Adaptive Command and Control of Theater Airpower

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Abstract

The Air Force doctrinally advocates centralized command and control (C^2) with decentralized execution as the best means to concentrate force on any facet of an enemy's power. Although there are historical examples of effective command and control that have been less centralized, the USAF views decentralization as the cause of inefficient and suboptimal use of airpower. Trends in modern business, government, economics, science, and computer and communications systems suggest that it is appropriate to develop predominantly decentralized C^2 methods to enhance the current doctrine. Two broad-based tools assist the development of the expanded spectrum of C^2 options. First, this study develops a conceptual framework and describes eight interconnected subject areas to consider in describing a C^2 system. Second, the author also describes the new science of complexity theory that provides interdisciplinary viewpoints to assess and enhance the adaptability and responsiveness of command and control. Juxtaposing the conceptual framework and complexity theory shows numerous intuitive connections between the two tools. By using the conceptual framework, this study describes the current archetype of centralized command and control through an organization built around a theater air operations center. Then, using complexity theory and other related sources, the study constructs a predominantly decentralized C^2 system characterized by a networked hierarchical organization. Other aspects of the decentralized system include the use of mission orders and requests, unified lines of combat command below the theater air component commander, different approaches to training, doctrine, and education, and decentralized planning, execution, and combat assessment networks. Using complexity theory, this study combines the adaptability and responsiveness of complex systems with the directed purpose of a theater campaign. If both centralized and decentralized C^2 options exist, then *adaptive* command and control describes operations at the most appropriate place on the spectrum. Several factors guide such a decision, among them the eight framework subjects and additional factors related to systems, airmen, the situation, and the commander. To operate at or between the two options, commanders must communicate their intent for commands based on mission, campaign phase, or objective, and there must be an infrastructure that can support both modes of operation. Regarding infrastructure, this study shows how a decentralized infrastructure can be centralized at will, while the opposite is not as easy to accomplish. The post-cold-war era presents an opportunity to begin building predominantly decentralized command and control as a viable option for theater airpower. A spectrum of options permits commanders to tailor their commands to the scenario and exploit the initiative and knowledge of their personnel to conduct effective operations regardless of magnitude, tempo, or complexity.

About the Author

Maj David K. Gerber, a native of Pennsylvania, was commissioned through the Reserve Officer Training Corps in 1984 upon graduating from the Massachusetts Institute of Technology (MIT). Following undergraduate pilot training at Williams Air Force Base (AFB), Arizona, he was assigned to fly the F-15C at Bitburg Air Base, Germany. He was subsequently assigned to Langley AFB, Virginia, as an F-15 instructor pilot and then to the F-15 Replacement Training Unit at Tyndall AFB, Florida, where he served as an instructor pilot and flight commander. Major Gerber is a senior pilot with more than 2,000 flying hours. He is a graduate of both Squadron Officer School and Air Command and Staff College. He holds bachelor's and master's degrees in electrical engineering and computer science from MIT, and a master's degree in airpower art and science from the School of Advanced Airpower Studies. In July 1997 Major Gerber was assigned to the Strategy, Resources, and Legislative Affairs Division, Plans and Policy Directorate—ECJ-5, Headquarters United States European Command, Stuttgart, Germany. Major Gerber is married to the former Louisa Gordy of Columbus, Georgia, and has two children, Christopher and Nichole.

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Chapter 1

Introduction

> *Confronted with a task, and having less information available than is needed to perform that task, an organization may react in either of two ways. One is to increase its information-processing capacity, the other to design the organization, and indeed the task itself, in such a way as to enable it to operate on the basis of less information. These approaches are exhaustive; no others are conceivable.*
>
> —Martin van Creveld
> *Command in War*

Martin van Creveld identifies a spectrum of command in war and describes the implications of moving in each direction.[1] The centralized approach requires increased information collection and processing capacity and leads to greater communications requirements and a larger, more complex central directing organ. The decentralized approach redesigns organizations to operate with less information or divides up the task to enable specialized subcomponents to handle smaller parts independently. Though these two general approaches are exhaustive, the options available within each approach and the gradations along the line connecting them are unlimited. An ideal command and control (C^2) solution remains as elusive as ever.

Nearly nine decades of combat experience form the basis for the United States Air Force's (USAF) master tenet of airpower. Centralized control by an airman with *decentralized* execution is the means by which the Air Force concentrates assets to attack any facet of the enemy's power.[2] According to USAF doctrine, centralized control provides advantageous synergies, establishes effective priorities, capitalizes on unique strategic and operational flexibilities, ensures unity of purpose, and minimizes the potential for conflicting objectives. Decentralized execution achieves effective spans of control, responsiveness, and tactical flexibility.[3] Based on van Creveld's analysis of command and control, centralized control places the USAF at the information-intensive end of his spectrum with the joint air operations center (JAOC) or combined air operations center (CAOC) serving as the complex, central directing organ.

This study asks whether the decentralized end of van Creveld's spectrum offers anything to the command and control of theater airpower. Regardless of its historical roots, centralized control with decentralized execution is still a *means* to achieving the goal of intelligent unity of effective effort toward a common objective.[4] Remembering the lessons of American aerial combat, this study's central question is asked. Is there a decentralized concept for command and control of the air component which may employ airpower more effectively than centralized command and control?

Significance

The Air Force has historically associated decentralized control with inefficient and sometimes noneffective employment of airpower. The poor record began in North Africa during World War II. Prior to the Casablanca Conference in January 1943, airpower was employed in small packages divided among army units with poor coordination and ineffective priorities. After the January reorganization and further fine tuning by Air Vice Marshal Arthur Coningham and Maj Gen James H. Doolittle, the Allies validated the primacy of air superiority, the need to cooperate with surface forces, and the importance of centralized control in combat, and the US Army Air Forces (USAAF) subsequently recorded the lessons in Army Field Manual (FM) 100-20, *Command and Employment of Air Power*, 21 July 1943.[5] Further combat in the Mediterranean and European theaters during World War II tended to reinforce the doctrinal lessons of North Africa.[6] The Korean War was notable for the disconnect between the Air Force and Navy, and the tension between the decentralized use of air assets for close air support (CAS) by the US Marine Corps (USMC) and the centralized control provided by the Far East Air Force (FEAF). In a classic conflict between effectiveness and efficiency, the decentralized Marine system was more effective for the CAS mission but wasteful of airpower across the spectrum of conflict according to the Air Force. Contrariwise, FEAF control denied the Marines the quantity, precision, and responsiveness they desired due to higher priority interdiction elsewhere in the theater.[7] Vietnam was the epitome of a decentralized quagmire. The Air Force divided theater command among three different levels but managed to construct a more responsive control system for Army CAS while conducting piecemeal interdiction theaterwide. The Marines had the most effective CAS, but from the Air Force perspective once again wasted airpower to get it. The Air Force and Navy used route packages for deconfliction, spreading airpower across the theater. Finally, the Army discovered how helicopters could provide CAS when fixed-wing aircraft were unavailable or delayed.[8] Although numerous factors contributed to the loss of the war, the association of these decentralized experiences with the loss in Vietnam argued for the return to doctrinal foundations during the Persian Gulf War in 1991.

In light of the turbulent historical record of decentralization and in spite of the decisive success of centralized control in the Gulf War, there are five compelling reasons to reexamine decentralized command and control of airpower. First, command and control is an interdisciplinary subject, and there are important similarities among recent experiences in many different fields. In business large corporations have had to adapt efficient mass production and long product design cycles to markets that are increasingly competitive because of rapid innovation and quickly changing customer requirements.[9] The most competitive corporations meet such a challenge through decentralized processes that allow them to take advantage of their large size but compete with the responsiveness of a small entrepreneurial firm.[10] Businesses failing in this task stagnate, go bankrupt, and operate in isolated or protected markets. In economics the abysmal productivity and ultimate collapse of the Soviet Union is a stunning example of the failure of centrally controlled economic policy. The Soviet Union is also among the numerous recent collapses of totalitarianism, governments that excessively concentrate political power in the hands of a few individuals or institutions.[11] In favor of decentralization, there is undeniably superior aggregate productivity in the open and largely uncontrolled markets in the free world. In communications the Internet is growing dramatically with the alignment of a decentralized architecture, personal computers, and innovative software. The Internet creates new avenues for collaboration and commerce that are independent of traditional time and geographical restrictions and have large economic effects of their own. The success of decentralization in these and other disciplines suggests that there may be applications which could benefit airpower.

Second, the increase in the speed of sensor-to-shooter communications combined with rapid movement and fleeting opportunities in a dynamic battlefield can quickly overwhelm a centralized decision-making authority. Assuming that important strategy decisions cannot be automated on a large scale (i.e., war by computer is unlikely), the only way to handle such a large number of decisions will be to permit more airmen to make them. Without a means to decentralize these decisions and still accomplish the goal of the master tenet of airpower, the future will be "data rich, information ragged, and decision poor."[12] While instantaneous communications and theater awareness permit a joint force air component commander (JFACC) to make *any* decision in the theater, he cannot make *every* decision in the theater. The sheer number of decisions in a dynamic theater mandate increasingly decentralized command and control.[13]

Third, there is a wealth of case studies on decentralization from other fields in addition to those cited above. A new interdisciplinary science that studies "complex adaptive systems" has established a foundation for studying decentralized phenomena across many environments.[14] This science has experienced explosive growth during its first decade, and there are now significant resources and many institutions throughout the world conducting research into decentralized, complex systems.[15] The potential for advances in this area to benefit the understanding of airpower command and control are enormous.

Fourth, centralized command and control inherently presents an enemy with a single, very critical friendly center of gravity (COG), regardless of where it is located. Such a COG will always depend on an airtight defense to ensure that it will be invulnerable to attack, an attack that can take place through either physical or informational means.

Fifth, C. Kenneth Allard commented on the impact of distributed information systems on organizations. "[Information networks] provide situation awareness independent of the limitations of standard hierarchical information flows. Ultimately, the proliferation of these distributed data systems could even involve considerable organizational stresses should command and information lines, once firmly welded together, begin to diverge."[16] In organizations where the command and information lines diverge, there is a choice to adapt command lines to exploit information flow or limit information flow to merge it with command lines. The information intensive modern battle space suggests that significantly limiting information flow will not lead to combat success.

Decentralization and centralization are a matter of degree, and the different approaches to command and control lean towards one label, the other, or somewhere in between. The objective of this study is not to reconstruct one of the historical versions of decentralization that demonstrably failed the test of combat. It also does not argue that current Air Force command and control is wrong or misguided. Instead, this study applies the principles of complexity theory to deductively construct a new, predominantly decentralized C^2 process for airpower. The new process does not replace current doctrine and processes and certainly has not been tested in combat, but it incorporates several combat-proven principles and may provide additional airpower capabilities. This proposal requires much more detail to make it practically useful, and it would experience its share of fog and friction like any system.

This study is written for military personnel with a knowledge or interest in the Air Force approach to the command and control of airpower. A background in Air Force C^2 organization and operation is helpful but not required—chapter 3 provides an overview. Additionally, the interdisciplinary nature of command and control may interest readers in other fields, especially fields involved in complex adaptive systems research.

Definitions

The concepts of command, control, and execution across the full spectrum of centralized to decentralized operations are key to this study. After reviewing the traditional definitions for each concept without the "centralized" or "decentralized" modifiers, the following definitions describe the purely centralized and decentralized limits for each concept and describe how its character changes across the spectrum. While no real-world system operates at the limits and the actual options (if they exist) between them may be finely or coarsely graded, a theoretical understanding of the absolute limits and the implications of movement between them provides valuable intuition.

Despite the common use of the terms, *command, control,* and *execution*, clear, succinct definitions do not exist in many doctrine documents. Air Force Manual (AFM) 1-1, *Basic Aerospace Doctrine of the United States Air Force*, offers no definitions but includes in the glossary of volume two the definition of the phrase *command and control* from Joint Publication (Pub) 1-02, *Department of Defense Dictionary of Military and Associated Terms*: "Command and control. The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in accomplishment of the mission."[17]

This definition is very similar to the 1995 definition in Joint Pub 3-0, *Doctrine for Joint Operations*.[18] Frank M. Snyder, in *Command and Control: The Literature and Commentaries*, divides the definition into three parts.

Command as a function is described by the first sentence in the above definition. Command, control, communications, and computers (C^4) as a system is described by the "arrangement of personnel . . ." and command and control as a process is described by the "procedures employed."[19] Unfortunately, the process definition includes the word it is in part defining, namely, *control*. Later, Snyder describes command as "the exercise of authority."[20]

Joint Pub 1-02 defines command very similarly. "The authority that a commander in the Military Service lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel."[21] The discussion here abbreviates the command definition to focus on its direct combat application. Command is the authority to formulate strategy and direct forces to accomplish missions based on that strategy while accepting responsibility for the results.

