REPORT DOCUMENTATION PAGE

Form Approved
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1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
28-05-2007	FINAL	

4. TITLE AND SUBTITLE
Command at the Edge of Chaos

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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Paper Advisor (if Any): Michael L. Felmly

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Joint Military Operations Department
Naval War College
686 Cushing Road
Newport, RI 02841-1207

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Statement A: Approved for public release; Distribution is unlimited.

13. SUPPLEMENTARY NOTES A paper submitted to the faculty of the NWC in partial satisfaction of the requirements of the JMO Department. The contents of this paper reflect my own personal views and are not necessarily endorsed by the NWC or the Department of the Navy.

14. ABSTRACT

Traditional hierarchical military staff organizations at the operational level of command remain suited for executing status quo and slowly evolving military operations focused on simple problems. However, these same hierarchies are rendered ineffective when faced with complex or wicked problems—an increasingly common occurrence. Replacing traditional staff structures with flat, self-organizing networks at the operational level of command and war will allow commanders to efficiently synchronize vast resources and more effectively attack rapidly evolving, complex and wicked problems. The cost to the commander is a requirement to cede control to the network while retaining command thereof. This paper looks at the limitations of hierarchical organizations, the advantages of leveraging self-organizing networks in a contemporary military context, and how such networks should be created and commanded. Finally, the paper provides recommendations to operational commanders concerning when and how to employ self-organizing networks within operational level staffs.

15. SUBJECT TERMS
Self-organizing networks, social networks, self-organization, hierarchies, organizational theory, operational level staffs, complex problems, wicked problems

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Chairman, JMO Dept
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		27	**19b. TELEPHONE NUMBER** *(include area code)* 401-841-3556

Standard Form 298 (Rev. 8-98)

NAVAL WAR COLLEGE
Newport, R.I.

Command at the Edge of Chaos

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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: _____

10 May 2007

Abstract

Traditional hierarchical military staff organizations at the operational level of command remain suited for executing status quo and slowly evolving military operations focused on simple problems. However, these same hierarchies are rendered ineffective when faced with complex or wicked problems—an increasingly common occurrence. Replacing traditional staff structures with flat, self-organizing networks at the operational level of command and war will allow commanders to efficiently synchronize vast resources and more effectively attack rapidly evolving, complex and wicked problems. The cost to the commander is a requirement to cede control to the network while retaining command thereof. This paper looks at the limitations of hierarchical organizations, the advantages of leveraging self-organizing networks in a contemporary military context, and how such networks should be created and commanded. Finally, the paper provides recommendations to operational commanders concerning when and how to employ self-organizing networks within operational level staffs.

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The "Big" Problem

Traditional hierarchical staff organizations at the operational level of command remain well suited for executing *status quo* and slowly evolving military operations focused on simple problems[1], but a more suitable alternative must be found for the planning and execution of new and rapidly evolving operations in the face of complex and wicked problems.[2] Complex and wicked problems are not simple problems on steroids—they are fundamentally different. Authoritarian strategies can only be successfully applied to relatively simple problems where the organization is sufficiently robust to identify and control all of the problem's variables—an increasingly rare condition in modern international politics or war. Complex and wicked problems (and their resolutions) are socially defined;[3] Rigid hierarchical organizations cannot solve them.[4] Yet, these are the types of problems our hierarchically structured military is increasingly tasked to solve.

1 A problem is defined as that which "distinguishes an observed condition from a desired condition." See Rittel and Webber, "Dilemmas in a General Theory of Planning," 159.

2 Simple problems are easy to identify and have simple solutions that all of the interested, involved and affected parties (stakeholders) can agree upon. Complex problems have uncertain solutions and are characterized by disagreement between stakeholders concerning their preferred solutions or courses of action. Additionally, there are often stakeholders who are difficult to identify. Wicked problems are problems that cannot be reduced to a definition acceptable to all stakeholders, that feature ever changing constraints, that continue to rapidly evolve in unanticipated ways as partial solutions are implemented against them, and that can never be solved. See Roberts, "Coping with Wicked Problems" as well as Rittel and Webber, "Dilemmas in a General Theory of Planning."

3 Socially defined problems (and their resolutions) are the product of multiple interactions between multiple entities and the relative strengths of the relationships between the entities. Theses problems cannot be described in linear terms, and rely upon the judgment of stakeholders to identify a suitable resolution. Such problems are never solved, but repeatedly re-solved. See Rittel and Webber, "Dilemmas in a General Theory of Planning," 160-7.

