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ECONOMY OF INFORMATION: A NECESSARY PRINCIPLE OF WAR

by

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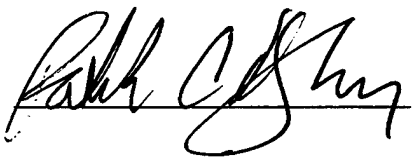
The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature: 

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Abstract of

ECONOMY OF INFORMATION: A NECESSARY PRINCIPLE OF WAR

Adopting Economy of Information as a Principle of War legitimizes the paradigms needed by operational commanders and their staffs to evolve doctrines and organizations necessary to exploit the technologies of the Information Age. Economy of Information is the careful or thrifty management of the transmission and interaction of ideas, facts, data, and instructions in any medium or form. A simpler definition, *stewardship of interaction*, is also acceptable. But Economy of Information is more than a definition, slogan, or dogmatic principle. It is a new way to think about nonlinearity, organizational structures, control, and decision making. Information drives interaction, which increases complexity. Thriving in complexity necessitates networked organizations, giving up direct control, pushing initiative down the chain-of-command and making decisions in the face of uncertainty. Each of these elements are optimized or impeded depending on the application of Economy of Information. Optimization hinges on an understanding of the information domain and its interactions with the physical, connectivity, and cognitive domains. Keeping American operational art competitive in this new Information Age calls for implementation of ten specific Economy of Information recommendations.

Introduction

Determining the best way to harness information to enhance military operations is a challenge that has faced military commanders throughout history. Today the challenge looms larger than ever, as the world is awash with information. During the past two decades, futurists Alvin and Heidi Toffler predicted the Industrial Age was ending and the Information Age was beginning. Along with this shift would come a concurrent change in the way wars are fought. Military thinkers began working feverishly to find the right technologies to exploit the new Revolution in Military Affairs (RMA). Some fruits of their labor are evident as commercial web browsers, email clients, satellite TV, and information infrastructure systems are adapted for widespread military use. Systems such as the Global Command and Control System (web browser technology), Defense Message System (email technology), Joint Broadcast System (small aperture satellite TV technology), and Combat Information Transport System (Asynchronous Transfer Mode switching infrastructure) are already integrated into large parts of the U.S. armed forces. Despite all this progress in leveraging technology, a true RMA is by definition not complete until the concurrent doctrinal and organizational changes occur.

Adopting Economy of Information as a Principle of War legitimizes the paradigms needed by operational commanders and their staffs to evolve doctrines and organizations necessary to exploit the technologies of the Information Age RMA. After an initial definition of Economy of Information, this paper focuses on the specific elements of Economy of Information that are of special interest to the operational commander: nonlinearity and complexity; adaptive organizational structures; recommendations for command and control and decision-making; and the information domain.

A Preliminary Definition

The term Economy of Information carries with it many potential connotations requiring clarification. Webster's defines *economy* as careful or thrifty management of resources; *information* is defined as facts learned about current or past events. Joint doctrine defines information as facts, data, or instructions in any medium or form.[1] A more comprehensive definition includes *ideas* along with facts, data, and instructions. Therefore, the baseline definition for Economy of Information is careful or thrifty management of the transmission and interaction of ideas, facts, data, and instructions in any medium or form.

But as a potential Principle of War, Economy of Information stands for more than just a definition. Characteristics such as prudence, mutual trust, stewardship, and discipline are required to make it effective. For example, a theater CINC demanding to know the exact location of each infantry squad deployed to a certain region of his theater is probably not prudently applying Economy of Information, especially if the motive is direct control.

Another mindset to accompany Economy of Information is the understanding that *economy*—careful or thrifty management—usually means the opposite of tight control. The U.S. Gross Domestic Product, for example, recently grew to nearly nine trillion dollars. This economic achievement was attained via free trade, open markets, and minimal centralized intervention rather than by centralized Soviet-style control.