This study takes a systemic view of command in which the essence of "exercising authority" is decision, the expression of choice.[22] In a purely centralized command architecture, all authority, decisions, and responsibility rest in an individual traditionally at the top of a hierarchy or "center" of the organization. The control and execution arms of such an organization perform only administrative functions that perfectly support or execute the commands of the central authority but do not change their strategic substance in any way. A purely centralized command element serves as the point of synthesis or directly controls the decisions inherent in any synthesis mechanisms for all data gathered by the organization to aid decisions. Conversely, a purely decentralized command architecture is a relationship among functional units within an overall system in which each unit has its own authority and responsibility to decide strategy, control forces, and execute. In a purely decentralized command system, units still affect one another, but each unit decides for itself what to do in light of other units' activity and not because another unit "commanded" an action. Decentralized unit strategy may be based on the environment, interaction with other units, and internal status, but no central strategy directs an entire unit in such a system. Decentralized systems may exhibit seemingly unified, purposeful collective behavior or chaotic, destructive behavior, but whatever their behavior, it emerges from the aggregation of unit-level strategies and interactions. Chapter 2 discusses the aggregate behavior of decentralized systems at length.

Moving from a centralized to decentralized command architecture shifts decisions from a single authority to increasing numbers of authorities within the structure of the organization. In hierarchical organizations the scope and duration of decisions ideally mirrors the hierarchy itself.[23] In nonhierarchical structures, the location and scope of decisions may be more ad hoc and depend on factors such as the mission, expertise, and situation awareness.

AFM 1-1 frequently uses control yet fails to define it. Control is more often associated with the phrase *command and control*, which is defined as a process that supports the function of command.[24] Joint Pub 1-02 defines control as authority that may be less than full command exercised by a commander over part of the activities of subordinate or other organizations.[25] This definition reflects the fact that control is inherent in command but not vice versa, and this may be the reason why control is infrequently used outside the phrase *command and control*.[26] FM 22-103, *Leadership and Command at Senior Levels*, describes control as a process used to establish limits and provide structure so as to serve as a compensating, correcting device for command in the presence of uncertainty.[27] Another description of control is the *ability* to direct forces, in contrast to command as the *authority* to direct forces.[28] For this study, control is the mechanism that enables the direction of forces through detailed planning, coordination, monitoring, and guidance to support a strategy. Control includes decisions that administratively support a strategy, but it cannot change the strategy.

Purely centralized control consolidates the mechanism in a single individual or organization that is closely tied to the commander. Centralized control does everything to support a strategy except execute the mission. Purely decentralized control places all planning, directing, and guiding mechanisms in the execution components of the system, to include coordinating and monitoring actions through or with other units. The "strategy" (the command) may come from within the component, from outside sources vertically or horizontally removed, or from a combination of the two, but the controlling processes exist purely within the unit responsible for execution.

Decentralization moves control mechanisms away from a single commander towards the execution components in a way that depends upon the structure of the organization. In a hierarchical organization, each level of the hierarchy normally adds a specified level of detail to the decisions from the level above, thus providing increasingly refined guidance to lower levels. Within such a control mechanism, command may still come from a single source, but the decentralized levels of control must be both coherent with each other and support the commanded strategy, sometimes called nesting. To the extent there is flexibility in the implementation of a commanded strategy, subordinate commanders make decisions supported by a corresponding control mechanism. The result is a hierarchical cascade of both command and control from the top to the bottom of the organization, a time-tested means for commanding large organizations like those found in the military. If there is no flexibility in the implementation of a commanded strategy, then a subordinate authority serves only in a control role and may be called a director. In nonhierarchical structures, there are many possible arrangements of decentralized control mechanisms that may be permanent or change dynamically based on the situation.

Execution is another term rarely defined by doctrine, which makes decentralization or centralization even more difficult to discuss. This study defines execution in the airpower context as the act of launching a vehicle or formation, marshaling, maneuvering, and accomplishing an airpower role in support of strategy. Execution begins upon the assignment of a mission to an operator and weapons system at the lowest level of an organization. Execution traditionally includes the planning efforts to administratively refine the mission at the operator level (in the wing, group, or squadron) and thus includes some aspects of control in the locus of decisions regarding launch, marshaling, maneuvering, and delivering ordnance or cargo. In purely centralized execution, the detailed decisions reside in a higher command authority or in automated systems controlled by that authority. The limit of purely centralized execution may actually exist in the form of a robot vehicle, such as a cruise missile or intercontinental ballistic missile (ICBM) that is remotely but centrally directed or preprogrammed to accomplish various mission tasks, to include evading an enemy. In effect the decision to employ force is indistinguishable from its control and execution. Purely decentralized execution implies that all decisions after mission assignment lie with the operator of the weapons system who cannot change the mission but may be permitted to abort or enhance it.

Remembering that these definitions are the theoretical limits, the Air Force traditionally leans towards decentralized execution for several practical reasons. One is the dynamic nature of most aerial missions. Another factor is the geographic distribution of airfields and the historically limited ability to communicate between airfields and from command authorities to airborne aircraft. While the limits of basing and geography are unlikely to disappear, modern communications makes centralization of execution increasingly possible.

Moving from centralization to decentralization of execution gives the operator of a weapon system progressively more authority to conduct operations and make decisions to complete an assigned mission. A more centralized system retains such authority at a higher level. For example, fighters on alert awaiting a scramble order are subject to a higher level of centralized execution than fighters launching on an air tasking order (ATO) mission against specified targets. Alert fighters typically contact a controlling agency that assigns the mission and may provide direct control to position for ordnance employment and subsequent permission to fire.

There are two additional ideas, uncertainty and distribution, which are related to the definitions above. First, uncertainty is commonly identified as the central problem of command. Van Creveld puts the quest for certainty in a central position in his book *Command in War*, with the often-quoted statement, “From Plato to NATO [North Atlantic Treaty Organization], the history of command in war consists essentially of an endless quest for certainty.” The impact of uncertainty on command is profound, but reducing or redistributing uncertainty represents the negative object of command. The positive object of command is purposeful decision and action based on strategic intent. Only human beings make decisions that reflect purpose or objective, even when human decisions are programmed into automatic equipment. This study frames command, control, and execution in human terms focusing on the arrangement and locus of decisions people make rather than the distribution of uncertainty throughout an organization.

Second, there is an important distinction between decentralization and distribution. Distribution refers to geographic or spatial location, but decentralization is a quality independent of location. Traditionally, geographic distribution implied a certain level of decentralization because communications technology could not overcome the effects of distance. Today, geographically distributed organizations may be decentralized to the extent command and control rests in the components or highly centralized if the components have no decision-making authority beyond execution level tasks. Likewise, collocated organizations can operate in a decentralized fashion depending on the arrangement of information flow and decision authority. Fast, pervasive modern communications have disassociated geographic distribution from the issue of decentralization. It is important to examine the actual processes with regard to the locus and location of decisions within an organization rather than the physical location of the organization's functional parts.

Scope and Background

Combining the centralized to decentralized spectrum defined above with a second dimension depicting the levels of command, control, and execution linking the JFACC to the operator yields a simplified depiction of the range of C^2 options (fig. 1). Command could be thought of as an upstream function, with control as a downstream process. As explained earlier, the C^2 interrelationship may cascade through several layers from the top to the bottom of an organization. The solid curve in figure 1 indicates the Air Force's current doctrinal preference for conventional airpower command and control. At point "a," command is relatively centralized in the JFACC, and at "b," control is predominantly centralized in the air operations center (AOC) but shared somewhat by the mission planning processes in wings, groups, and squadrons. At "c" execution remains almost fully decentralized at low levels in the organization. The region below the line, represented by dashed curve "d" for instance, represents the highly centralized command, control, and execution system that might characterize the employment of nuclear weapons. This study explores the region above

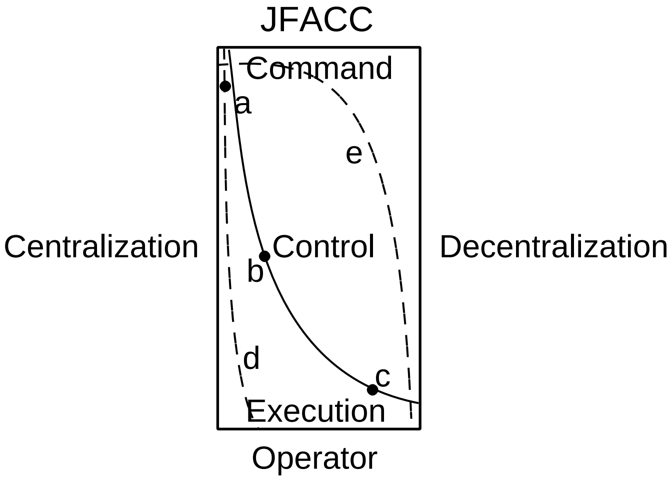


Figure 1. The Command, Control, and Execution Continuum

the solid curve (dashed curve "e") in which command and control is more decentralized than in the current architecture and suggests how commanders decide where to operate if the entire spectrum is actually available.

The scope is limited to the command and control of an air component at and below the JFACC level employed under joint (and Air Force) doctrine for air operations, command, and control in real-world theater operations. Real-world operations are nonroutine contingencies commanded by a commander in chief (CINC) or joint task force (JTF) commander who assigns missions to achieve specific objectives with a specified strategy usually in a certain period of time. There is no conceptual reason why these ideas, with appropriate adjustments, could not apply at higher command levels or to other components, but these topics lie beyond the current objectives. This study does not address the command and control of nuclear weapons.

Previous authors have laid a valuable foundation. Much of their work examining centralization and decentralization of airpower command and control falls into three general formats. First, historical case studies document, compare, and contrast past practice. The existing body of C^2 case studies provide a reasonably complete account of past practice in the airpower context.[29] The conclusions in this research include implications that flow directly from the case studies and the author's recommendations, which are not always derived from the case studies. If included, author recommendations are usually more general than specific since the goal of historical research is to describe and understand what happened more than to prescribe a solution to a specific problem. Second, this format focuses more on prescription to identify and perhaps to solve a problem in a specific technology, planning, or employment issue such as battlefield information distribution or sensor-to-shooter fusion.[30] Unfortunately, such studies rarely consider airpower as a whole as they recommend that command and control must change to accommodate a single specific capability. Third, theoretical studies aim at reductionism or general understanding based on a few principles and make limited attempts at practical application.[31] While all three categories provide a valuable foundation, especially so in the case of historical studies, they provide sparse material for building new airpower specific C^2 concepts. Fortunately, there is a growing body of work on command and control in the other military services, economics, government, engineering and physics, management, and even the cognitive and biological sciences.

Methodology and Organization

This study constructs an expanded spectrum for airpower command and control in three steps—structure, content, and application—which correspond to the organization of chapters 2 through 5.

In terms of structure, the study examines command and control using a conceptual framework, an approach which is important but apparently uncommon. Richard Butler, an organization design theorist, commented, that "because there are an infinite number of questions that a researcher can ask in any one situation, a theoretical framework is needed to help define the limits to the kinds of information that is sought."[32] Chapter 2 builds a theoretical framework for command and control that attempts to balance breadth and depth. The framework must be detailed enough to establish interdependencies yet general enough to avoid detail lying beyond the scope of this study. Chapter 2 further summarizes the theory of complex adaptive systems (or complexity theory) and links elements of this theory to the framework. John H. Holland, one of the leading scientists in complexity theory, remarked that "complex adaptive systems exhibit coherence under change, via conditional action and anticipation, and they do so without central direction."[33] Commanders covet qualities such as these in combat, so complexity theory will be helpful in building a concept for predominantly decentralized command and control.

Taken together, chapters 3 and 4 describe two options in an expanded C^2 spectrum. Chapter 3 applies the theoretical framework to current airpower C^2 practices. To quote Butler again, "in instituting change, organizations develop archetypes both of where they are in the present and of where they wish to go in the future."[34] Chapter 3 describes the current doctrinal archetype, avoiding the details of any particular theater. Chapter 4 is the core of this study, as it applies the principles of complexity theory and related disciplines to each part of the framework to build a vision of decentralized command and control of a theater air component. Although the framework is broad and complexity theory has distinct limitations, the goal in chapter 4 is to provide enough detail to show how the proposed system could enable hundreds of aircraft to accomplish missions in limited airspace with limited planning time and support assets.

Chapter 5 contrasts the systems presented in chapters 3 and 4 to outline the factors a commander should consider when deciding among a range C^2 options. Given that a range of options is actually available, chapter 5 describes the commander's intent for command as a vehicle for communicating the command, control, and organizational structure appropriate to the situation. Chapter 6 examines a transition path to the broader range of C^2 options and concludes with the study's recommendations.

Notes

1. Martin L. van Creveld, *Command in War* (Cambridge, Mass.: Harvard University Press, 1985). He defines command to include command, control, and communications.

2. AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*, vol. 2, March 1992, 113–15.

3. AFM 1-1, vol. 1, 8.

4. This observation also motivates the conclusion in Lt Col J. Taylor Sink, *Rethinking the Air Operations Center: Air Force Command and Control in Conventional War* (Maxwell AFB, Ala.: Air University Press, 1994), 47.