4 Rittel and Webber, "Dilemmas in a General Theory of Planning," 155-69. Roberts, "Coping with Wicked Problems," 353-75.

The antithesis of authoritarian, hierarchical organizations is not chaos as many imagine, but self-organization.[5] Systems displaying self-organizing properties exist all around us. They exist as highly adaptive, learning entities, that build their own relationships and internal processes to benefit the system as a whole. Examples include bacteria evolving to defeat antibiotics, independent programmers producing and refining open source software, free markets that efficiently produce and allocate resources, as well as ants and bees displaying "swarm intelligence."[6] These organizations leverage external actors and resources to perform critical tasks based on reciprocity vice contractual or transactional models.[7] The study of self-organizing networks continues to reveal critical attributes and dynamics that can be used to create and govern efficient, adaptive and responsive organizations able to effectively apply extensive internal and external resources to solve complex and wicked problems.[8]

Replacing traditional staff structures with flat, self-organizing networks at the operational level of command and war will allow commanders to efficiently synchronize vast resources and more effectively attack rapidly evolving, complex and wicked problems. Allowed to operate without the constraints inherent in hierarchical organizations, these new

5 Scientists studying organizational behavior have borrowed multiple definitions of "self-organizing" systems and networks from other scientific disciplines. Unfortunately, this has not yielded a common definition. For purposes of this paper, "self-organization" will be defined as *the development of cooperative relationships and processes amongst individual entities to produce commonly beneficial outputs occurring in the absence of a pre-ordained design or central direction.* This definition is a amalgamation of several definitions recounted and discussed by Mark Fleischer in "Foundations of Swarm Intelligence."

6 Swarm intelligence describes the concept of controlling and managing complex systems of interacting entities through simple, structured interactions between the entities. It is based upon a pattern of emergent or self-organizing behavior, and a population of entities with only minimal communications capabilities and processing capacity. The term originated from observations of social insects such as ants, bees and termites. See Fleischer's "Foundations of Swarm Intelligence."

7 In a reciprocity model, actions supporting the whole are undertaken by entities based on a non-binding expectation that another entity would do the same or similar to support the first. A contractual model requires that a binding agreement be negotiated between entities before such actions will be undertaken, and a transactional model requires that an exchange of value accompanies each such action.

8 Clippinger, "Order From the Bottom Up," 1-30.

staffs will synchronize military and non-military resources in ways that can resolve complex and wicked problems, and fully leverage the advantages of decentralized execution.

The Problem with Hierarchies

Research focused on social networks suggests that humans can only effectively manage 150-200 relationships within a given context. When a group of individuals or discrete entities in an organization exceeds this number, humans usually institute traditional hierarchies to facilitate better management.[9] Large, organized armies appear to have employed some sort of hierarchical structure as far back as the days of Sun Tzu and probably even well before then. However, the development of formal hierarchical staffs at the operational level of command and war seems to have begun with Napoleon I. After his death, the French and the Prussians developed the concept of standing staffs at the operational level of command and began to formally educate staff officers in operational art to populate the staffs.[10] The Prussian system for building and organizing their hierarchical staffs proved extremely effective in solving the simple problem posed by the French military in the Franco-Prussian War (1870-1871).[11] Notably, the overall design template for today's U.S. military staffs at the operational level of command is quite similar to that of the Prussian staffs in 1870.

9 Clippinger, "Human Nature and Social Networks."

10 Irvine, “French and Prussian Staff Systems,” 192-203.

11 The Prussian staff system of 1870 featured separate staffs to focus on peacetime affairs and preparations (man, train and equip functions) versus wartime operations, and a function-based organization (including sections for operations, communications and intelligence). Additionally, Prussia utilized a merit based system to develop and promote its staff officers. Though also hierarchically structured, the French staffs were not as efficiently organized, and French staff officers were not educated and developed as effectively as their Prussian counterparts. Predictably, the Prussian staff system proved vastly superior to the French staff system during the Franco-Prussian War (1870-1871). See Irvine, “French and Prussian Staff Systems.”

Large hierarchies are developed to maintain centralized control as span of control[12] and information volume increase. Such hierarchies are a rigid, authoritarian approach to ensuring unity of effort through the concentration of control and knowledge in a single leader. Business protocols and rules are implemented to enforce the structure of the organization. These very characteristics mean that as traditional military staff hierarchies grow, they tend to become less adaptive and slower to react to external situations and environmental changes. Even the most efficient hierarchical staff will be quickly overwhelmed by complex and wicked problems regardless of the size of the organization it commands. These organizations are simply overwhelmed by the same factors that exist in economic systems.[13]

(1) More data exists than can be aggregated[14]—a leader cannot fully comprehend or visualize the problem or the effects of ongoing efforts to solve it.

(2) Data is always changing and evolving; analytic processes studying the data are at maximum capacity and unprocessed data is constantly backlogged and thus becoming stale.

(3) No individual or small group is sufficiently diverse to recognize and solve all of the interrelated problems inherent in the data.

(4) A central leader attempting to coordinate the entire system will overwhelm everyone in the system with data and limit their ability to make good

12 "Span of control" is a human resources term that refers to the number of direct subordinates an individual can manage efficiently within an organizational hierarchy.

13 Most real world open markets are governed by a complex mix of inputs, transactions and results. The case of monopolies excepted, those that attempt to control or profit from such markets are attacking wicked problems in most cases.

14 Aggregated data refers to high-level information assembled from a multitude or combination of sources that has been analyzed and digested.

decisions.[15]

Hierarchical military staffs usually recognize and attempt to address the first two of these challenges[16], then dismiss the other two. This is a recipe for failure, but such failures are most often obscured. Bureaucratic organizations, to include the military, often encourage leaders to promote their own successes while subordinating the group's interests in order to ensure their own advancement. In such cases, leaders take credit liberally without accepting blame; that is to say that they compromise accountability and transparency within the organization to achieve personal success.[17] Most often, such leaders move on to new positions before complex and wicked problems are actually resolved.