The *interaction* aspect of the definition alludes to a further Economy of Information paradigm: the recognition that the world around us, and warfare in particular, is largely nonlinear. Information technology (IT) is a catalyst for interaction. Increased interaction between systems and within systems, using 360-degree feedback loops such as email, fosters

system complexity. Among the services, only the Marine Corps officially embraces complexity as a new paradigm.[2]

Nonlinearity and Complexity – Some Basics

To understand nonlinearity, one must first grasp linearity. Humans are essentially linear creatures, whether by nature or nurture. The features commonly associated with linearity are proportionality, additivity, replication, and demonstrability of causes and effects.[3] These characteristics make linear systems very manageable and understandable, since behaviors of a small part of a system are scaleable to describe the behavior of the entire system. Though not ideal, linear system analysis suffices for understanding bipolar systems such as the U.S. and USSR during the Cold War.

Nonlinear systems, contrarily, are more difficult to understand and analyze. According to Alberts and Czerwinski, nonlinear systems are "the arrangement of nature—life and its complications, such as warfare—in which inputs and outputs are not proportional, where the whole is not quantitatively equal to its parts...and where cause and effect are not evident."[4] A nonlinear system is composed of multiple parts, each acting individually according to its circumstances and which, by so acting, changes the circumstances affecting the other parts of the system. Understanding a single part of a nonlinear system cannot be used to understand the entire system and therefore predictability and control is difficult. Furthermore, small variations in the input to a nonlinear system can cause large fluctuations in the output. This phenomenon is commonly called the butterfly effect, deriving its name from the potential effects a distant butterfly flapping its wings has on the weather a few days later.

Figure 1: The Linearity Spectrum[5]

TYPE	LINEAR	NONLINEAR	
REGIME	EQUILIBRIUM	COMPLEXITY	CHAOS
CHARACTER	**STABLE** - Disturbance dies out - Damage is local	**EMERGENCE** - Poised to adapt & evolve - Damages are limited	**TURBULENCE** - Disturbances propagate - Destruction

Most of our schooling focuses here

Most systems thrive here, but energy is required to stay in the bounds, especially when outside influence increases

Systems self-destruct here

Edge of Equilibrium

Edge of Chaos

Figure 1 breaks the linearity spectrum into three distinct regimes: equilibrium, complexity, and chaos. Economy of Information is one of the potential levers applied to keep a military organization operating within the complexity region for maximum adaptability, robustness, and speed. Warfare can be viewed as an exchange of energy, matter, and information between competing open systems,[6] with the goal of driving the enemy system into the region of equilibrium or chaos.

If driven to the equilibrium region, or if already operating there at the onset of hostilities, a system becomes stagnant and unable to cope with nonlinear phenomenon. An example of this occurred during the Vietnam War. The U.S. system was very linear—control oriented, focused on statistics, and highly centralized. When confronted with the nonlinearity inherent in the war, the system hierarchy became especially obsessed with statistics and quantitative analysis: body counts, amount of ordnance expended, and the

number of sorties that "serviced" targets, to name a few. Thousands of such statistical messages flowed into the Pentagon daily as the war was being lost through linear reductionism and a violation of the Economy of Information principle.

At the other extreme is the region of chaos. If driven into chaos, a system eventually destroys itself. Somalia, though it was temporarily stabilized by outside influence, is a system in chaos. There is no functioning government in Somalia today, and interclan fighting and banditry are the norm.

Nonlinearity is the essential Economy of Information paradigm needed for structuring military organizations to effectively adapt to the complexities and uncertainties of warfare.