5. David Syrett, "Northwest Africa, 1942–1943," in Benjamin Franklin Cooling, ed., *Case Studies in the Achievement of Air Superiority* (Washington, D.C.: Center for Air Force History, 1994), 262–63; FM 100-20, *Command and Employment of Air Power*, 1943. See also AFM 1-1, vol. 2, 121.

6. Alan F. Wilt, "Allied Cooperation in Sicily and Italy, 1943–1945," in Benjamin Franklin Cooling, ed., *Case Studies in the Development of Close Air Support* (Washington, D.C.: Office of Air Force History, 1990), 193–98.

7. Allan R. Millet, "Korea, 1950–1953," in Benjamin Franklin Cooling, ed., *Case Studies in the Development of Close Air Support* (Washington, D.C.: Office of Air Force History,

1990), 397–99. See also Lt Col Stephen McNamara, *Air Power's Gordian Knot: Centralized versus Organic Control* (Maxwell AFB, Ala.: Air University Press, 1994), 89.

8. John J. Sbrega, "Southeast Asia," in Benjamin Franklin Cooling, ed., *Case Studies in the Development of Close Air Support* (Washington, D.C.: Office of Air Force History, 1990), 454–55.

9. James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine That Changed the World* (New York: Rawson Associates, 1990), 12–13.

10. See Anthony L. Velocci Jr., "Virtual Enterprise: A Plus for Lockheed Martin," *Aviation Week and Space Technology* 146, no. 6 (10 February 1997): 86. Koch Industries, Citicorp, Coca-Cola, Honda, and Intel corporations practice similar techniques as cited in Thomas Petzinger Jr., "The Front Lines: Self-Organization Will Free Employees to Act Like Bosses," *Wall Street Journal* 229, no. 1 (3 January 1997): B1.

11. Francis Fukuyama, *The End of History and the Last Man* (New York: Free Press, 1992), 13–22. Fukuyama discusses numerous countries in Southern Europe, Latin America, and East Asia that have recently moved away from totalitarian governments towards democracy.

12. William G. Chapman, *Organizational Concepts for the Sensor-to-Shooter World: The Impact of Real-Time Information on Airpower Targeting* (Maxwell AFB, Ala.: Air University Press, 1997).

13. Ibid. For contingencies that involve significant air operations, the joint force com mander normally designates a JFACC as the commander of the theater air component, a force which may include air assets from all services.

14. Complex adaptive phenomena appear in biology, psychology, neurology, all branches of physics, ecology, and seismology. See George A. Cowan et al., eds., *Complexity: Metaphors, Models, and Reality* (Reading, Mass.: Addison-Wesley Publishing Co., 1994). This is volume 19 of the proceedings of the Santa Fe Institute, a multidisciplinary research and teaching institution formed to study complex systems and their simpler elements.

15. The emergence of this science is traced to the founding of the Sante Fe Institute by a number of Nobel laureates in 1984, although the disciplines it describes extend back centuries in the fields of religion, economics, and philosophy.

16. C. Kenneth Allard, *Command, Control, and the Common Defense*, rev. ed. (Washington, D.C.: National Defense University [NDU] Press, 1996), 245.

17. Joint Pub 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington, D.C.: Government Printing Office [GPO], 1994), 78. This definition will also be used in AFDD 2-5.6 (first draft), "Command and Control (C^2) and Command, Control, Communications, and Computer (C^4) Systems," January 1997.

18. Joint Pub 3-0, *Doctrine for Joint Operations*, 1 February 1995, II-16.

19. Frank M. Snyder, *Command and Control: The Literature and Commentaries* (Washington, D.C.: NDU Press, 1993), 11–12.

20. Ibid., 18.

21. Joint Pub 1-02, 78.

22. A decision is a choice based on facts or values. See Lt Col Maris "Buster" McCrabb, "A Normative Theory of Air and Space Power Command and Control" (essay, School of Advanced Airpower Studies [SAAS], Maxwell AFB, Ala., 1997), 9.

23. The operative word is *ideally*. See Elliot Jaques and Stephen D. Clement, *Executive Leadership: A Practical Guide to Managing Complexity* (Oxford: Basil Blackwell, 1991), 100. The authors devised Stratified Systems Theory, which describes hierarchical organization based on time horizon, task, and cognitive complexity.

24. Snyder, 11–12; and McCrabb, 3.

25. The definitions of centralized and decentralized control in Joint Pub 1-02 apply to Army air defense operations.

26. Joint Pub 3-0, *Doctrine for Joint Operations*, February 1995, II-17.

27. FM 22-103, *Leadership and Command at Senior Levels*, June 1987, 41–42.

28. McCrabb, 3.

29. Historical case studies include Martin van Creveld, C. Kenneth Allard, and Lt Col Stephen J. McNamara; also Maj Michael E. Fischer, *Mission-Type Orders in Joint Air Operations: The Empowerment of Air Leadership* (Maxwell AFB, Ala.: Air University Press, 1995); James A. Winnefeld and Dana J. Johnson, *Joint Air Operations: Pursuit of Unity* in *Command and Control, 1942–1991* (Annapolis, Md.: Naval Institute Press, 1993); Maj

Edward B. Schmidt, “Targeting Organizations: Centralized or Decentralized?” (master’s thesis, SAAS, Maxwell AFB, Ala., 1993).

30. Problem-solving studies include Chapman; Maj P. Mason Carpenter, *Joint Operations in the Gulf War: An Allison Analysis* (Maxwell AFB, Ala.: Air University Press, 1995); and 1st Lt Gary A. Vincent, “In the Loop: Superiority in Command and Control,” *Airpower Journal* 7, no. 2 (Summer 1993): 15–25.

31. Theoretical works include Col John R. Boyd’s briefings, as well as Lt Col Robert P. Pellegrini, USA, *The Links between Science, Philosophy, and Military Theory: Understanding the Past, Implications for the Future* (Maxwell AFB, Ala.: Air University Press, 1997); Marine Corps Doctrine Publication (MCDP) 6, *Command and Control*, 4 October 1996; Col McCrabb; and doctrinal publications some of which are admittedly more practical.

32. Richard Butler, *Designing Organizations, A Decision-Making Perspective* (London: Routledge, 1991), 241.

33. John H. Holland, *Hidden Order: How Adaptation Builds Complexity* (Reading, Mass.: Addison-Wesley Publishing Co., 1995), 38.

34. Butler, 241.

Chapter 2

A Theoretical Framework for Command, Control, and Complexity

Three concepts form the backbone of this chapter. First, because command and control affects nearly all aspects of a military force, a conceptual framework is a more viable way to discuss command and control than an isolated, single-issue approach.[1] Second, complexity theory provides insight into the structure and behavior of decentralized systems. Third, the interdisciplinary nature of complexity theory suggests connections between the fundamentals of complexity and the C^2 framework. This chapter motivates and develops these ideas to set the stage for the remainder of this study.

Motivating the Framework

Gen Robert T. Herres, USAF, Retired, comments in the introduction to Thomas P. Coakley's 1992 book, *Command and Control for War and Peace*, "Although much has been written about specific command and control system problems over the past two decades, there is surprisingly little in print that addresses this business from a broad, conceptual viewpoint."[2] Coakley continues, "The breadth of command and control is one of the central difficulties in dealing with the topic." Unfortunately, "Everyone wants to remedy the problem by limiting command and control to the narrower definition his or her group would choose."[3] Studies that focus narrowly on one or two areas usually miss the essential interdependencies across a broader range of airpower issues. Such studies that optimize one isolated area then extract performance penalties in other areas cause an overall decrease in performance. While specialization is important, Coakley remarks that "uncoordinated prescriptions from noncommunicating specialists can be dangerous to one's health."[4]

It is critically important to comprehend the overall picture while addressing the details of command and control. Chapter 1 emphasizes the decision aspect of command, but the supporting C^2 process inherently involves communications and connections between systems and people with an underlying culture that enables them to understand each other. Subsequently, breaking down command and control into a set of fragmented problems to solve or optimize in isolation risks losing the intrinsic connection of each part back to the whole more than most disciplines. Further, as complexity theory demonstrates, interactions between the parts of a system may be its most important feature. This is true whether the command philosophy is centralized or decentralized. Two examples illustrate the problem in the C^2 context and provide additional background for this study.

The United States Army (USA) first incorporated mission orders, a decentralized approach to command and control, into its AirLand Battle doctrine in the 1982 version of FM 100-5, *Operations*. A mission has two components, a task and a purpose. The task specifies the who, what, and when of the mission but not how to accomplish it. The purpose of a mission, or commander's intent, is the more important of the two parts and provides a visualization of effect or end state so that tasks may be accomplished without further instruction.[5] Mission orders are traditional in the German army, but they represent only one part of a "seamless fabric in the German army's warfighting philosophy."[6] Unfortunately, the USA included mission orders in its doctrine without considering the rest of the German philosophy and culture. By 1986 a School of Advanced Military Studies (SAMS) student, Maj John T. Nelsen II, concludes in his monograph and article that mission orders will not work for the Army without the appropriate doctrine, command and control, leadership, training, and education.[7] Additional SAMS monographs during the following years documented how the role of mission orders in AirLand Battle was a source of continuing tension and misunderstanding.[8] One survey revealed that 59 percent of the Army officers at Fort Leavenworth, Kansas, believed that they understood mission orders but could not demonstrate the knowledge to support their contention. An additional 21 percent did not fully understand mission orders but were at least aware of their misunderstanding.[9] Several subsequent monographs identified the same shortcomings that Nelsen did in 1986, and these results, as well as C^2 difficulties at the Army's National Training Center, were noted by the Army's Training and Doctrine Command.[10] The Army has since refined its implementation of mission orders, but its experience is instructive and highlights the pitfall of adopting a C^2 doctrine without considering its broader impact.

Mission orders are not the organizing concept for current Air Force command and control below the component level, although they have been used during past Air Force operations.[11] The effort by the Air Staff in the late 1980s to reconcile Air Force C^2 doctrine with AirLand Battle led to a 1989 draft of AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*. This effort included mission orders, but the draft was never approved or disseminated.[12] The 1992 version of AFM 1-1 mentions commander's intent several times without discussing its meaning in airpower terms or as part of a mission order. Subsequent studies on mission orders and commander's intent took place in 1990 by Col Robert W. Peterman, in 1994 by Maj Michael Fischer, and in 1996 by Lt Col Michael Straight at Air University.[13] Air Force doctrinal publications that include commander's intent do not define the concept in an airpower context or describe the broader philosophy upon which it is based.[14]

Proposals to incorporate traditional commander's intent within the current ATO system would be ineffective at best or repeat the US Army's experience at worst. Colonel Peterman writes that a simple reformatting of the ATO message and increasing the number of joint staff officers would launch the Air Force into the conversion process to be followed by more specialized equipment.[15] Another first states that there are no major C^2

limitations on institutionalizing commander's intent, but then implies that there may be more to it, namely, doctrinal changes, training, and education peculiar to the Air Force's unique organizational structure.[16]

There are huge institutional obstacles to routinely using mission orders and commander's intent in the Air Force. Purpose or intent is the more important component of a mission because it guides a subordinate in planning how to accomplish the task to suit current combat conditions. This guidance includes *changing* the task entirely if it no longer satisfies the intent or if another task better satisfies the intent.[17] Command intent provides the vehicle for subordinates to exercise independent initiative in light of combat conditions that cannot be known by the commander when a mission is assigned. Command intent has little role to play within the current ATO structure for two reasons.

For most surface attack missions, the ATO normally provides copious detail, ordering targets, weapons, refueling, and even deconflicting routes of flight and run-in headings if there is sufficient planning time.[18] The aircrew has neither the authority nor the coordination ability to exercise initiative beyond canceling the task itself or attacking a preapproved alternate target. Only the centralized AOC has the ability or delegated authority to change tasks. Except for mission orders issued to composite wings, squadron, group, and wing commanders normally have no formal role in the decision processes that specifically task the forces under their command.[19] These decisions take place at the AOC, so these commanders have little role in exercising any form of command intent. The JFACC is the only commander who normally plays any role in the decisions that govern employment at the strategic, operational, and to a great extent, tactical levels of air warfare. A JFACC intent statement would provide "nice to know" information, but it has no practical utility in the traditional sense of the term.[20]

Major Fischer took a more broad approach to mission orders in his 1994 study. He examined the preconditions for successful mission-type orders in the airpower context at the theater level and one level below, the wing level. Fischer described how mission orders as a form of decentralized command and control were successful in several air combat situations, but only when certain conditions were present. Among his case studies were German combined arms warfare in World War II, Gen George C. Kenney in the Southwest Pacific, and JTF Proven Force during the Gulf War. These conditions include uniformity of thinking, reliability of action, and mutual trust throughout the organization in addition to broadly trained forces and staffs and a technical means to distribute intelligence, coordinate, and deconflict at the lowest levels. To employ mission orders in the absence of the proper conditions risks chaos, fratricide, and conflicting objectives. Major Fischer concluded that centralized control and decentralized execution as currently practiced is not compatible with mission-order command at the wing level.[21]

The Army's experience and most Air Force approaches to mission orders show that structural changes in command and control will not yield to one or two wishful ideas. It is with a sense of caution that this study proposes the following conceptual framework as an appropriate analytic structure.