An Alternative Approach to Organization

Taking the position hierarchical staffs are ill-suited for much of what the military depends upon them to do, it may seem odd that this paper has spent so much time discussing them. The purpose of this effort has been to understand why the alternative to hierarchical staffs already exists on a small scale within the existing hierarchical structures. The business rules of hierarchies are formal and impersonal in nature. Since these structures lack transparency and trust, real work tends to be done through social networks by a minority of the organization and not through the hierarchy. In effect, self-organizing networks are doing the real work, while their members consciously disregard the business rules of their largely non-productive host hierarchies.[18] The challenge is to understand these internal social

15 Denning and Hayes-Roth, "Decision Making in Very Large Networks," 23. Adapted from the work of F.A. Hayek.

16 Commonly attempted solutions to the first two challenges are an increase in local manpower, and/or new technological solutions for information management. Applying increased manpower results in an ever larger hierarchical staff with an ever slower data flow rate, and new technologies usually improve information flow predominantly to their sponsors at the top of the hierarchy, and strengthen the hierarchical leader's centralized control of subordinate entities.

17 Clippinger, "Leadership."

18 Clippinger, "Human Nature and Social Networks."

networks and then find ways to leverage them on a larger scale as the primary process within existing organizations.

There are four critical attributes that appear in all effective self-organizing networks. These include (1) an innate and common understanding of the organization's overarching goal, (2) trust, (3) transparency, and (4) a commons for communication.[19]

(1) Entities may be programmed with a common goal much like insects that seek food. They may simply recognize an advantage in cooperation, or they may find themselves sharing an altruistic purpose. Their reason for participating in a network that shares a common purpose is not important; however, it is critical that their operations abide by the intent to advance the network toward that purpose. If the network is of sufficient size and diversity, even misguided efforts will help the network advance provided the intent was positive. This happens because other members of the group will make countering errors. In fact, the average of all member efforts will usually provide a better solution than the effort of even the smartest (or most accurate) single member.[20]

(2) Trust is a measure of quality for social relationships. Each entity within a network will have its own evaluations of its relationships, though many initial transactions (exchanges of value) between unfamiliar entities may assume a certain degree of trust based on the admission criteria of the network. In most networks, transaction costs[21] are inversely proportional to trust. Since minimal transactions costs are in the interest of all participants,

19 Denning, "Hastily Formed Networks," 15-20. Clippinger, "Human Nature and Social Networks." Surowiecki, *Wisdom of Crowds*, 69-83, 108-42.

20 Surowiecki, *Wisdom of Crowds*, xi-xxi, 29-36, 69-83, 189-91.

21 Transaction costs refer to fiscal and temporal costs incurred in executing an exchange. Such costs include commissions to brokers, costs associated with drawing up and signing contracts, costs to verify the goods or services being exchanged, and insurance fees to protect against unscrupulous business practices.

many networks are self-enforcing and will sideline or reject untrusted entities. A network with a high degree of trust between its members will enjoy very low transaction costs.[22]

(3) Transparency ensures that all entities in a network can monitor each other's behavior. If there are no hidden agendas or actions, the entities can adjust their actions in response to others. Transparency is a fundamental tenant of effective markets, self-synchronization, and peer enforcement of network rules and norms.[23]

(4) Finally, a commons for communication allows social transactions to occur. The commons may take many forms. For an insect colony, it might be an environment that will allow the placement and collection of pheromones,[24] while for organizations involved in disaster response it may be the Internet or a framework for face-to-face meetings. Without a commons, there would be no way to communicate or execute transactions and thus the network would cease to exist except as individual entities. Ensuring that the commons is open and available to support all network transactions helps to ensure transparency throughout the network. Additionally, the extent to which the network can efficiently exchange data within the commons will have a direct impact on the overall efficiency of the network and its ability to self-synchronize.[25]

A Self-Organizing Model

One example of a self-organizing network, that a military Joint Task Force might participate in as a component is a hastily formed network (HFN). A HFN is defined as an organizational structure that is (1) rapidly assembled in response to a crisis or other urgent

22 Clippinger, "Human Nature and Social Networks."
23 Ibid.
24 A pheromone is a biochemical secreted by an animal, especially an insect, that functions as a signal to influence the behavior of others of the same species. Social insects, such as termites and ants, may secrete a dozen or more discrete pheromones to coordinate the complex activities that a colony must execute to maintain its health.
25 Denning, “Hastily Formed Networks,” 15-20. Surowiecki, *Wisdom of Crowds*. Clippinger, "Human Nature and Social Networks."

development, (2) using entities with the expertise or local responsibility to assist, (3) but that have not previously worked together, (4) and that do not accept a higher decision-making authority. Entities within the HFN may be hierarchical or flat organizations, however the HFN itself will not be entirely hierarchical or flat. When the HFN is operating at peak efficacy, it will be a system of collaborating organizations working towards an objective that exceeds the normal scope of any of the participants. At such a point, the HFN is termed a *hyper-network*. Decisions are not made by a central leader, but through a collaborative process at the system's periphery. Individual entities within the HFN retain their own separate identities, but the whole becomes a highly complex and adaptive system-of-systems. Like all self-organizing networks, the HFN's members learn from the results of their collective behavior and apply their accumulated knowledge to future behavior. The network actually comes to function as a free market in which many players commit to rational transactions transferring resources to further a common purpose.[26]