Adaptive Military Organizations for the Information Age

Martin Van Creveld, in his 1985 work Command in War, puts forth the following rule: "Confronted with a task, and having less information available than is needed to perform the task, an organization may...increase its information-processing capacity [or] design the organization, and indeed the task itself, in such a way as to enable it to operate on the basis of less information."[7] The first option, multiplying the organization's information-processing capacity, increases the size of the central directing organ. This is self-defeating. As bureaucracy grows, an inordinate amount of overhead burden is placed on the organization, thereby reducing flexibility and efficiency. Therefore, only the second option offers a possible solution. The organization must design itself, or the task, to operate with less information. This is the superior approach, offering greater adaptability to changes and technological developments. One approach is empowering teams capable of dealing with different parts of the task on a semi-independent basis. Van Creveld further identifies five specific requirements for success:

1. The need for decision thresholds to be fixed as far down the hierarchy as possible, and for freedom of action at the bottom of the military structure;
2. The need for an organization that will make such low-decision thresholds possible by providing self-contained units at a fairly low level;
3. The need for a regular reporting and information-transmission system working both from the top down and from the bottom up;
4. The need for the active search of information by headquarters in order to supplement the information routinely sent to it at its command; and
5. The need to maintain an informal, as well as a formal, network of communications inside the organization.

These are all excellent recommendations ready for adoption under the Economy of Information principle, but they are merely an evolutional step for a hierarchical organization to adapt to the Information Age. The U.S. military currently faces a dilemma in wanting to fight like a purely networked structure in the complexity region—fast, adaptable, and open-ended—but simultaneously wanting to maintain the traditional hierarchical control so common for linear systems. This dilemma is part of a larger Information Age struggle between so-called "dynamists" (accepting complexity and open-endedness) and "stasists" (desiring equilibrium and control) described by author Virginia Postrel in The Future and Its Enemies.[8] A visible manifestation of this struggle is the slow evolution from hierarchies into hybrid organizations, where most transactions still follow the formal hierarchical process but some lateral connections—bypassing the chains of command—are used in the interest of timeliness. The next control structure evolution in the Economy of Information continuum is a purely networked structure where system actors (soldiers) communicate directly with other

system nodes (displays, databases, or other soldiers) without going through a common commander. This is known as 360-degree communication. Soldiers' ability to quickly "pull" a real-time relevant operational picture from any other node in the network enhances adaptability, redundancy, and responsiveness, allowing networked military structures to thrive in the complexity region. Simultaneously, soldiers "push" updates of their own into the operational picture. The informational challenges of such an arrangement seem daunting, but they are not insurmountable. Viewing commanders as virtual "hubs" or "pulsetakers" in a networked structure is one of many paradigms that help in the evolution.[9]

Achieving unity of effort within a networked organizational structure requires understanding the "strange attractor" characteristic of complex systems.[10] A strange attractor is the unifying force in a complex system which creates a given system behavioral pattern. Developing a common vision or strategic purpose, sincerely accepted by all members of the networked organization, is one way to implement a desirable strange attractor pattern. Once the strange attractor is established, mission-type orders (Auftragstaktik) allow the system to thrive within the complexity bounds discussed earlier. This leads to the command and control paradigm necessary for Economy of Information.

Command and Control

Czerwinski reminds us of the three command methodologies proposed by Van Creveld: command-by-direction, command-by-plan, and command-by-influence.[11]

Command-by-direction envisions a battlefield where all actors are tied to a centralized controlling node, similar to the Army's Force XXI concept. Although Information Age technologies are ideal to enable such an environment, the Economy of Information principle stands against it. Command-by-direction seeks equilibrium and relies

on certainty, which are futile endeavors in warfare. Additionally, as mentioned earlier, the controlling node grows in size and bureaucracy.

The second command methodology, command-by-plan, is also greatly enabled by IT. Command-by-plan seeks to plan all moves and decisions in advance. The information contribution is therefore greatest during the critical planning phase. This method trades flexibility for focus, and seeks to allow simplified organizational elements to operate with less information, which seems in accordance with Van Creveld's rules. The subtle problem with this approach, however, is centralization of uncertainty and decisions. This approach is tolerable provided the enemy remains in static equilibrium, as exemplified by the Iraqi Army during Desert Storm. But if complexity arises once execution begins, the command-by-plan method, by itself, offers minimal adaptability.