Developing the Framework

The framework has eight subject areas: organization, operations, command, leadership, doctrine, training, education, and systems. Additionally, the operations area has three subcategories: planning, execution and assessment, and joint considerations. Of the few writings that take a broad approach to command and control, some identify as few as three category headings (e.g., people, technology, and organization) while others use many more than the aforementioned eight.[22] These eight subjects are general enough to avoid overly specific detail, but explicit enough to reveal the interdependencies inherent in command and control. This framework includes the shortfall areas identified by the USA in the late 1980s as described earlier. Major Fischer analyzed command relations, leadership, organization, technical requirements, and procedures in his study, and some of these categories also appear in the framework. A final source is the C^2 doctrine of the USMC, the only US military doctrine that unambiguously requires decentralization to execute maneuver warfare.[23] Marine Corps Doctrine Publication (MCDP) 6, *Command and Control*, discusses leadership, planning, organization, communications, information management, and decision making. These topics are also part of the framework although the labels slightly differ. The framework does not include personnel management, systems research and development, and programming and budgeting. These subjects are important in the sense that they develop and acquire theater C^2 system hardware and software, but they play a smaller role in determining what kind of C^2 system will be created or how it will be doctrinally employed in theater. The ideas in this study also apply to logistics and support, but few examples from these disciplines are discussed.

Even in the airpower context, each of the subjects has significance beyond theater command and control. Therefore, the following specific questions in each subject will standardize and focus the discussion in chapters 3 and 4.

Organization

Organization and operations describe the control mechanisms from the definition in chapter 1, the particular structural arrangement of staffs, systems, and processes that support theater command. As noted in chapter 1, this study examines the organization of the air component only, beginning at the JFACC and extending downward to wings, groups, and squadrons. The qualities in the last question come from the January 1997 draft of Air Force Doctrine Document 2-5.6, "Command and Control (C^2) and Command, Control, Communications, and Computer (C^4) Systems," which echoes similar issues in Joint Pub 6-0, *Doctrine for Joint Command, Control, Communications, and Computer (C^4) Systems*, and apply both to the organization and to systems. What is the structure of the C^2 organization? Why is the organization so structured? Does the structure change? How and when does it change? How does the organization achieve flexibility, responsiveness, survivability, and interoperability?

Operations

Planning issues include these three questions. What are the main planning processes? Why are the processes the way they are? How responsive are they and why?

There are three questions within the execution and assessment category. What are the execution and assessment processes? How do they achieve coherence with the planning processes? How responsive are they to the theater situation?

Joint considerations have these specific questions. How are joint operations planned and executed? At what levels are joint synergy possible?

Command

Based on the definition in chapter 1, command focuses on the authority to make decisions and the responsibility for their implementation and results, which includes the content of orders and the relationships between decision-making authorities within the organization. This definition and the discussion in the previous section lead to the following questions: What is the location and locus of command decisions? What are the command relationships? How is command exercised in terms of orders and commander's intent?

Leadership

Two straightforward concepts frame the leadership discussion. First is a description from FM 22-103, "Leadership is an influence process and refers to motivational relations between the leader and the led."[24]

The second concept breaks the essential leadership process into three parts: vision or goal setting, team building, and motivation.[25] The process approach explicitly avoids the complications of identifying leadership traits and qualities in individuals. From this perspective, the following questions emerge: What are the leadership relationships? How are the relationships exercised in terms of vision, team building, and motivation? What are the implications of these relationships on leadership style and vice versa?

Doctrine

Doctrine in American terms is a set of principles that guides action and is authoritative but requires judgment in application.[26] AFM 1-1 (1992) cites collected experience as the source for Air Force doctrine.[27] In broad terms, this study proposes new ideas for command and control at a doctrinal level.[28] Command and control must address both war-fighting doctrine and doctrine for command and control itself. Ideally, the two doctrines should support and reinforce each other since command and control enables the planning and execution of strategy at all levels of warfare. Some relevant questions: What is the structure and content of C^2 doctrine? (Does it describe organization, processes, and a common terminology for communication?) Who uses the doctrine and how? How does C^2 doctrine influence the development and understanding of operational and tactical doctrine?

Training

Training questions must address the C^2 system primarily and the operational war-fighting units secondarily: How does the human element in the C^2 system train? Is this training realistic, frequent, and effective? Are trained personnel identified, available, and used in crisis situations? Is there any relationship between C^2 training and routine training of operational units?

Education

Education is included in the framework because it strongly determines whether the Air Force can meet the cognitive challenges of command and control. Education and training are related, but it is important to distinguish between them. Training passes existing organized knowledge from one person to another and applies this knowledge in familiar contexts. Education builds on training and involves an enlarged understanding and application of ideas across a variety of contexts, to include the understanding of learning itself and the creation of new knowledge.[29] These considerations suggest the following questions: How does education support command and control? Which personnel get educated and how? Where and how are educated personnel used in the C^2 organization?

Systems

The physical systems of command and control are the communications and computer equipment as well as intelligence, surveillance, and reconnaissance systems (C^{4}ISR). These systems provide the infrastructure for command and control and support its processes. Once again, the qualities in the last question come from the January 1997 draft of AFDD 2-5.6. How do systems support the organization and operation of command and control? What are the implications on vertical/horizontal/diagonal information flow? How do systems support leadership and command relationships? How do systems enhance survivability, reliability, security, and interoperability?

This framework and the questions within it indicate that command and control is clearly a cultural issue. Allard in his book *Command, Control, and the Common Defense* observes how important an understanding of the sociology of service command is to understanding the subject of modern command and control.[30] Lt Col Stephen J. McNamara in *Air Power's Gordian Knot: Centralized versus Organic Control* also chronicled the disparate service historical and cultural perspectives on centralized versus organic (decentralized) control from World War II to the Gulf War. While specific service culture builds an understanding of the context of current and past command and control, it should not be the only source for developing future command and control. The search for alternatives should take an open interdisciplinary approach that reconciles the context of the present with a variety of solutions to potential problems of the future. This study next examines complex adaptive systems to build this interdisciplinary approach.

Complex Adaptive Systems

Complexity theory is an interdisciplinary science that seeks to understand the behavior of a remarkable variety of natural, man-made, and man-inclusive systems. The fundamentals of complexity theory are easy to understand, but the application of those ideas to airpower may be less intuitive. The goal of this section is to describe complex adaptive systems in sufficient detail to justify the connection between complexity and the C^2 framework. This section first describes the characteristics and behavior of complex adaptive systems. It concludes with the significance, methods, and goals of the science.

Overview

A complex adaptive system is a group of interacting units or agents.[31] The characteristics of such systems can best be understood at two levels, the micro-level and the macro-level (fig. 2). The micro-level specifies the characteristics of agents, their interactions, and environment. The macro-level describes the overall behavior of a system as a collection of agents. Although complex systems typically have many more than two levels, the relationship between any two levels follows the micro/macro pattern. It is important not to confuse micro- and macro-behaviors, even though a collection of agents at one level may behave like a single agent one level higher. Mistaking a facade of macro-behaviors as indications of complexity without looking for the presence of underlying micro-characteristics may identify a *complicated* system but not a complex adaptive system. After explaining the micro-characteristics and macro-behaviors, the difference between complicated and complex will become clear.[32]

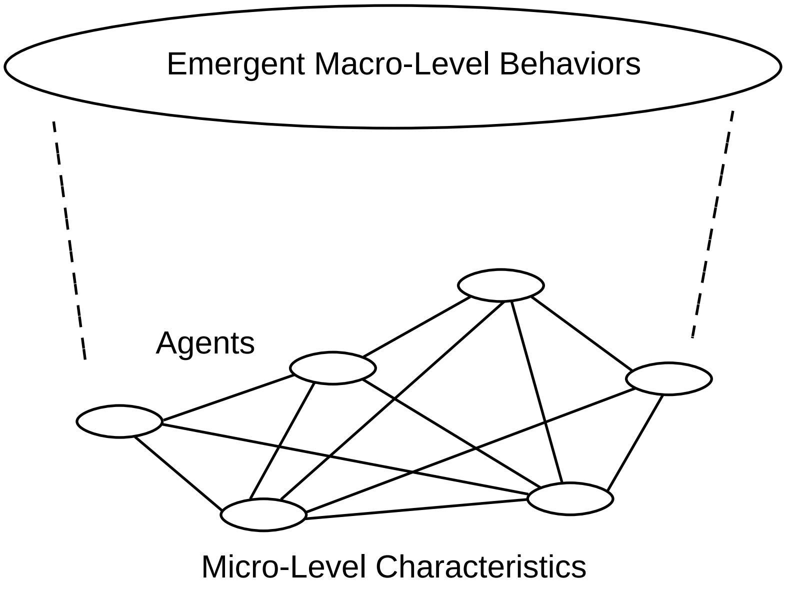


Figure 2. Structure of a complex adaptive system. Micro-level characteristics produce macro-level behaviors.

Micro-Level Characteristics

The micro-level begins with agents, usually in very large numbers. Through some form of a dynamic communication infrastructure, agents interact and exchange resources and information with each other and their environment. This exchange occurs via sensory inputs and action-based output. Connections may be physical or via carriers that use tags or labels to rapidly identify other agents with specific qualities from the entire collection of all agents.[33] The macro-behavior of a complex system depends strongly on the density of connections and frequency of interaction, both of which may change constantly based on the micro- and macro-level environment. The connections between agents are often more important to the macro-level adaptive system than the qualities of the individual agents themselves. A good example of a communications infrastructure displaying these characteristics is the Internet with its use of worldwide web search engines. Keywords and website addresses are tags that allow the user to rapidly connect to sites of interest. Without these tools, using the Internet would be more difficult and time consuming.

In order for complex behavior to occur, the dominant interactions between agents must be nonlinear, although linear interactions may also be present. The reason nonlinearity must be present will become clear in the macro-behavior discussion. Nonlinearity is most easily explained by what it is not. Linear interactions obey the rules of proportionality and superposition. Proportionality means that if an input is multiplied by a constant, then the output of the system is proportional to the same constant. Superposition requires the total output of several simultaneous inputs to a system to be equivalent to the sum of outputs resulting from each input individually. Nonlinear interactions do not obey proportionality or superposition.

Agents are sometimes said to have loose or tight coupling in describing their interactions. *Coupling* is a relative term and has nothing to do with linearity or nonlinearity. Loose coupling implies a weak interaction between agents and their environment, where one agent has a finite but small effect on the activity of another. Tight coupling implies a stronger interaction. Loose and tight have no meaning unless defined in relation to some other interaction. In the sense that nonlinear interactions must dominate in a complex system, it could be said that they must be more strongly coupled than any existing linear interactions.

Agents must behave according to internal models or sets of rules that govern their interactions with other agents and the environment. Rules change based on experience, but only the set of rules in force at the time of an interaction determines the agent's behavior. Agents preserve past experience by continuously building more appropriate sets of rules to govern their behavior in a specific environment.[34] Although there may be invariant rules (such as physical laws) that an agent must also follow, it is the rules that an agent can control which provides the possibility of adaptive behavior.

Next, there must exist some mechanism to judge the fitness of agents, such as direct competition for resources, which enables agents with more viable behavior to become stronger and reproduce and those with poor behavior to weaken or die. Fitness is purely relative in that the judgment takes place between two or more agents, or between an agent and its environment. An agent either has an appropriate set of rules to survive or gain strength, or it doesn't. Complex system agents follow a survival-of-the-fittest rule. When judging fitness, all rules supporting fit agent behavior must get credit during an interaction, not just the single rule that clinches the victory. Without this mechanism, a kind of distributed positive feedback, an agent would be unable to determine which combination of rules produced the positive result.[35] Judging interactions depends totally on competition with the environment and other agents. Sometimes an agent may win in a specific environment over one that would later be judged as more viable, leading to widespread reproduction of relatively inferior traits and the phenomenon of "early lock in." In the open market, a quintessential complex system, examples of early lock in include the VHS videotape format winning over the Beta format due to superior early market share and the use of the QWERTY keyboard on computer systems, despite the fact it was intentionally designed to slow down the operator to prevent mechanical typewriter jams.[36]

The last micro-level characteristic is a nonrandom method to generate new rule candidates from weaker rules while preserving strong rules. Again using the open market as an illustration, this is an agent's research and development department. Agents would get nowhere if they generated randomly mutated rules in an attempt to improve fitness. While some random mutation does in fact occur, there are a number of other mechanisms simulated in software by "genetic algorithms" that generate higher viability rules more quickly. Rule generation in this manner includes recycling and recombining weak rules using inversion and crossover (mixing part of one rule and part of another) to produce new candidates.[37]

A business example illustrates the five micro-level attributes—agents, interactions (nonlinear, coupling), rule-based behavior, fitness judging, and rule generation. In a large corporation, product divisions are the agents. They manufacture products that compete in an open marketplace against products from other companies or from other divisions in the same company. The product trademarks are the tags customers use to readily identify that company's products. The product division's rules are the production and sales methods it uses and continually updates to keep its products competitive and profitable. When a product sells, all of the contributing internal divisions and outside subcontractors receive their proportional part of the income and become stronger. While preserving the core product line, the division researches and test markets variations on the core product (tries new rules) in order to strengthen its sales and profits, the fitness test of the division. Successful new products become part of the division's production rules. From time to time, a new product might be so successful that it prompts the division to split into two divisions to more efficiently produce two main product lines, demonstrating reproduction based on rules, fitness, and resources.