U.S. military participation in the disaster relief operations that followed the October 2005 earthquake in northern Pakistan followed the HFN model. The combined military and civilian effort did not achieve hyper-network status (resource allocation never achieved the efficiency of an open market); however, it achieved the goals set by its participants and averted further loss of life in the aftermath of the earthquake which was a complex problem. In a somewhat unfamiliar role, the U.S. military functioned not as a coordinating authority, but as a proactive and on-demand supplier of transportation and other services to the Pakistani military, the United Nations (UN), U.S. Agency for International Development (USAID), and a large number of non-governmental organizations (NGOs). The overall response wasn't coordinated by any one organization, to include the Pakistani Federal

26 Denning and Hayes-Roth, "Decision Making in Very Large Networks," 19-23.

Response Center (FRC) that was ostensibly created to do just that, or the UN agencies that served as its principle advisors. The UN provided a commons for communication and transactions through face-to-face, collaborative sessions at the local and regional levels, while the Internet served as a commons for electronic information exchange. The collaborative management and widespread use of the commons ensured transparency and trust. Organizations that did not collaborate transparently were ostracized by other members of the network.

The failed Federal Emergency Management Agency (FEMA) relief and recovery efforts after Hurricane Katrina were a clear expression of what happens when an attempt is made to forcefully create a hierarchical version of a HFN and address a complex problem. The participating entities did not universally accept FEMA as their higher authority. FEMA attempted to force centralized decision making, but was unable to handle the data flow required to make decisions. FEMA lacked the expertise required to solve aspects of the problem and was unable to provide a widely accepted commons for communication that could be accessed by all the participants. The result was "severe interorganization coordination problems, jurisdictional disputes, information overload, and fraud and waste of relief funds." To be fair, FEMA was not designed to handle the role of response coordinator in such a crises, and only a true HFN operating as a hyper-network could have coordinated the response that the public expected in this case.[27]

27 Ibid, 19-23.

Function	Hierarchical (Centralized) Approach (Examples: FEMA and the military)	Self-Organizing (Decentralized) Approach (Example: HFNs)
Modeling	The organization operates on beliefs about how the world works. Their world model shapes perception and action. Lower levels of the organization are tasked with collecting data to update and confirm the model. Some organizations are good at noticing discrepancies and responding to them by changing their models, but this is difficult and not usually done well.	Models can be built and validated by *ad hoc* communities of interest, such as those that detect outbreaks of disease, determine most desirable and affordable consumer products, or assess the effects of human activity on global environmental measures.
Declaring	Top-level managers define missions and strategic direction. Lower-level managers interpret those for action within their units. The chain of command resolves disagreements by moving them up to the nearest common manager.	Declarations can be made by a governing board of peer representatives who bring different expertise to the table and reach consensus over group actions. Tools such as blogs and wikis have been successful in helping people and their representatives in such groups form their opinions and reach consensus.
Giving Orders	Orders are passed down the chain of command. Requests and proposals are passed up. Individuals feel strong obligations to obey orders within their chains of command.	Orders are replaced by local decisions conforming to the group strategy articulated by the community's board, by a consensus process, or even simply by opinion leaders.
Allocating Resources	Top-level managers allocate resources to next-level units, who subdivide and allocate to smaller units, and so on. Requests for resources are passed up the chain of command and are aggregated into larger requests as they move up.	Resources are allocated by market mechanisms. Those in need find those who can supply valued goods and services through some type of market that moves information efficiently and simplifies transactions. The distributed suppliers make locally optimal decisions about how best to maximize their value.

Table 1. Approaches to organizational functions.
Reprinted from: Denning and Hayes-Roth, "Decision Making in Very Large Networks," 22.

Leveraging Self-Organizing Networks Within the Military

While self-organizing networks are by definition not controllable by any single entity whether internal or external, they can be commanded. The U.S. military codified much of the doctrine required to command networks long ago, though it should be noted that it differs little from that of Lord Nelson's fleet. A commander's intent is the governing guidance for a given strategy. The specific intent of the commander with respect to a given operation and/or campaign is instilled in subordinate unit leaders through issued orders. The subordinate units then operate autonomously according to that intent while reporting their results and anticipated major actions to the overall commander. When the United States first entered into Afghanistan to attack al-Qa'ida and the Taliban, Special Operations Forces and other U.S. agents led the way. These forces consisted of highly decentralized, small teams that had uncontested authority to establish local alliances, plan and execute local operations, procure and distribute resources locally, and directly coordinate with adjacent teams. Their only

guidance was the commander's intent instilled before they entered the operation. They were highly effective until the U.S. military moved major units into country, established a rigid hierarchical command and control system in country, and shifted operating authorities to senior military officers. At this point, U.S. forces were no longer free to operate as a part of the indigenous systems. The larger U.S. units established their own camps, began operating according to their own formal doctrine and tactics, and became a parallel entity to the indigenous network of forces that had been executing the war. Instead of leveraging local social relationships and resources to collect intelligence and execute the war, they relied entirely on their own hierarchical organization. The large units were centrally controlled, information and opportunities were directed to be forwarded to a senior officer before they could be acted upon. Additionally, the trust and transparency that had existed between indigenous forces and the small teams who lived and operated amongst them was lost in the face of the new hierarchies, and the costs and risks associated with cooperation increased for both sides. The result was not a failed effort, but a greatly slowed effort.[28]