The preferred Economy of Information command methodology is command-by-influence. This methodology, which relies heavily on Auftragstaktik, accepts uncertainty and distributes it in smaller doses across the organization, rather than centralizing it at the command element. The paradox of this command approach is that giving up direct control results in more indirect control. Mission type orders permit extensive flexibility, initiative, and speed at the lowest levels, so uncertainty and disorder are embraced, as they will also affect the enemy, who may not be as adaptable. A chilling testimony of this is given by French historian Marc Bloch in describing the fall of France in 1940: "Our own rate of progress was too slow and our minds too unelastic for us ever to admit the possibility that the enemy might move with the speed which he actually achieved."[12] The French Army was highly centralized, built around command-by-direction, whereas the German attackers used Auftragstaktik (command-by-influence) as a central part of their Blitzkrieg operations. IT

enables command-by-influence by creating visual displays (common relevant operational picture) for the commander to see subordinates' initiative unfold. Economy of Information can be applied to highlight the level of uncertainty of each element in the display, perhaps bolding individual attributes once a given certainty level is reached. Nearly instantaneous decision-making follows, allowing seizure of the initiative. This is commonly referred to as "getting inside the enemy's OODA loop."

OODA and Decision-Making

John Boyd's famous Observe, Orient, Decide, Act (OODA) model is a good example of a nonlinear system which is unfortunately too often interpreted in a strictly linear sense. Rather than calling it an OODA loop, perhaps OODA loops is a more appropriate paradigm. Since each stage of the model has an often-overlooked feedback path to the other stages, a possible sequence might be orient-decide-act-decide-act-decide-act. This series of smaller loops would certainly get "inside an enemy's loop" if an enemy goes through each stage of the OODA process for each action taken. In either case, information is the enabler or disabler for the OODA model. Too much or too little information will paralyze the continuous process, either by driving it into chaos or into equilibrium. Economy of Information is especially critical to enable the decision stage of the OODA process.

Two decision schemes are generally recognized in military literature: the analytical method and the recognitional method.[13] The most common analytical method is called multiattribute utility analysis. This is the "idealized" scheme described in textbooks and doctrinal pubs. Many options are simultaneously considered, evaluation criteria established and weighted, and each option scored based on the selected criteria. The option with the highest tabulated score is then selected as the appropriate decision. This analytical method

works well for developing general courses of action (COA) during what Clausewitz terms the "war preparation" (war planning) stage. These are situations where time is not a factor, group resolution is needed, and an inexperienced staff is trying to determine the best COA. The operational commander unwittingly uses Economy of Information during the analytical decision phase of war planning by shaping the information domain through issuance of Priority Intelligence Requirements (how the commander sees the enemy), Essential Elements of Friendly Information (how the enemy sees the commander), and Friendly Forces Information Requirements (how the commander sees himself).

Contrary to the analytical method, the recognitional method relies on high decision-making experience levels. The advantage of the recognitional method is timeliness and adaptability. The goal of the recognitional method is recognizing patterns to find the fastest workable COA during actual warfare. Ultimately, most command decisions are made based on the recognitional method, in one minute or less, with minimal amounts of information.[14] The Economy of Information paradigm that must be remembered here is that more information is not necessarily better. More information, even if "timely, accurate, and relevant,"[15] is superfluous if it matches the pattern already recognized. This interaction between information and cognition is best portrayed in terms of different domains.

The Information Domain: A Tough Shell to Crack

There are numerous ways of observing one's surroundings. When analyzing electromagnetic signals, for example, one can observe a signal in either the time domain or in the frequency domain. In the time domain, signal voltage is plotted over time, usually resulting in some form of sine waves. In the frequency domain, the signal power is plotted over frequency, usually resulting in some form of spectral lines. Although the two plots look

completely different, they nevertheless represent the same signal. To "translate" from one domain to another, signal analysts use a mathematical tool called a Fourier Transform.

