of excellence would be achieved. Such a benchmark focuses on the parts and ignores the interactions (such as camaraderie, leadership culture, etc.). Typically, benchmark efforts fail when they overlook the psychological, social, and cultural dynamics that are present in the whole (Dent, 1999a).

With a reductionist mentality born of the scientific revolution, military officers instinctively adopt a "divide and conquer" strategy to solve the many physical, biological, psychological, social, economic, cultural, and even military puzzles that perplex them. Seeing the operational art of air power as a CAS is still a serious bone of contention between the Air Force and the Army. The Army's view of warfare is (not surprisingly) framed by imaginary boundaries on the ground that divide the theater commanders' battle space into discrete Areas of Responsibility (AORs). Actions between AORs are "synchronized" sequentially. In the Second World War, most Army commanders believed—as some still do—that air power should be divided up between the ground commanders to provide "area umbrellas" in support of the synchronized actions of individual ground troops in each AOR. Some even believe that the aircraft in each AOR should remain on the ground until needed by their respective AOR commander, like an "aerial artillery unit."

When Operation Torch began in North Africa during the Second World War, that is exactly the way it was. The hard lessons that followed

in North Africa demonstrated that air power loses its effectiveness if it is split up. The German Luftwaffe gained air superiority because it was able to mass its air power against American parceled-out “area umbrellas,” while other airplanes in neighboring AORs either sat idle across imaginary lines on the map or engaged in equally linear force-on-force conflicts. The holistic nature of air power was so painfully apparent that the rules were changed midstream during the North Africa Campaign. Shortly after the campaign, Field Manual (FM) 100-20 Command and Employment of Air Power brought all air power under centralized integrated control and immediately superseded all previous conflicting air power regulations. It remained the prevailing doctrine for the remainder of the war. As McNamara (1994) notes, “FM 100-20 ... is the Magna Carta of American air power and the basis for today’s U. S. Air Force Manual (AFM) 1-1, Basic Aerospace Doctrine of the United States Air Force” (McNamara, 1994: 7). More recent doctrinal developments in the Army and in the Marine Corps have begun to reframe ground warfare as a holistic endeavor as well (Wheatley, 1995).

Whether talking about air power or organizational structure, it is clear that the whole does not equal the sum of the parts. The US Air Force is replete with examples of divisions of disciplines into discrete categories that have led to compartmentalized thinking by dividing up problems and the associated responsibility for solving them. The result is that Air Force personnel begin to believe that they can’t think about issues transcending their own “AOR.” US Air Force career fields are managed using discrete codes called Air Force Specialty Codes (AFSCs) and relative skill levels within each AFSC are identified by rank and/or by a skill level number.

This system encourages “stove-piping,” whereby individuals concentrate on gaining proficiency and knowledge exclusively within their own AFSC. Individuals who ponder the overall challenges faced by the US Air Force are either not encouraged or are implicitly discouraged from doing so. Many non-productive stereotypes have emerged and a person’s career potential can actually be limited because of their AFSC. At the same time, there have been important, albeit isolated, successes. Flightline maintenance organizations have been brought together with the fighter squadrons they support to consider the whole problem of generating sorties. Integrated product/process teams (IPTs) have formed around several important issues including weapon system acquisition, and the Aerospace Basic Course was initiated to give all US Air Force officers a basic understanding of operational art before their first assignment.

*INTERDEPENDENT (MUTUALLY CAUSAL)*

In linear systems, we expect to understand cause and effect as a direct relationship; for example, if *X* happens, then *Y* follows. However, people often fail to adjust their thinking for nonlinear complex adaptive systems. Leaders can “get into trouble because they forget to think in circles” (Weick, 1979: 86) by relying on direct, linear causality. They must also realize that “three essential organizational functions merge and interact. ‘Planning’, ‘doing’, and ‘learning’ become a matter of emphasis and not separable functions, for any corporate act is all three simultaneously. To do is to plan is to learn—and the efficiencies achieved are staggering” (Owen, 1997: 114).