The initial U.S. network on the ground in Afghanistan might have been labeled “in command and out of control.”[29] While U.S. doctrine advocates decentralized execution, it is rarely practiced as written. Instead, commander's at all levels tend to utilize their advanced communications systems and information technologies to keep very closely apprised of subordinate actions and to provide almost continual control of these forces. This is not, however, necessarily to the commander's advantage.

28 Denning, "Network Laws," 19-20.
29 Gladwell, *Blink*, 118.

During the first iteration of the Millennium Challenge[30] war game that preceded the United States led invasion of Iraq in 2003, the Red team produced an overwhelming victory against a vastly more powerful Blue force by operating according to a self-organizing model at the operational level. Red exploited Blue's inherent inability to rapidly adapt its hierarchical organization to rapidly changing threats and a rapidly changing battlefield environment. After the first iteration of the war game, it was replayed with Red constrained to employing a centralized hierarchical command and control organization, and employing cooperative and non-evolving tactics. With Red so constrained, the result of the second iteration of the game was the expected overwhelming Blue victory.[31]

Building Effective Self-Organizing Networks

In early-March 2003, the World Health Organization (WHO) set out to identify the cause of a severe acute respiratory syndrome (SARS) with flu-like symptoms that had originated in China. On 15-16 March, the WHO contacted 11 research laboratories from around the world and asked them to collaborate to resolve the issue. On 17 March, the labs embarked on the project with the only ground rules being that they agreed (1) to share all research results on a WHO website, and (2) to participate in a daily teleconference to share their work, discuss findings, and discuss courses of action for future research to resolve the problem. The labs were otherwise left to self-organize their collective effort. On 16 April, the labs confidently announced that the unlikely coronavirus was the cause of SARS. Able to

30 Millennium Challenge was a Joint Forces Command (JFCOM) sponsored war game executed over two-and-a-half weeks in 2002. The objective of the game was to test effects-based warfare concepts and JFCOM's operational net assessment tool set. The war game pitted the full capabilities of the U.S. military (Blue) as the invading force aimed against a rogue leader with a strong ethnic power base who was harboring terrorists in an unnamed Middle Eastern state (Red). Blue was expected to lift the “fog of war” through the use of extensive reconnaissance assets, robust communications connecting the tactical to the strategic levels of command, and an advanced common operating picture. In the second iteration of the game, Blue was declared to have fulfilled this expectation and validated the concept of effects-based warfare. See Gladwell's *Blink*.

31 Gladwell, *Blink*, 104-11, 117-9, 124-5, 143-6.

benefit in real time from the research being done by the partner labs, each lab had been able to concentrate on what it saw to be the most promising lines of research and to approach them using their respective strengths. The labs self-organized to avoid duplication of effort, self-synchronize their work, and to efficiently exchange data and biological samples. The success of the 1-month effort was remarkable as any one of the labs could have been expected to take months, if not years, to identify the cause of SARS. To achieve its objective, the WHO had provided the network overall direction by issuing a statement of intent, built trust in the network by controlling its membership, and ensured transparency in the network by insisting that all data be freely exchanged through the daily teleconferences and its website—tools that the WHO provided as a commons for communication and data exchange transactions. In addition to the provision of these four factors critical to all self-organizing networks, the WHO had increased the collective power of the network by selecting a very diverse group of labs with different capabilities and experience. By doing so, the WHO ensured that a very diverse series of possible causes for the disease and methods to isolate them would be considered from the beginning of the collective's work.[32]

In human networks, the goal of the organization is articulated through a common language, as was the WHO's statement of intent in the SARS case. When a leader or commander desires to influence or impose guidance upon a network, there are ways that they can do this to greater or lesser effect. Orders are rarely constructed so as to be effective if literally interpreted, and common sense tells us that we should follow the intent of an order vice its literal direction. How then can a commander effectively communicate intent that will be correctly applied in a variety of anticipated and unanticipated situations? The answer lies in the language used. The English vocabulary is divided into two levels of specificity or

32 Surowiecki, *Wisdom of Crowds*, 158-63.

registers. Low register words are the non-specific, colloquial terms used in everyday speech. High register terms are those words that are highly-specific, technical terms that leave little room for interpretation by the listener.[33] Social decorum has defined those situations and topics for which language of a particular register is appropriate. High register terms are often used in issuing commands in an attempt to remove chances of misinterpretation through precision of language. Except in the case of extremely specific tasks, this is misguided. By using low register terms, the commander can better express intent that can be applied to a broad array of situations. Low register terms provide clear signaling to listeners because their applicability extends beyond a very narrow context, and they rely instead upon shared experiences and the organization's social protocols that are deeply understood in a common fashion. As such, low register terms are best suited for creating a shared vision of the commander's intent.[34]