Because complexity theory is an interdisciplinary science, micro-level characteristics similar to these appear in other disciplines. For example, James G. March, an organization theorist, lists six adaptive rules (complexity theory parallels are added in the following list) in his 1988 book

Decisions and Organizations. Similarly, Col John R. Boyd's observation-orientation-decide-act (OODA) loop concept parallels the micro-level of complexity theory exceptionally well.[38] There are numerous similar expressions of Boyd's concept that reflect the same basic ideas with different words.

1. Rule following—rules-based behavior (orientation);
2. Problem solving—apply rules based on inputs (observation and decision);
3. Learning from experience—modifying rules based on conflict and results (orientation);
4. Conflict—interaction and fitness judgment (action);
5. Contagion—reproduction and interactions (action); and
6. Regeneration—creation of new rules and reproduction (orientation and action).[39]

Macro-Level Behaviors

There are also five macro-level behaviors that describe the behavior of interacting agents with the micro-level characteristics discussed above. The first is emergence, also called aggregation, the most enigmatic concept in the science. The aggregate of all of the individual agents interactions leads to an emergent systemic behavior and associated structure. The most difficult behavior to understand, and the only behavior referred to as "emergent," takes place due to dominant (strongly coupled) nonlinear interactions between agents. Because of nonlinearity, aggregate behavior cannot be predicted based on a superposition or scaling of the individual agent behaviors or interactions. Emergent behavior can be very simple while the underlying agent behavior is complex, or very complex with exceedingly simple underlying agent behavior. If all agent interactions were linear, then the behavior of an aggregate could be calculated based on a knowledge of the interactions and the initial state of the system—a useful idea, but no longer very interesting. A mechanical clock is an example of a complicated system with predictable, predominantly linear behavior. Nonlinearity causes interesting emergent behavior but makes it difficult to understand.[40]

Emergent behavior also appears to be self-organizing because the overall organization of the system seems to spontaneously arise from agent interactions rather than conscious design or planning. One common type of emergent structure happens to be hierarchy. Agents form groupings that have an emergent character and in turn become the "meta" agents for the next echelon of hierarchy. But hierarchy is an emergent macro quality. Hierarchy in a system may be an indicator of complexity, but hierarchical systems are not by definition complex. This belief is a common mistake in understanding micro- and macro-level qualities.[41]

The second macro-level behavior is coevolution or adaptation that leads to diversity. Agents affect each other and their environment in a large-scale competitive game in which their rules and relative fitness of behavior constantly change. Adapt or perish is the name of the game.[42] Adaptation leads to increasing diversity as agents perpetually evolve to fill specific niche environments and relationships with other agents. While some agents evolve to fill niches, others may go extinct when they cannot adapt rapidly enough to survive in a changing environment or in the presence of more competitive agents.

Third, the combination of self-organization and adaptation leads to the most profound, and the only concrete, result in complexity theory, self-organized criticality. Complex adaptive systems naturally seek an equilibrium between order and chaos, and two very interesting phenomena occur at this critical "edge." First, this edge maximizes aggregate relative fitness of the entire complex system, and second, the system is most adaptive at this edge.[43] That such behavior can occur naturally with no central planning or outside direction is stunning. However, to call this edge an equilibrium is actually a misnomer. In the complex regime, a system is at anything but equilibrium as it continuously churns and coevolves. The notion of equilibrium comes from higher-order classification of the system as balanced between two other behavioral modes. One mode is "order," which has uninteresting dynamics and usually equates to death or a high degree of predictability in nature.[44] The other mode is "chaos," where a system of agents experiences a supercritical avalanche of adaptive activity and large extinctions of agents before it settles down. Complex, self-organized adaptive systems balance themselves between order and chaos, at the "edge of chaos" so often cited in complexity literature.[45]

The idea of extinctions as a cost of adaptivity in the military context is no doubt uncomfortable, but there is a broader way to think about the concept. No squadron, group, or wing fails during combat by intentional design or as a unitary agent. Rather it is a combination of military assets that must be viable in wartime. Such combinations get formulated and tested in training and exercises, and the most robust concepts go to combat in the form of tactics, operational art, and strategy. Although combat never goes perfectly and its lessons are paid for in blood, the continual innovation of employment concepts in peacetime—with the extinction of some and the survival of others—is the price every service gladly pays for more robust performance during combat.

Dr. Stuart Kauffman demonstrated adaptive fitness maximization in a special genre of adaptive system he calls N-K networks.[46] In these networks, each node represents an agent that has N different characteristics—equivalent to rules—that form the basis to assess the fitness of each node and determine how nodes interact. K specifies a level of interconnectedness among different agents in a network, or among the rules within a single node. For small values of K, nodes are connected with few other nodes and the network exhibits ordered, stable behavior in the presence of an arbitrary input. For large values of K, on the order of the number of nodes or the number of characteristics, N, the network is so interconnected that it never settles down or reaches a steady state, exhibiting chaotic behavior. The most interesting behavior occurs when the nodes are allowed to change their own values of K so as to maximize their own fitness. In this instance, the system tunes itself to a midrange value of K that is neither ordered nor chaotic and also maximizes the average fitness of all nodes in the network in a self-organized manner.[47] For N-K networks, the density of micro-connections, K, could be thought of as a tuning parameter that drastically influences the emergent behavior of the system.

The fourth macro trait of complex systems partially explains why such systems are able to find the equilibrium between order and chaos. The interaction of credit assignment during competition and nonrandom rule generation converges on viably adapted agents much more rapidly than either exhaustive search to find the optimal rule or totally random mutation. The difference lies in the term *viable*. In such systems, “satisficing” is the operative strategy, and while a solution may be optimal from time to time, optimality is usually not the case. The game of chess, where strategy has complex adaptive characteristics, is a good example of this concept. It is impossible to calculate every possible move from the beginning of a game through checkmate. The fastest supercomputers would take millions of times the age of the universe to accomplish this because the space of possible moves and countermoves is simply too large. Yet human chess players with finite chess experience are a good match against a supercomputer that exhaustively searches an enormous but limited number of moves in advance while looking for the optimal strategy.[48] Clearly, the human player does not exhaustively search every possibility prior to each move. Instead, the human player learns by recognizing a large number of patterns on the chessboard and associating moves with those patterns. The better a chess player, the more patterns he recognizes, although the comparison between the human and computer strategies shows that the human moves are “satisficing,” not optimizing.[49]

Another outcome of the fourth characteristic is punctuated equilibrium. A complex system may rapidly evolve to a relatively steady state, whereupon an input occurs that requires more than a small, gradual adaptation. The result is rapid, large-scale adaptation to adjust to the new situation. This situation gives the appearance that adaptation occurs in fits and starts when in fact adaptation takes place continuously but on a variety of scales. It is the large changes, often called revolutionary, that get our attention, not the smaller scale, continuous tide of evolution.[50]

The fifth macro-level quality is anticipation. Anticipation is a product of the rule-based behavior of agents in complex systems. Rules are said to “anticipate” the environment in that they change to reflect certain environmental conditions and assumptions. Rules may fit the environment so well that the agent, or the entire system, may be able to take action in anticipation of an event in order to be able to rapidly exploit the situation when it occurs.[51] Anticipation can take place even though underlying dynamics of the driving event are not clearly understood or unpredictable in a quantitative sense.

In summary, there are five significant macro-level behaviors—emergence, coevolution, self-organized criticality, rapid convergence or punctuated equilibrium, and anticipation. Collectively, these behaviors describe systems that are capable of learning as they interact in a competitive environment. Extending the business example from the micro-level discussion provides more good examples. Emergence is illustrated by the behavior of a market-based economy which, without central design, economically delivers an increasing variety and quantity of more capable products. This behavior comes at the price of coevolution, as new businesses continually form, older ones adapt to keep their market share, and others go bankrupt. Self-organized criticality and fitness maximization are illustrated by the idea that an overall corporation may be strong and competitive although some of the divisions within it falter and close. Fitness maximization also shows in the greater average economic prosperity of Western citizens compared to those of the former Union of Soviet Socialist Republics, which had a centralized, nonadaptive economic system that preempted the development of a financial infrastructure, the dynamic communication medium for consumer agents. Russia is now experiencing the uncomfortable throes of evolving such an infrastructure in a short period of time. On a smaller scale, punctuated equilibrium took place in typewriter development over a period of nearly 100 years as gradual improvements were made to the basic manual machine. Typewriter development culminated with the IBM Correcting Selectric II®, before the leap to personal computers and the occurrence of word processors. Finally, anticipation takes place as the stock market adjusts current prices based on the expected direction of future interest rates and other economic indicators. Adaptivity and learning certainly cannot prevent surprises, but such systems have a better chance to react and survive when surprises inevitably occur.

Significance of Complex Adaptive Systems

The traditional approach to understanding complicated systems is to break them down into smaller parts and understand the parts individually. After learning how each part works and interacts, it is possible to reconstruct the whole system and calculate its overall behavior. For many kinds of complicated and linear systems, this reductionist method works well, following the comfortable Newtonian cause-effect model of the world. Knowing dynamics and initial state of a linear system, it is possible to calculate its behavior at any time in the future, much like a complicated watch mechanism keeps time. Unfortunately, this method does not work for the broad class of complex adaptive systems due to nonlinearity. The behavior of these systems defies analysis based on the interactions of their constituent parts. It is still possible to understand system behavior, but in a different manner. The new "Heraclitian" model takes its name from a Greek philosopher, who viewed the world as being in a constant state of flux and once said, "You can never step into the same river twice."[52] The behavior of a river is well understood even though the water flowing down it, the shape of the shoreline, and the sediment on the bottom change continuously. The Newtonian model has not become useless, but there are limits to its power to explain by analogy the limitations of Newtonian physics.[53]

The parallels between complex adaptive systems and warfare are profound, both in the fundamental characteristics of the components of these systems and the overall emergent behavior that they exhibit. The examination of warfare in its entirety through the lens of complexity theory is a vigorous area of current research.[54] Many sciences stop at the point where human decisions and judgment become part of a system. The theory of complex adaptive systems does not have this limitation. For example, simulated complex systems successfully mimic stock market behaviors, a system that includes human judgment.[55]

Because complex behavior occurs across many different scales, often organized in a hierarchy, complexity theory applies across the same scales without losing its inherent power to explain. It provides an understanding of how small changes deep in an organization can result in either great improvements in performance, such as the effect of a vaccine, or a drastic crippling of performance, such as the impact of misguided monetary policy on an economy. The interdisciplinary impact of complexity theory suggests that results from other fields may apply to similar problems in the military as well as subject to careful translation to account for military uniqueness.

Methods and Goals of Complexity Research

The primary tool for complexity research is computer simulation. Computers accomplish the horrendous nonlinear calculations and enable repeatability and controllability that would be impossible with a real system, so it is possible to repeat a simulation and get a "feel" for a complex system. Given the nature of complex adaptive systems, it is difficult to isolate one in a laboratory in the classical tradition of scientific experimentation, although data collected on natural phenomena dramatically corroborate simulated results from time to time.[56] In complexity, computer simulations represent an intermediate stage between theory and real systems, the equivalent of a military war game. Unfortunately, complexity and specifically the macro-behavior of emergence tend to challenge most people's understanding of causality, often in unexpected ways, so it is extremely easy to draw inappropriate conclusions from simulations.[57] There are few concrete answers, and complex simulations rarely yield precise quantitative results. Getting a "feel" for the system is in fact the most that a researcher might expect from a computer simulation. Complexity research currently focuses on a qualitative understanding of behavioral patterns and relationships rather than a quantitative calculation of the precise future state of a system.

So why study complex systems or emergent behavior? The prime research objective is to understand complex adaptive systems well enough to predict their macro-level behavior. A related goal is to design and construct a complex adaptive system with a desired, or perhaps bounded, emergent behavior with a theoretical understanding that the emergent behavior will be most fit for a particular objective. Unfortunately, the science has not found an answer to either of these problems. Another way to view the problem is in terms of micro-level characteristics and coevolutionary adaptation. While it is possible to construct a system that is adaptive, to specify the end-state of its evolution is impossible. The system will maximize the average fitness of the agents within it, but the specific behavior of the most robust agents is unpredictable. Evolution has no favorites.