The nonlinear complex adaptive system of warfare between two or more nations is an excellent example of interdependence. Sun-tzu argued that wise generals “shape” their enemies and allow the enemy’s reactions to govern their strategy. He contended that “what is of supreme importance in war is to attack the enemy’s strategy” (Sun-tzu, 1963: 77). He believed that action or inaction could be used to shape the enemy. To shape the enemy with action, Sun-tzu proposed the use of influences that are themselves interdependent called *cheng* and *ch’i*. He stated that the normal, or direct, *cheng* force and the extraordinary, or indirect, *ch’i* force are reciprocals of one another and their effects are “mutually reproductive.” Commentator Samuel Griffith notes that “we may define the *cheng* element as fixing and the *ch’i* as flanking or encircling, or again as the force(s) of distraction and the force(s) of decision. Their blows are correlated. The *cheng* and the *ch’i* are compared to two interlocking rings: who can tell where one begins and the other ends? Their possible permutations are infinite; the *cheng* effort may be transformed into a *ch’i*, a *ch’i* into a *cheng*” (Sun-tzu, 1963: 42).

The very same dynamic of interdependence is found in both the application of air power and the organization of the US Air Force. Meilinger (1995) points out that, at its essence, air power is targeting, targeting is intelligence, and intelligence is analyzing the (potential and actual) effects of air power. Independently valid intelligence may be invalidated by poor targeting or the poor execution of air power. Likewise, as was learned from the unfortunate precision bombing of the Chinese Embassy in Serbia during Operation Allied Force, independently effective air power execution can be rendered wholly ineffective by poor targeting or poor intelligence. In addition, Meilinger warns that although air power has gained the physical ability to strike anything, it will not be effective against critical targets of which we are unaware. The

ultimate success of air power is therefore interdependent and mutually causal with both intelligence and targeting.

In the Second World War, the Air Corps Tactical School employed the familiar “industrial web” theory for targeting the enemy. Meilinger notes that this theory recognized that the enemy force structure was so centralized and set up in such a linear way that “like a house of cards, if just the right piece was removed the entire edifice would collapse and with it a country’s capacity to wage war” (Meilinger, 1995: 20–21). Today, we wouldn’t use the term “web” to describe such a centralized, linear system. If our current defense force is viewed as a CAS, and led accordingly, it will develop into a true web, an interconnected network that increases the resilience of the system against loss at a single point in the network. Diversity, apparent redundancy, broad communication networks, and distributed and decentralized decision making authority all make webs resilient.

The thinking in the organizational Air Force is different, continuing to seek organizational solutions and track down problems using a direct, linear, cause-and-effect assumption. If a Fully Mission Capable (FMC) rate for a Wing of aircraft drops below acceptable levels, the first question asked is, “Who should be blamed?” Where is the cause that generated this effect? The linear organizational science worldview may suggest that it is time to replace the Maintenance Squadron Commander. Using the new organizational art, a working model of the “FMC system” may be developed to evaluate the interdependencies at work. It may be that the interdependencies that need to be influenced include many simultaneous relationships: how airplanes are flown, how everything is coordinated within the system, the impact of maintenance personnel turnover, the role of faulty or delayed spare parts, etc. These opportunities can be used to bring new understanding to the interdependent relationships and perhaps even simultaneously influence both the system and its environment in such a way that the FMC rate is less likely to fall below acceptable levels in the future.

Successful organizations of the future will see themselves as a complex adaptive system within a mutually causal network of complex adaptive systems. Ideas and options will be weighed according to the systemic effects on both the organization and its environment simultaneously. The strategies that are pursued will not only be simply in line with the goals of the organization, but also must have the effect of increasing the likelihood that future goals will be attained.

*PERSPECTIVAL*

When people in organizations are exposed to information, they create their own interpretations of reality (Maturana & Varela, 1987). This claim can be verified by walking into any organization and separately asking a handful of co-workers what “quality,” “communication,” or “leadership” means in their organization. Each person will likely have at least a slightly different response, and often a dramatically different response!