The business rules for decision making in a network also play a large role in the quality of the network's outputs. Complex and wicked problems dictate that decision makers will require very large volumes of very specific knowledge in order to make good decisions. The delivery of such knowledge to a central decision maker rapidly becomes impractical and paralyzing to a centralized hierarchical organization. Consequently, decisions tend to be made with too little specific information (a common practice). Decentralized, self-organizing systems offer alternative approaches for decision making. According to the business rules created by the network, specific knowledge holders may be empowered to make decisions dependent on their knowledge, or a collaborative decision making process

33 Clippinger provides the following examples of high and low register terms for “mad” behavior:
High register terms: Melancholic, Hypochondriac, Catatonic, Manic, Schizoid, Non compos mentis, Schizophrenic, Psychotic, Neurotic
Low register terms: Demented, Insane, Mad, Mental, Bonkers, Cuckoo, Loony, Crazy, Nuts

34 Clippinger, "Human Nature and Social Networks."

may be employed. Given a large and diverse decision making body, an effective collaborative system might involve a tool as simple as straight majority voting by secret ballots.[35] However, in the context of operational level staffs, the decision making body may comprise a relatively small, homogeneous group of military officers, particularly in a war time scenario. While such a group's decisions will always benefit from diverse membership, they are likely to make good decisions so long as they are not polarized. By ensuring that group membership is not weighted towards one extreme or another, depolarization is relatively easy and research suggests that even a group constructed of equal numbers of members from the extremes will produce optimal decisions given a fair process. Small committees that deliberate collectively, then vote independently, have been shown to outperform even the most accurate individual in the group. Additionally, no correlation is seen between the performance of the smartest individual in a group and the group's performance. Thus, the group is smarter than the smartest people within it. The advantage of the group is its collective knowledge. Notably, multiple studies have also shown that effective group deliberation does not have to take any more time than individual decision making if properly governed.[36]

Given a networked organizational model such as a staff at the operational level of command where self-organizational layers could be interspersed between hierarchical layers, there are several ways that the advantages of the self-organizing layers could be instantly negated. If a self-organizing layer is included in a decision making process, it must be allowed to aggregate its knowledge through a voting process and make the decision. If this is

35 Ibid. Surowiecki, *Wisdom of Crowds*. 66-84. Throughout *The Wisdom of Crowds,* Surowiecki provides a number of more sophisticated methods for collaborative decision making suited to a variety of networks and groups.

36 Surowiecki, *Wisdom of Crowds,* 188-90.

not done, its collective knowledge is lost. Such a mistake played a role in the Challenger disaster when the committee studying the potential implications of the foam impact during launch was not given the opportunity to aggregate their knowledge and be included in the decision to dismiss the potential damage and cease efforts to inspect the shuttle's protective tiles prior to reentry.[37] If a higher echelon of the organization wishes to accept recommendations from a lower, self-organizing layer and then make the decision based on additional knowledge possessed by the leader, it should instead provide its additional knowledge to the lower network to be aggregated therein. All limitations and considerations that might affect a higher echelon's choice of a course of action should be included in the guidance given to the lower echelon of the network.[38] Another dangerous practice is for leaders to reach down past a self-organizing layer to direct a lower entity's actions. This layer transection undermines trust within the network and consequently undermines the network's ability to self-organize. Network leaders cannot episodically individualize elements of the network in this way if they want an effective and efficient whole.[39]

Challenges to the Utility of Self-Organizing Networks

In practice, self-organizing networks formed of companies and institutions dedicated to developing new innovations have shown several weaknesses that can develop over time. Network failures may include detrimental conflicts between entities, an over-reliance on stale

37 The committee chair reportedly began with the assumption that nothing could be done if the tiles comprising the shuttle's heat shield had been damaged (hardly the NASA spirit that brought *Apollo 13* home), then prevented the committee from concluding that an effort should be made to attempt to inspect the tiles. The group never had the opportunity to aggregate its knowledge due to the way the chair conducted the committee's meetings—asking specific questions to targeted individuals and then discouraging any additional conversation. The committee chair also presented the group with her conclusion as its decision without allowing the committee members to discuss contrary opinions or present their findings. Again, any further input was discouraged by the way the decision was presented. Whether intended or not, these actions directly led to the decision to cancel plans to ask DoD to image the tiles prior to reentry. See Surowiecki, *Wisdom of Crowds,* 172-83 for additional information.