So, again, why study complex systems? There are many less daunting intermediate objectives that fall short of a complete understanding of emergence but are interesting and provide valuable results. First, though it is impossible to build a complex adaptive system with a given macro-level behavior, it is possible to construct a simulation that qualitatively mimics the behavior of a real system. Using such a simulation, it may be possible to repetitively experiment with the simulated system in ways that would be impossible with the real system. For example, simulated turbulence and systems failures in a flight simulator are a proven way to hone the skills of an aircrew in situations they may face rarely in actual practice. Such trials provide understanding of the behavior of the real system even though they have little ability to quantitatively duplicate (in the case of turbulence) the nature of the results when applied to the real system. If understanding is adequate for the task, such a simulation may provide it.[58]

Second, it seems possible to determine whether a given system is operating in an ordered, complex adaptive, or chaotic regime.[59] Based on a desired mode of operation, it may be possible to alter a system to push it into one regime or another. To gain the ability to improve friendly airpower performance while crippling enemy performance during a conflict would be very valuable. For example, Maj Steven M. Rinaldi suggested how genetic algorithms might be employed to target enemy economic systems.[60] The current study uses complexity to examine the operation of friendly command and control of theater airpower.

Third, although it is impossible to design a system with a given macro-level emergent behavior, it may be possible to influence or bound the emergent behavior of a complex system. Such influences include concepts of lever points, control parameters, and amplifier effects that occur by modifying density or span of connections (like the value of K relative to N in Kauffman's networks), frequency of agent interactions, or depth of payback in fitness credit assignment. Medicinal vaccines are an excellent example of how a small input to the complex adaptive immune system causes a beneficial change in its performance. These concepts have more than a passing resemblance to the military concept of center of gravity, and they also have attractive economy of force implications.

Complexity theory is a young science that cannot offer blanket or even concrete solutions. Some C^2 realities lie outside the current boundaries of complexity theory and therefore demand a prudent approach to identify the useful connections between the two disciplines.

Connecting Command and Control to Complexity Theory

To identify the potential of a system to exhibit complex adaptive macro-behaviors, it is important to look for supporting micro-characteristics. This task becomes easier by turning the micro-characteristics into questions. Regarding agents (rule-based, interactive, competitive entities): What are the agents? How many are there? Regarding agent interactions: How are agents organized with respect to each other? How do agents interact? How often and over what locus? Can agents change the way they interact? What is the density of connections between agents? Regarding rule-based behavior: How do agents apply rules to their behavior? How do agents preserve rules for future use? Regarding fitness judgment: How is fitness judged during interactions? How do relative fitness judgments change agent rules? Regarding rule generation: How do agents generate new rules? Are new rules limited in any sense? How do agents test new rules during interactions?

With one major exception to be discussed subsequently, these questions are very similar to the questions posed by the C^2 framework. They ask for similar information, but primarily use the terminology and perspective of the micro-characteristics of complexity theory because macro-behaviors cannot be specifically designed. The following chart highlights these connections.

Command and Control	**Complex Adaptive**
Framework Subjects	**System Micro-Characteristics**
Organization	Numbers and types of agents Patterns and structure of agents connections Types/density of interactions (Macro-level self organization)
Operations	Rule-based behavior Fitness judgment (combat)
Command	No macro-level parallel Rule application
Leadership	Organization design and micro-characteristics
Doctrine	Agent rules Experience preservation, anticipation Common language for interaction (tags)
Training	Competition and fitness judgment Applied rule generation Successful rule dissemination
Education	Theoretical rule generation Successful rule dissemination
Systems	Coordination infrastructure Connection density, bandwidth Frequency of interaction

There is no macro-level parallel for command in the complex adaptive systems sense. The discussion in chapter 1 noted that the absolute limit of decentralized command could be interpreted as the absence of command because each agent commands itself and no other. Even in completely decentralized command, agents still influence one another because they are by definition not isolated and participate in a communications infrastructure. If the task of decentralizing airpower command and control is equivalent to turning a theater air component into a large complex adaptive system, the problem to solve is that of command. "In the modern era, it is much more accurate and descriptive to consider strategy as a complex *decisionmaking* process that connects the ends sought (objectives) with the ways and means of achieving those ends" (emphasis in original).[61]

This definition of strategy and those of command and control from chapter 1 clearly connect the task of strategy formulation to command. Strategy organizes the planning and execution of a military force so that it will behave in a certain manner during war to achieve specified objectives, usually in a specified period of time. This concept is not difficult to grasp for a military force that is centrally commanded and controlled, but complex adaptive systems have no central authority. Complex systems meet the intent of the decentralized command and decentralized control definitions from chapter 1. The problem of decentralized command is therefore synonymous with the problem of decentralized strategy.

In one sense, decentralized strategy could be considered the rules that govern how individual agents behave. Unfortunately, this says little about how the overall system will behave. In order to discuss decentralized strategy in complexity terms, the macro-behaviors offer a useful analogy. Strategy is the arrangement of micro-characteristics that enables a decentralized system to exhibit a particular (desired) emergent behavior. Based on this analogy, the decentralized strategy dilemma becomes clear. Since it is impossible to design a decentralized system with a given emergent behavior, it is likewise impossible to design a totally decentralized military force that will fight a certain strategy. It is possible to build a large complex adaptive system and "turn it loose"; but it is impossible to command it to behave in any particular manner or guarantee that it will achieve any specified objectives.

Another beneficial macro-behavior of complex systems is the maximization of overall relative fitness in a dynamic environment. In war fighting and competition at the micro-level, greater relative fitness equates to victory. The fitness maximization macro-behavior would also seem to pull a C^2 system towards decentralization as a means to achieve greater overall relative fitness, but this seems to be of little use if the system will not behave in a desired manner.

Complexity theory therefore provides a conceptual understanding of the basic challenge of decentralizing command and control, namely, to marry specified purpose or command with the benefits of the macro-behaviors of complex adaptive systems (i.e., the adaptability and responsiveness offered by decentralization). Chapter 3 uses the C^2 framework developed here to examine current command and control of a theater air component.

Notes

1. Martin van Creveld, *Command in War* (Cambridge, Mass.: Harvard University Press, 1985), 5.

2. Thomas P. Coakley, *Command and Control for War and Peace* (Washington, D.C.: NDU Press, 1991), xv.

3. Ibid., 9.

4. Ibid., 12.

5. Joint Pub 3-0, *Doctrine for Joint Operations*, 1 February 1995, III-24 and III-25. See also Richard E. Simpkin, *Race to the Swift: Thoughts on Twenty-First Century Warfare* (London: Brassey's Defence Publishers, 1985), 232; and Maj John C. Coleman, "Comprehension or Confusion: Commander's Intent in the AirLand Battle" (student monograph, Fort Leavenworth, Kans.: School of Advanced Military Studies [SAMS], 1991), 43.

6. John T. Nelsen II, "Auftragstaktik: A Case for Decentralized Battle," *Parameters* 17, no. 3 (September 1987): 21.

7. Ibid., 32.

8. See Maj James H. Willbanks, "AirLand Battle Tactical Command and Control: Reducing the Need to Communicate Electronically in the Command and Control of Combat Operations at the Tactical Level" (Fort Leavenworth, Kans.: SAMS, 1984); Maj John M. Vermillion, "Tactical Implications of the Adoption of Auftragstaktik for Command and Control on the Airland Battlefield" (Fort Leavenworth, Kans.: Army Command and General Staff College, 1985); Maj John T. Nelsen II, "Where to Go from Here? Considerations for the Formal Adoption of *Auftragstaktik* by the US Army" (Fort Leavenworth, Kans.: SAMS, 1986); Maj Stephen E. Runals, "Command and Control: Does Current US Army Tactical Command and Control Doctrine Meet the Requirement for Today's High Intensity Battlefield?" (Fort Leavenworth, Kans.: SAMS, 1985); Maj Michael A. Burton, "Command and Control: Is the US Army's Current Problem with Decentralized Command and Control a Function of Doctrine or Training?" (Fort Leavenworth, Kans.: SAMS, 1986); Maj Robert J. Tezza, "Teaching Mission Orders on Officer Advance Course: Reality or Myth?" (Fort Leavenworth, Kans.: Army Command and General Staff College, 1989); Maj William F. Crain, "The Mission: The Dilemma of Specified Task and Implied Commander's Intent" (Fort Leavenworth, Kans.: SAMS, 1990); Maj John D. Johnson, "Mission Orders in the United States Army: Is the Doctrine Effective?" (master's thesis, Fort Leavenworth, Kans.: Army Command and General Staff College, 1990); Coleman; Maj Thomas M. Jordan, "Is Decentralized Command and Control of Tactical Maneuver Units a Myth or a Reality?" (Fort Leavenworth, Kans.: SAMS, 1991).

9. Johnson, 85.

10. US Army Training Board, "Discussion Paper 1-86: *Auftragstaktik* in the US Army," Fort Monroe, Va.: Army Training and Doctrine Command, 12 June 1986. *Auftragstaktik* is the German word for mission orders.

11. The definitions of mission and commander's intent in joint doctrine, especially Joint Pub 3-0, closely match the traditional definitions for mission orders. The JFC–JFACC relationship takes place in mission order terms. Chap. 3 discusses the current air tasking order with respect to mission orders.

12. Maj Michael E. Fischer, *Mission-Type Orders in Joint Air Operations: The Empowerment of Air Leadership* (Maxwell AFB, Ala.: Air University Press, 1995), 58. This version of AFM 1-1 may have been overcome by events surrounding the Gulf War.

13. Col Robert W. Peterman, "Mission-Type Orders: An Employment Concept for the Future" (unpublished paper, Air War College, Maxwell AFB, Ala., 1990); Fischer; Lt Col Michael Straight, "Commander's Intent: An Aerospace Tool for Command and Control?" *Airpower Journal* 10, no. 1 (Spring 1996): 36–48; and Lt Col Stephen J. McNamara's *Air Power's Gordian Knot: Centralized versus Organic Control* takes a historical case study approach to examine centralization across the services, that is, whether a JFACC is a good idea. This study assumes the JFACC is a good idea and examines the arrangement of command and control at and below the JFACC.

14. The most recent example is in AFDD 2-5.6, "Command and Control (C^2) and Command, Control, Communications, and Computer (C^4) Systems" (first draft), 31 January 1997, 11–12.

15. Peterman, 27.

16. Straight, 48.

17. Simpkin, 232. Thirty eight percent of the Army officers surveyed by John Johnson did not understand this particular aspect of intent. Joint Pub 3-0 does not discuss this aspect of commander's intent.

18. There are exceptions for missions such as air superiority and close air support for which specifying targets on the ATO is either irrelevant or impossible.

19. See also Fischer, 56–57.

20. In fact, intent could have an adverse effect. If it were possible for the aircrew to determine that delivering a certain weapon could not achieve the intended effect, the crew would be in the odd position of being ordered to fly a mission that may be risky and tactically successful but would be useless.

21. Fischer, 58.

22. Coakley uses four main categories: the system, technology, people, and organization. Under the subject of "people" he discusses command philosophy and aspects of education (creativity and cognitive development), while he includes doctrine in his discussion of the C^2 system. Van Creveld mentions many more than the eight categories.

23. MCDP 6, *Command and Control*, October 1996.

24. FM 22-103, *Leadership and Command at Senior Levels*, June 1987, 44.

25. John P. Kotter, "What Leaders Really Do," in *Military Leadership: In Pursuit of Excellence*, Robert L. Taylor and William E. Rosenbach, eds. (Boulder, Colo.: Westview Press, 1992), 21.

26. AFM 1-1, vol. 1, *Basic Doctrine of the United States Air Force*, 1992, vii. Also Dr. Harold R. Winton, AS 600: War Theory, SAAS, 1996.

27. Ibid. Other services, most notably the US Army, also use doctrine as a tool for change. The Army formulates and tests doctrinal proposals and then constructs the force and procedures around this vision of operations. AirLand Battle as a replacement for active defense with the mission orders experience cited earlier is an excellent example of this, as is the next iteration in the "Force 21" effort.

28. This study makes doctrine level proposals, not proposals for doctrine. Though some parts of the decentralized system described in part four are combat tested, the proposed plan certainly would not become doctrine without a thorough vetting in academia, training, and of course, combat.

29. Mortimer J. Adler, *The Paideia Proposal, An Educational Manifesto* (New York: Macmillan, 1982), 21–36.

30. C. Kenneth Allard, *Command, Control, and the Common Defense*, rev. ed. (Washington, D.C.: NDU Press, 1996), 125.

31. Agents in complex adaptive systems should not be confused with the class of computer software called agents. Software agents refer to programs that accomplish a task on behalf of the user, much like a booking agent. There is an effort to incorporate some elements related to complexity theory (such as neural networks) into these software packages to give them an ability to adapt to the preferences of the user, but this is not why they are called agents.