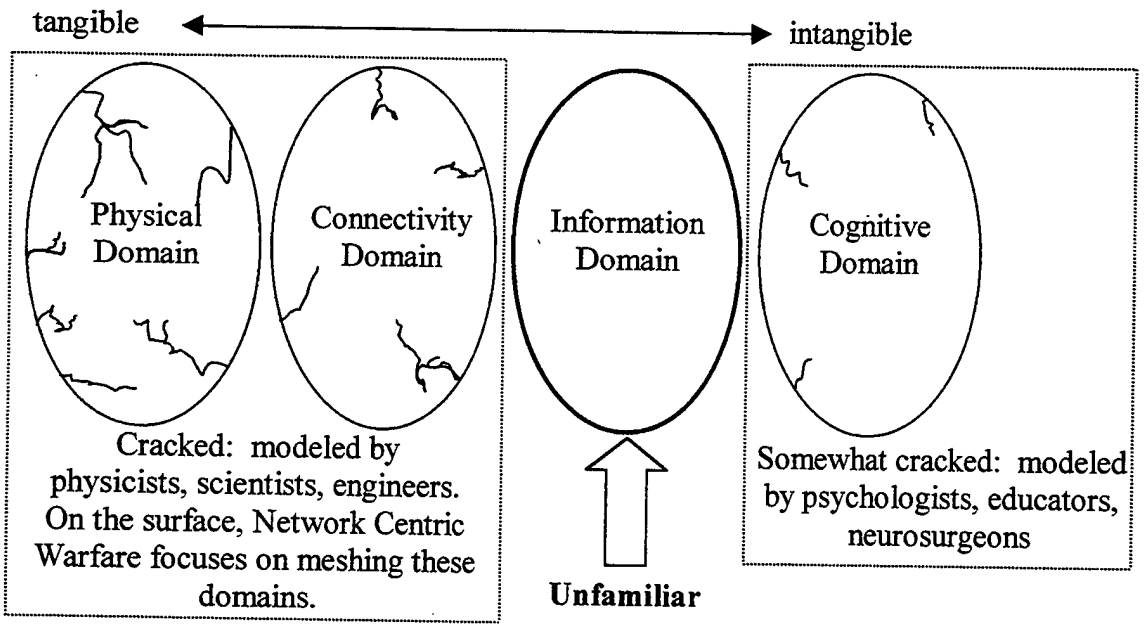
For contemplating Economy of Information, four such domains are proposed: the physical domain, connectivity domain, cognitive domain, and information domain.[16]

The physical domain represents one's tangible surroundings, usually in three-dimensional space. This domain is very well known and modeled by Newtonian physics.

The connectivity domain examines physical and virtual connections for potential flow of information, similar to a network topology. Relevant characteristics of an entity in the connectivity domain include bandwidth, circuit connections, nodes, processing speed, signal-to-noise ratios, and computational power. Not as well modeled as the physical domain, the connectivity domain is nevertheless fairly well understood and continues to receive a great deal of attention. Many proponents of the current RMA are focused on the benefits of increased interconnectivity (connectivity domain) to enhance awareness of the battlespace (physical domain). This yields concepts such as Network Centric Warfare, dominant battlespace knowledge, and the Global Grid.

Perhaps the most intangible domain is the cognitive domain. The cognitive domain is concerned with understanding the workings of the human mind and brain: neurochemical behavior, learning, visualization, memory, and recall. This is where information is converted to knowledge, and ultimately, to understanding and wisdom. Though not as well modeled as the physical domain or connectivity domain, extensive work continues on understanding this domain and the workings of the human mind. Development of the common operating *picture* concept is a response to the recognition that in the cognitive domain, pictures are preferred to text for communicating extensive amounts of related information.