38 Surowiecki, *Wisdom of Crowds,* 188-90.

39 Clippinger, "Leadership."

paths and processes, and free riders.[40] It is also apparent that further cooperation results from successful interactive learning, and that successful participation in one network improves the entity's ability to benefit another network.[41]

It is clear that the membership of a network can significantly affect its ability to self-organize and efficiently produce a valuable output. As such, organizations wishing to leverage such networks should take advantage of their opportunity to control the initial network membership to ensure diversity and quality. If members of previous successful networks are available, they should be included to "seed" the new network. Free-riders and members creating conflict within the network are usually only temporary problems and do not tend to drag down large self-organizing networks as they tend to rapidly ostracize participants that have proven to be untrustworthy or otherwise destructive to the network.[42]

The tendency of humans to gravitate toward the known and to rely on existing structures when they are believed to be adequate is well demonstrated in everyday life. As such, it stands to reason that human self-organizing networks will cease to evolve and change form if their environment and membership become constants. This suggests that they will evolve into stable organizations once they achieve a network resolution and a controlled *status quo* situation, but also that there may be utility in altering the network membership if a workable, but not ideal resolution to the problem at hand results from a network's efforts. Additionally, this suggests that organizations may realize little gain from supporting self-organizing networks to manage simple, non-evolving problems as the self-organizing

40 Free riders are members of a network that benefit from its collective actions, but provide no contributions that support the network's purpose or maintenance.
41 Rycroft, "Self-Organizing Innovation Networks," 11-12.
42 Clippinger, "Human Nature and Social Networks."

networks will rapidly devolve into rigid organizations such as hierarchies that are well suited for addressing such problems.

An argument has also been made that there is an inherent conflict between self-organized synchronization and operational synchronization in the military realm. The argument may rely upon Milan Vego's definition of operational synchronization, but purports that operational synchronization is inherently "purposeful, planned and centrally controlled."[43] However, Vego's definition of operational synchronization[44] does not mandate that operational synchronization be centrally controlled, just that the operational commander is responsible for the synchronization. In fact, Vego insists that operational synchronization must be flexible and adaptive to the changing operational situation. While he warns against fragmentary organizations, he maintains that a degree of decentralized command and control is essential and that commander's intent must be used to govern actions in wartime.[45] If a self-organizing network is functional and coordinating entities working to resolve a given problem, the network will not be fragmentary, and there will be no inherent reason that the members cannot self-synchronize at the operational level—instead, they will naturally do so to maximize their individual efforts according to the behaviors of the other members.

Recommendations To Operational Level Commanders

1. When faced with complex or wicked problems, operational level staffs should create *ad hoc* self-organizing networks to plan and execute relevant operations. There are several reasons to abandon the traditional J-code staffed joint planning group (JPG) or operational

43 Scherrer, "Risks and Vulnerabilities of Network-Centric Forces."
44 Operational Synchronization—arrangement of actions of multiservice (and often multinational) forces and the use of nonmilitary sources of power in terms of time, space, and objective in a campaign or major operation. *Reprinted from*: Vego, *Operational Warfare,* 644.
45 Vego, *Operational Warfare,* 548-53, 644.

planning group (OPG) organizational model for planning and the traditional J-code hierarchy for execution of such operations.

- Both the JPG and J-code organizations concentrate decision making in an individual who will be unable to aggregate all of the information necessary to make fully informed decisions, and who is unlikely to make decisions superior to a properly constructed group or network. It is not a mistake that Federal Reserve Board decisions are made by the Board vice the Chairman.
- Self-organizing networks can effectively coordinate and synchronize vastly larger systems than hierarchies and become more effective given greater diversity. The membership of such networks should be initially defined in a manner similar to that used for most joint task force (JTF) staffs. That is using a known core of personnel, augmenting it with a larger number of personnel drawn from diverse backgrounds with specialized skill sets, adding liaison officers from partner agencies and organizations, and finally including liaison officers from the units that will be immediately subordinate to the commander. Unlike a JPG or OPG built primarily from the commander's normal staff, such a group is not already structured and is free to self-organize and create an effective, socially defined structure if encouraged to abandon traditional structures. Such networks are inherently flat and ensure minimal separation between entities and maximize information sharing. While effective layers in hierarchies are limited by the number of social relationships a human can maintain (150-200), self-organizing networks can maintain much larger, flat layers since all entities in a layer do not need to be directly linked to all of the others in the given layer, in a layer above, or in a layer below in order for the system to operate at peak

efficiency.

- Given that self-organizing networks are unlikely to continue to improvise given an unchanging situation and stabilized membership, they should not be used to address simple problems or those complex and wicked problems that have been stabilized. Such organizations are not well suited for such tasks, and maintaining them will rarely be justified in such situations.

2. When committing to the employment of a self-organizing network at the operational level of command, commanders should take additional actions to ensure their success.

- The effective communication of commander's intent is clearly required to instill organizations with correct direction. While applicable to all staffs and units, it is particularly true of self-organizing networks where control must be given to the network. Low register terms should be used to define commander's intent, and maximum effort should be made to ensure that clarifications in the intent that are communicated in subsequent meetings and video teleconferences are captured and disseminated to the entire organization.
- Technologies such as blogs and virtual workspaces (Information Work Space, Defense Collaborative Tool Set, Groove) are readily available on unclassified and classified government networks, and can be further protected in secure enclaves if additional controls are required. Using a commander's blog to record the evolution and refinement of commander's intent will allow all of the commander's thoughts to be recorded and accurately reviewed by all helping to ensure that the intended shared vision is conveyed to the entire network. This is also a means to define the digital commons that the commander is providing to the network. Virtual workspaces can

allow self-organizing networks to function across dispersed geographic locations. In most cases, if a self-organizing network is to function effectively using a virtual workspace, all communications between system entities need to be forced into this commons. If a minority of members are only linked by the virtual workspace while other members utilize a localized commons, the social connectivity of the virtually connected will be limited, and their participation in the network will be limited accordingly.