32. This discussion synthesizes the research of several prominent scientists in the field, most notably that of John H. Holland, a computer scientist, Stuart Kauffman, a biologist, and Brian Arthur, an economist. M. Mitchell Waldrop's *Complexity: The Science at the Edge of Chaos* (New York: Simon and Shuster, 1993) is one of the best introductions to the subject.

33. For a discussion of tagging, see John H. Holland, *Hidden Order: How Adaptation Builds Complexity* (Reading, Mass.: Addison-Wesley Publishing Co., 1995), 12–15.

34. Holland, 43–52.

35. Ibid., 53–60. This is called a bucket brigade mechanism. For example, the credit for an air-to-air victory goes not only to the pilot but to good maintenance, supply, weapons, production, and engineering.

36. Early lock in is a feature of systems that have positive feedback. See W. Brian Arthur, "Positive Feedbacks in the Economy," *Scientific American* 262, no. 2 (February 1990): 92–99.

37. Holland, 60–80. In a related discussion Kauffman shows that random mutation cannot explain the rapid evolution of biological species. Instead, a combination of self-organization and Darwin's natural selection is necessary. See also Stuart Kauffman, *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity* (New York: Oxford University Press, 1995), 149–89.

38. John R. Boyd, "Organic Design for Command and Control," unpublished briefing, 1987.

39. James G. March, *Decisions and Organizations* (New York: Free Press, 1988), 169–70.

40. Holland, 10–12. While there are nonlinear elements in mechanical clocks, clocks are purposely designed to make nonlinear effects as insignificant as possible.

41. An additional point of confusion regarding emergent behavior is whether the agents in the system can observe or be aware of emergent behavior. Agents may have a complete awareness of current or past emergent behavior, but this does not give them the ability to precisely predict or control future emergent behavior based on their own actions or those of any other agent. For example, in the complex adaptive stock market, traders keep track of broad market averages, but this is only one factor in their decisions, and any trader's individual decision cannot (a priori) drive the market in a desired direction.

42. Patrick Henry, the colonial leader, proclaimed "Give me liberty, or give me death!" This phrase is particularly insightful in political and economic adaptive systems.

43. Kauffman demonstrated this phenomenon for his N-K models. Per Bak and Kan Chen suggest that self-organized criticality is the *only* model that has led to a holistic theory for dynamic systems. See Per Bak and Kan Chen, "Self-Organized Criticality," *Scientific American* 264, no. 1 (January 1991): 46–53.

44. Ordered systems include linear systems and nonlinear systems that have single or dual point attractors, and whose behavior is chaotic but follows bounded limit cycles. Waldrop, 225–30.

45. There is no requirement for agents to be "unaware" of the emergent behavior of the system within which they operate. Such emergent qualities could be viewed as another part of the agents environment. For example, in the stock market (a complex system) a stock trader observes both the overall market indicators as well as the activity of the traders he competes with.

46. Kauffman, 207–43.

47. This is a very simplified description of the topic of Kauffman's book, although the book is accessible to the layman. Kauffman examines systems with up to several hundred nodes (values of N and K). By way of comparison, the brain, also a complex adaptive system, has several hundred million neurons, each with up to 10,000 connections. See Waldrop, 160.

48. Deep Blue, IBM's chess-playing supercomputer, defeated Gary Kasparov, the world chess champion, in a match that began on 3 May 1997. In an advertisement, IBM stated, "Although Deep Blue can't be taught to bluff or feel pressure, it can plan 13 moves in advance while crunching over 400,000 positions per second." International Business Machines, *Wall Street Journal*, 29 April 1997. It is significant, however, that Deep Blue's opening moves were orchestrated by human grand masters.

49. Waldrop, 150–51.

50. Bak and Chen, 53.

51. Holland, 10.

52. Andrew Illachinski, *Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamic and Complex Systems Theory to the Study of Land Warfare* (Alexandria, Va.: Center for Naval Analyses, July 1996), 48. Illachinski attributes the "Heraclitian" label to geneticist Richard Lewontin.

53. For a discussion of the "Heraclitian" metaphor in terms of the history of military theory, science, and philosophy, see, Lt Col Robert P. Pellegrini, USA, *The Links between Science, Philosophy, and Military Theory: Understanding the Past, Implications for the Future* (Maxwell AFB, Ala.: Air University Press, 1997), 57. Pellegrini does not use the term Heraclitian, but his discussion concerns similar relationships.

54. The best unclassified single-source survey of the application of complexity to warfare is a two-volume report by Andrew Illachinski, *Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook (CIM 461.10)* and *Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamic and Complex Systems Theory to the Study of Land Warfare (CRM 96-68)* (Alexandria, Va.: Center for Naval Analyses, July 1996), 48. "Land Warfare" in the title is indicative more of the sponsor of the study than its true applicability to warfare in general.

55. Holland, 85–86. Complexity theory provides very powerful models for understanding the function of the human brain. See J. A. Scott Kelso, *Dynamic Patterns: The Self-Organization of Brain and Behavior* (Cambridge, Mass.: MIT Press, 1995).

56. Bak and Chen, 53.

57. See Mitchel Resnick, *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds* (Cambridge, Mass.: MIT Press, 1995), 119–30, for an excellent discussion of the centralized mindset, the tendency for people to assume the existence of a

"lead or seed" to explain the existence of patterns and behaviors when in fact no specific unitary cause exists.

58. Illachinski, Part II, 97–104.

59. There is a close relationship between chaos theory and complexity theory. Both describe the behavior of dynamic systems, but complexity theory subsumes chaos theory in its holistic approach to understanding systems that are ordered, chaotic, or complex adaptive, even though the formally labeled complex adaptive regime is only one mode of behavior.

60. Maj Steven M. Rinaldi, *Beyond the Industrial Web: Economic Synergies and Targeting Methodologies* (Maxwell AFB, Ala.: Air University Press, 1995).

61. Col Dennis M. Drew and Dr. Donald M. Snow, *Making Strategy: An Introduction to National Security Processes and Problems* (Maxwell AFB, Ala.: Air University Press, 1988), 13.

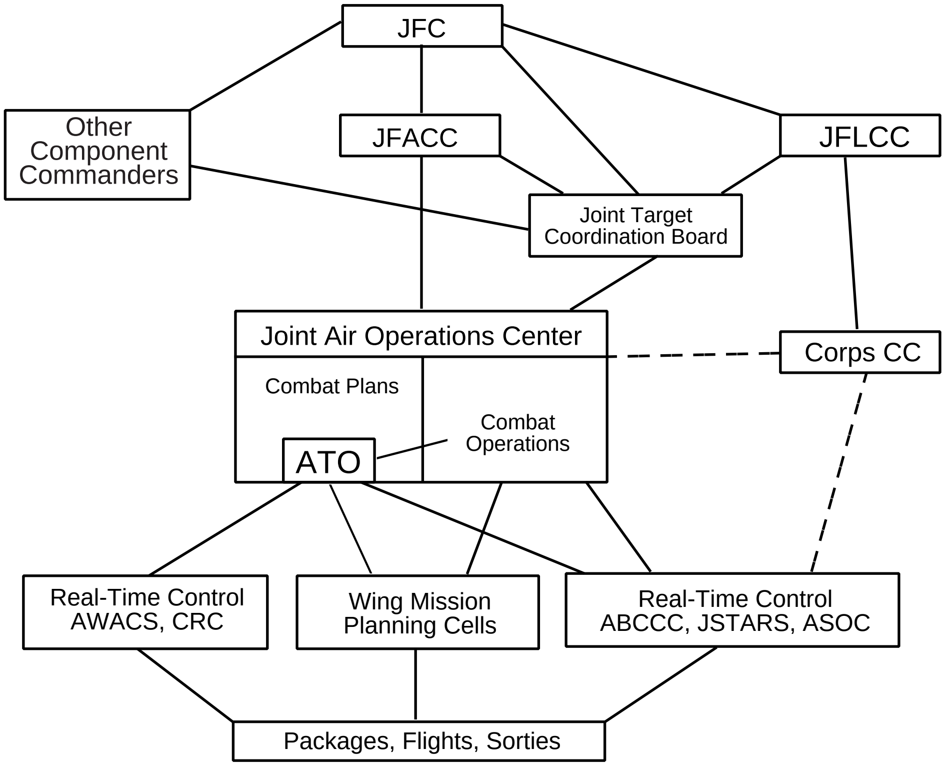
Chapter 3

Describing Centralized Command and Control with the Theoretical Framework

Using the framework from chapter 2, this chapter discusses centralized command and control (C^2) based on current US Air Force theory, doctrine, and recent practice. The goal is to describe the main elements of the C^2 system for a generic USAF-organized air component. This chapter will not examine details that vary depending on the theater. The interrelated nature of the framework makes it difficult to select a leading subject, but this chapter begins with organization because organizational structures show most clearly on a diagram and provide a good foundation for discussion. Operations is the second topic. It explains the processes by which the organization plans and executes strategy. Two closely related topics, command and leadership, are discussed and then followed by the trio of doctrine, training, and education. The last framework topic is C^2 systems, the hardware and software that knit the whole discipline together. Systems are particularly appropriate to lead the transition from predominantly centralized operations to a concept for predominantly decentralized operations.

The Centralized Organization

Figure 3 diagrams the organization of the Theater Air Control System (TACS) in a typical combat environment as commanded by a joint force air component commander (JFACC) and controlled through the staffs and forces below him. At the center of the TACS is the air operations center (AOC), which may be joint or combined.[1] The JAOC (used for the remainder of this discussion) is a theater-level command post, commanded by the JFACC, which directs theater and global assets participating in or supporting the theater air campaign. The JAOC geographically collocates a large portion of the personnel and systems necessary to plan and direct an air campaign. Real-time control assets such as an airborne warning and control system (AWACS), a joint surveillance and target attack reconnaissance system (JSTARS), and an air support operations center (ASOC) function as extensions of the JAOC and are distributed throughout the theater. Standing AOCs focus primarily on real-world operations and play a much smaller role in the command and control of daily peacetime flying operations.[2] Garrisoned AOCs mobilize and deploy only during a real contingency and have no peacetime C^2 function beyond training and exercises.[3] In peacetime, the JAOC is typically a cadre of staff members serving on a numbered air force (NAF) staff, commanded by an O-9, the designated JFACC. Upon deployment or employment, the JAOC staff dramatically grows in size as augmentees from Air Force, joint, and allied or coalition organizations provide both manpower and expertise.



Source: Adapted from Lt Col Michael Straight, "Commander's Intent: An Aerospace Tool for Command and Control?" *Airpower Journal* 10, no. 1 (Spring 1996): 43.

Figure 3. Typical Theater Air Control System Showing Combat Tasking Authority

The JFACC guides the JAOC staff in the combat plans division to create a theater air campaign strategy or air operations plan. The JAOC distributes this plan in daily slices to frontline units and real-time airborne and ground-based control elements using the ATO. Real-time control elements, usually in coordination with the combat operations division of the JAOC, direct real-time changes to the ATO. The combination of detailed centralized planning and real-time control provides the JFACC a measure of responsiveness to unexpected conditions not possible through centralized planning alone. The operations section discusses planning, execution, and responsiveness in greater detail.

The organizational principle underlying the JAOC is the master tenet of airpower. Centralized command and control with decentralized execution places most of the personnel, systems, and decision authority necessary to plan and direct an air campaign into a single, geographically collocated organization. The JAOC is a centralized nexus of information and authority that provides the JFACC with an enormous span of control extending to the individual targets, sorties, and weapons for every unit he commands.[4] This span of control gives the JFACC the flexibility to concentrate force when and where it is needed while simultaneously using his assets in the most efficient manner possible.

As a centralized controlling agency, physical survivability is especially important to a JAOC. Information survivability and security are different topics and are discussed in the systems section. While there are sometimes designated alternate JAOCs, they normally do not have the connectivity a primary facility has, nor the same number of personnel. While it has never occurred, a successful attack on a JAOC would delay the execution of an air campaign. Because protection from attack is important, the JAOC is usually located in a rear area that is less vulnerable. Historically, this rear area has always been in theater, whether on land or at sea, but as communications technology has improved, the location of the JAOC in terms of its ability to command and control has lost importance. New concepts such as reachback operations and virtual (usually distributed) air combat staffs are technically feasible today and could permanently garrison the JAOC in a protected location regardless of the theater.[5] These concepts may include a small, mobile, in theater "JAOC forward" to gain the extra measure of situation awareness and coordination that comes only through physical presence.[6] The location or multiple locations of the JAOC are transparent to centralized command and control if the fusion of inputs and decision authority remains under centralized control. The impact of physical location on other issues, such as the exercise of leadership and command in the absence of face-to-face contact, will be discussed later.

A JAOC achieves flexibility via the information it can access, the forces it commands, and its internal planning processes that connect air strategy to the daily ATO. The centralized structure remains constant while different assets hook up to the JAOC either as input or output devices, much like a mainframe computer. The main challenge to flexibility is interoperability—linking any asset a JFACC wants to employ to the JAOC planning and execution processes, a link that is more than just a communications channel. Normally, a representative of each weapons system or other agency is present in the JAOC to integrate objectives, priorities, limitations, capabilities, and doctrine into the campaign.