Figure 2: The Four Eggs of Information



Wedged between the connectivity domain and cognitive domain (figure 2) lies the neglected information domain. The unfamiliar information domain views the world in terms of information attributes and interaction. Error, ambiguity, completeness, accuracy, relevance, and timeliness are some of the possible characteristics observed in this domain. Although the other domains play a critical part, it is the information domain that military thinkers must "crack" to maximize Economy of Information for operational commanders. Unfortunately, due to perceived shortages in transfer capabilities—too much demand, insufficient supply—the connectivity domain received most of the attention since the dawn of the Information Age. Only recently has some focus begun to shift from the "how" of information exchange (connectivity domain) to the "what" and "why" (information domain). Nevertheless, very little is currently known about this domain, and even less is known about the complex, nonlinear interactions between all four domains. Finding the right balance of filtering, focusing, and prioritizing information is the key to transcending "information

overload," which is a disconnect between the information domain and cognitive domain. Much more work is needed to crack this eggshell.

Pathology of Information and Other Counterarguments

Some will argue there is an obsession with information within the U.S. military and that Economy of Information is just another information buzzword like information superiority, dominant battlespace knowledge, or Network Centric Warfare. On one hand, this obsession with information—information pathology—results in a cascading demand for information that far exceeds supply and overwhelms subordinates. On the other hand, many staff organizations are now inundated with bandwidth-sapping "spam" (useless information). One could further argue that the transition from the Industrial Age to the Information Age already occurred and vast amounts of innovative information technology is already being used by the military. Trying to somehow apply "thrifty management" to something that has already transpired is folly.

On the surface, these are good arguments. But a deeper look reveals the abundance of new information lingo is a symptom of searching for adequate doctrine to fully harness capabilities afforded by new information technologies. The World War I use of the tank is an example of new technology being applied without satisfactory doctrine. The initial potential appeared stunning, but after an actual tactical breakthrough it quickly became evident that no one involved knew what to do next. Interwar doctrines developed by Fuller, Liddell-Hart, and Guderian led to the German Blitzkrieg doctrine. Subsequently, the tank in World War II was viewed as more than an armored machinegun nest to support infantry. It became the centerpiece of a rapid, interconnected, combined arms team. Similarly, as a result of the IT explosion, *information* is readily available for military applications. But to

date, only the USMC's Command and Control Doctrine (MCDP 6) begins to meet Economy of Information guidelines. Development of doctrinal concepts and organizational methods must therefore continue—adopting Economy of Information as a Principle of War will insure this happens.

One could then say that Economy of Information is not, in Jomini's words, "an unchanging principle affecting the conduct of war,"[17] and it therefore does not qualify for adoption as a Principle of War.

But as was shown, it is only too easy to find positive and negative examples of the diverse elements encapsulated by Economy of Information throughout military history: Auftragstaktik, getting inside the enemy's decision loop, over-centralization, and the pitfalls of linear reductionism. For further investigation, Operations Desert Storm and Allied Force serve as contemporary case studies for positive and negative examples, respectively, of Economy of Information at the operational level. Furthermore, in the sense that Principles of War should serve as guidelines during the planning and execution of military operations, Economy of Information clearly qualifies, not just from an information management perspective, but also for implementing dynamic command and control structures.

The current Principles of War were valid for the Industrial Age that spawned them. If Principles of War are still a relevant concept in the Information Age, the individual principles may need to change, especially in light of the "discovery" of complexity theory. Of these, Economy of Information transcends all others, even if the Principles of War evolve into something like "Strange Attractors of War" to suit the context of the Information Age.

The Way Ahead

The initial definition given for Economy of Information was the careful or thrifty management of the transmission and interaction of ideas, facts, data, and instructions in any medium or form. Evaluation of its elements reveals a simpler definition: *stewardship of interaction.* But Economy of Information is more than a definition, slogan, or dogma. It is a new way to think about nonlinearity, organizational structures, control, and decision making. Information drives interaction, which increases complexity. Thriving in complexity necessitates networked organizations, giving up direct control, pushing initiative down the chain-of-command, and making decisions in the face of uncertainty. Adopting Economy of Information as a Principle of War is necessary to develop the doctrines and organizations needed to exploit the current RMA. Here are some specific vectors for the way ahead:

- Adopt Economy of Information as a Principle of War
- Develop information doctrine and organizational structures, not just technology
- Continue to develop complexity theory and related military applications
- Teach complexity as part of Joint Professional Military Education
- Follow the USMC in adopting command-by-influence as the desired command method[18]
- Expand research on informational implications of pattern recognition decision-making
- Develop presentation methods that alleviate information overload
- Research the information domain and its internal/external interactions
- Adopt Van Creveld's five requirements as an interim step toward networked structures
- Train forces to wage war with too much information and without any

Keeping American operational art competitive in the Information Age calls for implementation of these urgent Economy of Information recommendations.