Most organizations see this variation as undesirable. They fear novelty and diversity as possible sources of disorder and dissent. They have procedures and structures that have the effect of limiting the number of perspectives. The two most common in the US Air Force seem to be “information filtering” and exhaustive mandatory regulations. Information filtering either limits the number of people in the organization who are exposed to raw information (internal or environmental), or limits the number of potentialities that exist before people in the organization are exposed to it. Both cases tend to produce self-fulfilling prophecies that could be dangerous to the organization.

In the first case, assume that in a 500-person organization only the top five leaders of the organization get together to discuss what action will be taken based on some new data. The organization has lost the opportunity of getting the viewpoints of a number of different people who may have a perspective or an insight that none of the five has. Piderit (2000), for example, has called for a similar idea, that “the first stage in creating change should be generating widespread conversation, rather than beginning the change process by engaging a small group of managers in identifying the desired change and later aiming to gain broader employee support” (Piderit, 2000: 791). This notion stands in direct contrast to most planned change models.

The typical communication problem is compounded by the filtering that occurs when the chosen action is communicated by each of the five leaders to their respective sub-organizations. When leaders meet with their people, they will have already limited the number of potentialities that can exist with their own acts of observation. All other potentialities are lost. It may indeed be desirable, even critical, for an organization to strive toward a single vision identified by the leader of that organization. However, good vision statements work to define the future state of the organization without limiting the number of possible paths that lead to that future state. In fact, a widely understood and accepted vision can increase the value of each potentiality to the organization.

The existence of exhaustive regulations can have a similar effect because they can drastically limit both the numbers of potentialities and

the numbers of resulting actions that are consistent with all the regulations. Exhaustive regulations combined with information filtering may result in an organization in which the boss always hears what they expect to hear. Although this may be desirable under the old model of prediction and control, it could leave the organization of the future blind to new information, which is increasingly seen as the critical resource in organizations. By contrast, an organization that has guiding principles or a shared vision of its future state instead of exhaustive regulations does not have to limit the potentialities. It can allow all 500 employees access to unfiltered information, get the maximum number of realities from the information “wave packets,” and then consider options for action in light of the shared significance created by the non-mandatory guiding principles or the shared vision of the organization (Kellner-Rogers & Wheatley, 1998: 7).

Kotter (1996) discusses the importance of empowering employees for broad-based action during periods of major organizational change. He stresses the importance of trusting employees with environmental information, and he suggests that the role of leadership is to “help more people become more powerful” by removing the barriers to empowerment. This includes removing burdensome organizational structures, which includes restrictive regulations beyond what is needed to provide a “container” for self-organization—described below—providing needed training, conforming personnel and information systems, and dealing with restrictive supervisors (Kotter, 1996: 102).

Microsoft chairman Bill Gates (1999) proposes several steps to survival in the digital age. These steps, Gates postulates, are necessary to maximize information flow for knowledge work, for business operations, and for commerce. Step #2: “Study Sales Data Online to Find Patterns and Share Insights Easily” and Step #3: “Shift Knowledge Workers into High-Level Thinking About Products, Services, and Profitability” specifically work together to empower every employee with unfiltered information access and the ability to develop shared significance by considering the problems facing the organization in a holistic manner (Gates, 1999).

Again, the dichotomy between operational art and organizational method is apparent. The US Air Force uses the guiding principles of doctrine to develop air campaigns, but would never expect campaign planners to limit their perspectives to the specifics of air power doctrine. Yet there are reams of exhaustive mandatory regulations to control the organization. If the peacetime organization was seen in the same way, it

would replace the reams with guiding principles and trust its people to interpret, discuss, and act on unfiltered information. Successful organizations of the future will seek to understand and embrace the effects of unique perspectives rather than attempt to eradicate them. Detailed and highly standardized sets of instructions will be avoided whenever possible. Explicit feedback processes will be in place to maximize individual, team, and organizational learning and foster a sense of shared significance. The effects of differing perspectives will be the information “fuel” that feeds these learning processes. Group decision support systems (GDSS) present one method for effectively promoting these feedback, learning, and decision processes (Huang & Wei, 2000).