- Transparency in the network can be ensured by defining the commons as an open environment. Open virtual workspaces can help, but the same needs to be applied to local meetings. QUALCOMM[46] requires that all of its meetings be included on a local calendar with a list of the topics to be covered in the meeting. This calendar is available to all members of the company, and the meetings are all held in conference rooms similar to surgical theaters. Meeting invitees all have seats at the table, however anyone in the company may attend the meetings taking a seat in the theater. The employees are further encouraged to freely flow in and out of the theater at their discretion so that they are not trapped in a meeting irrelevant to them, but are given the ability to collect all information they believe relevant to their activities and ensure that their actions are coordinated with related actions.

3. In opting to employ an *ad hoc* self-organizing network to manage an operation, the commander will have to balance the new network with standing organizations (to include their own hierarchical staff in many cases) at the same level of command and war that are responsible for problems in the same or adjacent geographic areas.

46 QUALCOMM is a wireless telecommunications research and development company based in San Diego, California.

- Articulating clear commander's intent for each organization will help to define the bounds of their activities and deconflict them at inception.
- Both the standing organizations and the new *ad hoc* self-organizing network are likely to find that they are at least stakeholders in the problem(s) addressed by the others. Most likely, they will be drawn to overlapping objectives over time and discover that their missions are converging. One way to counter this is to include the standing organizations as members of the self-organizing network (they are likely to be stakeholders in any case). The standing organizations can then seamlessly synchronize their actions outside of the network with those of the network, and provide direct support to the self-organizing network in accordance with their own needs and capabilities.

Letting Go

Traditional operational level staff hierarchies are no longer suitable for coordinating many of the operations with which the U.S. military is now routinely tasked. Complex and wicked problems, as well as the coordination of very large and diverse forces demand an alternative organizational structure to efficiently resolve and manage them. Adopting self-organizing networks at the operational level of command and war offers the commander an organizational option that can function and adapt at speeds matching the evolution rates of complex and wicked problems. These flat, socially defined networks are capable of taming even the most challenging situations, but require a degree of freedom that commander's may be anxious or reluctant to grant. To be effective, the self-organized networks must be trusted, empowered, and well programmed with an accurate vision of the commander's intent. To effectively conquer the problems operational commanders are most likely to face today and

in the future, they will have to accept an operations staff that is purposely out of control, but in command.

Bibliography

Clippinger, John H. "Human Nature and Social Networks" (draft chapter for a forthcoming book). SocialPhysics.org. Open source project sponsored by Parity Communications, Inc. Post date unknown. Accessed 09 Feb 2007. http://www.socialphysics.org/images/Human_Nature.pdf

Clippinger, John H. "Leadership" (draft chapter for a forthcoming book). SocialPhysics.org . Open source project sponsored by Parity Communications, Inc. Post date unknown. Accessed 09 Feb 2007. http://www.socialphysics.org/images/Leadership.pdf

Clippinger, John H. "Order From the Bottom Up." *The Biology of Business: Decoding the Natural Laws of Enterprise*. Ed. John Henry Clippinger III. San Francisco: Jossey-Bass, 1999.

Denning, Peter J. "Hastily Formed Networks." *Communications of the ACM.* Vol. 49, No. 4, April 2006.

Denning, Peter J. "Network Laws." *Communications of the ACM*. Vol. 47, No. 11, November 2004.

Denning, Peter J. and Hayes-Roth, Rick. "Decision Making in Very Large Networks." *Communications of the ACM*. Vol. 49, No. 11, November 2006.

Fleischer, Mark. "Foundations of Swarm Intelligence: From Principles to Practice." Center for Satellite and Hybrid Communication Networks. CSHCN TR 2003-05, 2003.

Gladwell, Malcolm. *Blink: The Power of Thinking Without Thinking*. New York: Little, Brown and Co, 2005.

Irvine, Dallas D. "The French and Prussian Staff Systems Before 1870." *The Journal of the American Military History Foundation*. Vol. 2, No. 4, Winter 1938.

Rittel, Horace W.J. and Webber, Melvin M. "Dilemmas in a General Theory of Planning." *Policy Sciences.* Vol. 4. 1973.

Roberts, Nancy. "Coping with Wicked Problems: The Case of Afghanistan." *Research in Public Policy Management, Volume 11b: Learning from International Public Management Reform*. Ed. Lawrence Jones, James Guthrie & Peter Steane. Oxford: Elsevier Science, 2001.

Rycroft, Robert. "Self-Organizing Innovation Networks: Implications for Globalization." *Occasional Paper Series*. Washington, DC: George Washington University, 2003.

Scherrer, Joseph H. "Risks and Vulnerabilities of Network-Centric Forces: Insights from the Science of Complexity." Naval War College. Newport: February 2003.

Surowiecki, James. *The Wisdom of Crowds*. New York: Doubleday, 2004.

Vego, Milan N. *Operational Warfare*. Newport: Naval War College, 2000.