Notes

[1] Joint Chiefs of Staff, Joint Doctrine for Command and Control Warfare (Joint Pub 3-13.1)(Washington, D.C.: 7 Feb 96), GL-8.

[2] U.S. Marine Corps, Command and Control (MCDP 6)(Washington, D.C.: 4 Oct 96), Chapter 1.

[3] Tom Czerwinski, Coping with the Bounds (Washington, D.C.: Institute for National Strategic Studies, 1998), 8.

[4] David Alberts and Tom Czerwinski, Complexity, Global Politics, and National Security (Washington, D.C.: Institute for National Strategic Studies, 1997), xiii-xiv.

[5] Chart is adapted from Tom Czerwinski, Coping with the Bounds (Washington, D.C.: Institute for National Strategic Studies, 1998), 43.

[6] John F. Schmitt, "Command and (Out of) Control: The Military Implications of Complexity Theory," in Complexity, Global Politics, and National Security, ed. David Alberts and Tom Czerwinski (Washington, D.C.: Institute for National Strategic Studies, 1997), 231.

[7] Martin Van Creveld, Command in War (Cambridge: Harvard University Press, 1985), 269-270.

[8] Virginia Postrel, "The Future and Its Enemies," Lecture, Naval War College Foundation, Naval War College, Newport RI: 19 January 2000. The lecture is based on a book by the same name.

[9] Dr. Karen Stephenson, "Networks and the Opportunity for Organizational Innovation," Lecture, Hawaii Conference on Performance Excellence, Sheraton Waikiki Hotel: 14 October 1998. The terms pulsetaker, hub, and gatekeeper were all used to describe elements of an organizational network's DNA, though not in the context of their hierarchical equivalents.

[10] Tom Czerwinski, Coping with the Bounds (Washington, D.C.: Institute for National Strategic Studies, 1998), 85.

[11] Ibid., 234.

[12] Marc Bloch, Strange Defeat (New York, 1968), 36-37, 40, quoted in Williamson Murray, "Armored Warfare," in Military Innovation in the Interwar Period, ed. Williamson Murray and Allan Millet (Cambridge: Cambridge University Press, 1996), 34.

[13] Joseph J. McMenamin, "Operational Decision Making: The Impact of Time and Information" (Unpublished Research Paper, U.S. Naval War College, Newport, RI: 1995), 3-4; and Gary Klein, "Strategies of Decision Making," in Coping with the Bounds, ed. Tom Czerwinski (Washington, D.C.: Institute for National Strategic Studies, 1998), 140.

[14] Gary Klein, "Strategies of Decision Making," in Coping with the Bounds, ed. Tom Czerwinski (Washington, D.C.: Institute for National Strategic Studies, 1998), 145-155.

[15] Timeliness, accuracy, and relevance are the three desirable aspects of information cited by David Alberts, John Garstka, and Frederick Stein, Network Centric Warfare, (Washington, D.C.: C4ISR Cooperative Research Program, 1999), 56.

[16] These four domains are a variant of the four "spaces" or "topologies" (physical, computational, informational, and cognitive) formulated by LCDR Jeff Cares, Naval War College Strategic Studies Group, during a 20 Jan 00 discussion with CDR John Dickmann and myself.

[17] Milan Vego, On Operational Art (Joint Military Operations Department, U.S. Naval War College, Newport, RI: 1999), 195.

[18] U.S. Marine Corps, Command and Control (MCDP 6)(Washington, D.C.: 4 Oct 96).

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