### *SELF-ORGANIZING*

Top-down control has long been a tenet of the military’s success. Today’s world environment, of which the military is a part, is such that top-down control will not even be possible (or desirable) in many circumstances. Self-organization takes place when a complex adaptive system is in far-from-equilibrium (FFE) conditions. By most measures, today’s military would rarely be characterized as being in a state of equilibrium. What is exciting about the self-organization perspective is the prospect that in dynamic circumstances, self-organization can outperform imposed or control-based organization (Goldstein, 1994).

Self-organization has a number of benefits, including being adaptable, evolvable, resilient, boundless, and creative. These benefits must be weighed against the disadvantages, which include being nonoptimal (in that they often require redundant resources), uncontrollable, unpredictable, nonunderstandable (the “method” used by self-organization may not be apparent), and nonimmediate (Kelly, 1994: 22). Perhaps the scariest of the disadvantages is “uncontrollable.” A paradox is clearly raised: “In an age of smartness and superintelligence, the most intelligent control methods will appear as uncontrol methods” (Kelly, 1994: 127). Giving people freedom is the only way to achieve superior intelligent control. Although this idea may be new to modern organizations, the underlying philosophy is not. Lao Tzu expressed this very concept over 2,500 years ago.

Demonstration of the advantages of self-organization has come from Kauffman’s work using a nonlinear Boolean network to explore the connectedness of the CAS. Kauffman discovered that if there are not enough information flows, the system tends toward a stable state, essentially dying down to nothing. If there are too many connections, the system

flies into a chaotic regime when perturbed even slightly. Kauffman found a middle range of connectedness, the “edge of chaos” where adaptation and self-organization become inevitable (Kauffman, 1995: 80–92).

Again, although self-organization is a fairly new term in today’s organizations, Sun-tzu captured the essence of the possibility that an army can adapt to the changing conditions of its enemy and its environment when he said, “Now an Army may be likened unto water, ... as water shapes its flow in accordance with the ground, so an army manages its victory in accordance with the situation of the enemy. And as water has no constant form, there are in war no constant conditions. Thus, one able to gain victory by modifying his tactics in accordance with the enemy situation may be said to be divine” (Sun-tzu, 1963: 101).

The Marine Corps is taking Sun-tzu very seriously when it comes to urban warfare. The front page of the *Washington Post* on March 6, 1999 included a story entitled “Point Men for a Revolution,” which documented the Marine Corps’ transformation using the principles of complexity science and chaos theory. As part of an experiment, each marine has been outfitted with a miniature computer that includes a keyboard, a pop-up display, a miniature video camera, and a global positioning system sensor. Once equipped, each marine becomes a globally aware part of a network of marines. Each marine’s location and identity show up on the shared display. This enables a marine to share unique intelligence information in real time or even show other marines what they’re looking at. The result is “an instantaneously reacting, self-organizing swarm that can metamorphose on the fly” (Garreau, 1999: A12). The Marine Corps calls this “riding the dragon.”

Microsoft is doing something very similar. Bill Gates’ ninth step to survival in the digital age is to “Use Digital Communication to Redefine the Nature of Your Business and the Boundaries Around Your Business.” He calls it a “web work style, in which each contributor or company organizes itself optimally” (Gates, 1999: xxi).

A dilemma with self-organization is keeping the identity of the organization intact in the face of shifting organizational structures and truly empowered and autonomous employees. How do we retain order out of chaos? Complex adaptive systems in a chaotic regime respond paradoxically to attractors. The system remains completely unpredictable, yet boundaries (attractors) form over time that contain and define the system. In nature, these chaotic regimes may form fractals that consist of an infinite pattern of repetitive shapes within shapes. At the local level chaos reigns, while at the global level order emerges.

Self-organization requires a strongly bounded arena to contain non-linear transformations. The boundaries should be firm, yet permeable to allow vital exchange with the organization's environment (Goldstein, 1994: 99). Good candidates for such boundaries in organizations are guiding visions, strong values, and organizational beliefs. The leader's task is to "communicate them, to keep them ever-present and clear, and then allow individuals in the system their random, sometimes chaotic-looking meanderings" (Wheatley, 1992: 133).

The US Air Force's "Global Engagement" vision for the twenty-first century is a firm foundation on which to explore the self-organizing trait of complex adaptive systems. Its most powerful "attractors of meaning" are its core values: "integrity first," "service before self," and "excellence in all we do." In addition, the core competencies of air and space superiority, global attack, rapid global mobility, precision engagement, information superiority, and agile combat support provide a strong backbone of self-reference that can enable self-renewal while retaining a core identity. These values are met in the organizational method by a strong, implicit set of values concerning prediction and control. The emphasis on prediction and control must be diminished in order for the "attractors of meaning" to permeate throughout the peacetime US Air Force.

Successful organizations of the future will maximize their members' understanding of the mission and vision, optimize the connections inside and outside the organization, and then seek to remove barriers to formal structural change. They will be identifiable by their core values, beliefs, and culture. An organization's values will be the source of its self-referential stability and order. They will provide the organization with a strong anchor that will enable self-renewal without experiencing chaos. The emergence of informal structures within the organization will be encouraged and supported but not prescribed. Senior leadership will not insulate organizational members from the realities of the environment. Organizational change will be governed only by a few guiding principles or core values that are central to the identity of the organization.

### *THE IMPETUS FOR RENAISSANCE*

Never before in the history of the US Air Force has the impetus for a renaissance of operational art into organizational method been stronger. The nature of modern warfare, the expanding roles of the military, and a scarcity of resources are driving the need to break out of the traditional mechanistic worldview. The challenge for the Air Force is to allow the

lessons of complexity and chaos understood in its operational art to instruct its thinking about the development of a new organizational art.

In *War and Anti-War*, Alvin and Heidi Toffler (1993) paint a vivid and alarming picture of warfare in the third wave world: Nuclear terrorism, robot warriors, flying miniature smart bombs, urban warfare, all-out information attacks, and the mass proliferation of advanced weapons technology. The truth is that no one really knows what the wars of the future will look like and that is perhaps what is most alarming. Nevertheless, it seems certain that they will be increasingly time sensitive and unpredictable.

In the Second World War, the oceans were the United States' strongest defensive allies. They afforded the opportunity of time to fire up the linear machines of mass production to fight a war for which the US was not prepared. Wars of the future will be a "come as you are" affair. The US will never again have the opportunity to mobilize the second wave industrial might of the country. While the possibility of a protracted war cannot be ruled out, one of the keys to victory in the future may be found in the ability to master the fourth dimension of time.

For all of the tension, fear, and potential for disaster of the cold war world, at least it retained a quality of predictability that is expected and comfortable to those holding a mechanistic worldview. The wars of the future will not be predictable. As Clausewitz warned, "There is no other human activity that stands in such constant and universal contact with chance as does war" (Clausewitz, 1965: 52). The United States' comparatively large and potent military, while necessary, will not insulate the country from nonlinear asymmetric attacks, which can be just as devastating to vital national interests as any world war could be. An information attack on Wall Street, an electromagnetic pulse that renders satellites useless, a nuclear device left in the middle of an urban population center by groups that have no national affiliations whatsoever: All of these potentials and more exist. (An excellent, comprehensive scenario of a biological attack, a satellite attack, and a computer systems attack, all without engaging a single American weapon system, is found in Kennedy, Welch, & Fessler, 1998.)

Ever since the Second World War, the US Air Force has recognized the unique qualities of warfare and the application of air power. These qualities are not unique to operational art but are the common traits that underpin all nonlinear complex adaptive systems. As the requirements on the military get higher, and the ratio of expectations to resources provided increases, there has never been a greater need than right now to apply the learnings in operational art to develop a new organizational art.

## NOTE

Both authors contributed equally and are listed in alphabetical order.

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