Centralized Operations

This section describes how the typical JAOC plans, executes, and assesses joint air campaigns.

Centralized Planning

Planning begins with a 5-phase analysis process to research the operational environment, determine objectives, identify a strategy and the COGs, and integrate these into a joint air operations plan (JAOP) as seen in figure 4. The JFACC works with the other components, the joint force commander (JFC), the combat plans strategy cell, and previous campaign assessments to formulate a sound JAOP to guide the ATO cycle.

Figure 5 diagrams the ATO process executed by the combat plans branch of the JAOC. The joint guidance, apportionment, and targeting (JGAT) cell uses the JAOP, updated inputs from each component commander, the JFC, and the Joint Target Coordination Board (JTCB) to pro-

Phase 1: Operations Environment Research
Collect information about friendly and adversary capabilities and intentions, doctrine, and the operational environment.

Phase 2: Objective Determination
Produce clearly defined and quantifiable objectives that contribute to the joint force commander’s (JFC) operations or campaign objectives.

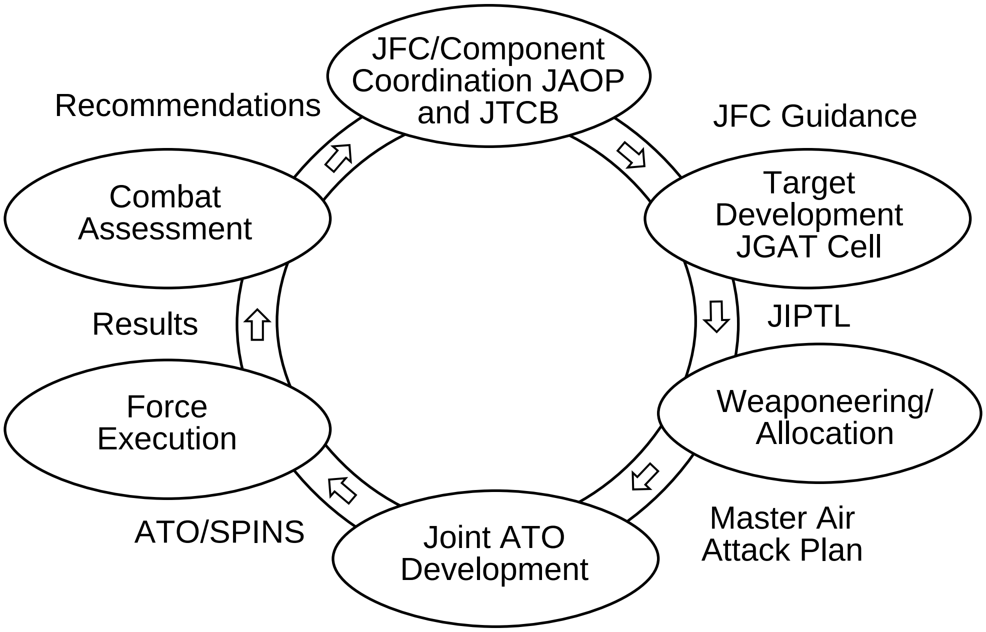
Phase 3: Strategy Identification
Produce a joint air strategy statement that describes how the joint force air component commander (JFACC) plans to exploit joint air forces/capabilities to support the JFC’s objectives.

Phase 4: Center(s) of Gravity (COG) Identification
Identify those adversary COGs that could be attacked to satisfy the JFC’s strategic, operational, and tactical objectives and friendly COGs that should be defended.

Phase 5: Joint Air Operations Plan (JAOP) Development
Produce the JAOP to detail how joint air operations will support the JFC’s operation or campaign plan. The JFACC develops the JAOP based on the JFC’s guidance.

Source: Adapted from Joint Publication 3-56.1, *Command and Control for Joint Air Operations,* 14 November 1994, 2.

Figure 4. Joint Air Operations Planning Process



JAOP - joint air operations plan
JGAT - joint guidance, apportionment, and targeting
JIPTL - joint integrated prioritized target list
ATO - air tasking order
SPINS - special instructions

Source: Adapted from JP 3-56.1, 3.

Figure 5. Generic Air Tasking Cycle

duce the joint integrated prioritized target list (JIPTL). The JIPTL enumerates every target in priority based on the theater strategy, regardless of which component identified or proposed the target. Next, weaponeering and allocation matches the targets on the JIPTL to the actual resources (aircraft and weapons) available to produce the master air attack plan (MAAP). If the JIPTL has more targets than there are resources available to hit them, the MAAP must draw a line on the prioritized list and plan targets based on priority, timing, and location so that the available assets can efficiently attack as many of the highest priority targets as possible. Finally, the ATO development shop uses the MAAP to produce the ATO, special instructions (SPINS), and airspace control order (ACO), integrating a number of other considerations such as identification criteria, weather, and the nature of the threat.[7] The SPINS and ACO are important but purely administrative documents which specify deconfliction procedures. After JFACC approval, the ATO shop disseminates the ATO, SPINS, and ACO to the rest of the JAOC, wing mission planning cells, other service components, and real-time control assets.[8]

The ATO takes effect on a set day and time, traditionally 0600. For a given ATO execution time, the strategy cell refines the JAOP 48–72 hours prior, and the JGAT cell produces the JIPTL 36–48 hours prior. The MAAP is completed 24–36 hours prior so that the final ATO can be developed and distributed not later than 12 hours prior to execution. The remaining time goes to the wings and real-time control assets for mission planning.

The planning process is designed to optimally match limited air resources with the typically unlimited requirements of the air campaign and priority land and sea target nominations vulnerable only to air attack. Centrally planning all available assets is the doctrinally preferred means by which the JFACC can accomplish as much as possible with the limited assets available. Optimization and efficiency are means by which the process seeks to maximize effectiveness. Air campaigns, by definition larger in scope and duration than limited strikes or raids, cannot achieve every objective with a single 24-hour ATO. Therefore, each ATO seeks to move as far as possible towards the end-state in an efficient, optimized manner. Developing and executing the closest approximation of an optimum air plan is the goal of the JFACC and JAOC.

Decentralized Execution and Centralized Assessment

For a given ATO, the formal planning processes end when the combat plans branch distributes the approved ATO to the theater. Depending on the number of sorties tasked, the combined ATO/SPINS/ACO document easily has several hundred pages. During the peak of operations in Desert Storm, more than 3,000 sorties were tasked in a daily ATO that peaked at over 800 pages.[9] ATOs are a tasking, not a mission plan, so wing mission planning cells extract pertinent data from the ATO, plan the details of sorties and packages, and organize them in a cockpit-friendly format. Last, mission commanders conduct final planning and brief the mission while ground crews prepare the aircraft. A wing usually needs 6 to 12 hours prior to takeoff to properly complete preparations, and more time is always better. This is a critical constraint that the JAOC planning process must meet if there is any hope of executing the ATO "as fragged."

Deployed wings normally employ with collocated aircraft as well as those located at other bases or on aircraft carriers. Deployed composite wings may launch all aircraft in a package from one base and have a straightforward, face-to-face mission planning process. When mission requirements task packages of aircraft from several bases or carriers, the ATO must provide the necessary coordination to marshal the desired mission package after takeoff. In order to minimize difficult lateral coordination, the ATO is more detailed when forces operate from different bases or involve several components or composite operations. When the ATO tasks a single component or base, less detail is necessary.[10]

Real-time assets direct ATO execution. These assets include airborne control elements such as AWACS, JSTARS, or the airborne battlefield command and control center and surface control elements such as the control reporting center, ASOC, and C^2 ships. All real-time control elements communicate with combat operations and possess the ATO. Unfortunately, JAOC combat operations personnel and the real-time control assets are normally unable to participate directly in the campaign planning process.[11] In a long ATO it is impossible to deduce the overall air strategy from a list of sorties and target coordinates. Thus, combat operations' broader understanding of the 24-hour slice of strategy comes from descriptions in the ATO itself, verbally from combat plans, or through an informal, nondoctrinal "JFACC daily guidance" or "daily operations order."

Combat operations compensates for errors or omissions in the ATO and real-time events such as mission aborts, bad weather, or unexpected enemy combat activity. To adjust the plan, the combat operations division changes missions after ATO distribution (ideally well before takeoff), scrambles alert aircraft for short notice missions, or retasks aircraft already airborne. There are a number of innovative combinations of these basic ideas that add flexibility and responsiveness to the game plan.[12] Combat operations normally does not alter the operational intent of the ATO tasked sorties, except in reaction to unexpected enemy activity. As currently mechanized, there is no formal means to formulate real-time air strategy. In the event of a large-scale change in the theater situation, the JFACC, combat operations personnel, real-time controllers, and aircrews effectively create strategy until the JFACC and strategy cell working through combat plans responds to the situation with an appropriate ATO. According to Lt Col J. Taylor Sink, "Unfortunately, there still seems to be no recognition for the need to continually revalidate the translation of military objectives into air strategy during a dynamic air war."[13]

Combat assessment is a collaborative effort led by the JAOC combat intelligence division. The most immediate feedback is often the weapons system video recording and the observations of the aircrew. Perfect video of a bomb on target does not always indicate that the desired effect has been achieved, and sometimes cannot even assess destruction since near misses make big explosions too. To measure effects, the JAOC increasingly uses sensors carried by theater and national level assets such as U-2s, unmanned aerial vehicles (UAV), and satellites to supplement aircrew feedback. These assets have separate communications channels through outside agencies to the JAOC, where intelligence staffs fuse the data into the information and knowledge necessary to build the JAOC's situation awareness. Feedback on resource status comes directly from the wings along with mission feedback.

The details of planning, execution, and assessment permit an estimate of C^2 responsiveness, the speed of the OODA loop or ATO cycle.[14] The ATO cycle is the nominal time it takes for the JFACC to make an input to the front end of the planning process, see that input result in an ATO tasking, execute it, and close the loop through assessment—once around the circle shown in figure 5. If the JFACC or combat operations do not bypass the normal process, the total length of this cycle is four to five days. The timeliness of the ATO is primarily a function of the complexity of the effects sought, the number of sorties and targets planned, and the size of the planning staff. Likewise, the timeliness of campaign assessment is a function of the quantity of raw data and the personnel available to fuse it into information and knowledge, something only humans can accomplish.

Five days is an eternity in modern combat, but the planning cycle does not begin and end at the JFACC, once every five days. It is better to envision a series of superimposed planning cycles in a production line format where the chassis of a new ATO is laid down every day. The JFACC provides continuous daily supervision and approval authority and when each "cell" finishes one day's planning products, it begins working on the next day's. The JAOC thus produces a continuous stream of air strategy in 24-hour slices. In this stream, it is routine to continuously modify an ATO that has moved farther down the line and provide inputs directly to combat operations. While such inputs provide responsiveness, they also increase confusion. Eliot A. Cohen remarked, "The flood of combat information prompts commanders to change targets or tactics at the last minute . . . In all cases, they created great uncertainty among the pilots flying the missions."[15] There are exceptions to the ATO planning cycle for missions such as air superiority and close air support in which preplanning targets is irrelevant or impossible. In these cases, the ATO generates sorties or alert postures, and specific taskings depend on real-time control elements (i.e., AWACS or JSTARS) coordinating with the aircraft commander or surface forces to engage fleeting airborne or surface targets.

The major challenge of the current and near-future planning, execution, and assessment process mechanized in the TACS is to speed up the process to improve responsiveness and strategic coherence in the face of enemy action. Since Operation Desert Storm, most improvements involve faster, automated computer and communications systems for the processes within the JAOC and to distribute the ATO to frontline units. There is relatively little emphasis on changing the organization or infrastructure of the decision-making processes themselves. The second major challenge concerns connectivity and interoperability. According to Air Force doctrine, the JAOC best employs airpower when it can logically and speedily incorporate every available theater or national asset in planning, conducting, and assessing the air war. A "plug and play" capability with the JAOC across all services is the ultimate goal.

Joint Considerations

The processes mechanized in the AOC are much the same whether the air component is predominantly single service, joint, or combined. Beyond basic systems interoperability, other components provide liaisons to the JAOC and the Air Force provides forward air controllers, air liaison officers, and assets like JSTARS for planning and execution control, all of which ultimately connect back to the JAOC.[16] Although personnel of all ranks execute synergistically during joint operations, planning for joint operations takes place only at the component level before it is delegated downward for execution. The ability to plan and execute any form of true combined arms warfare below the component level for a campaign phase, for a particular mission or objective, or for a certain period of time is extremely limited.[17] Squadron, group, and wing commanders do not conduct joint operations with their counterparts in other services except as planned by the JAOC and tasked in the ATO.

Command in the Centralized Air Component

There are three command relationships in the centralized air component organization: the command relationship between the JFACC and his JAOC (including real-time control elements), the command relationship between the JFACC/JAOC and the forces they command, and the command relationships within the forces themselves. The command relationships referenced here most closely resemble the joint definition of tactical control (TACON): the authority to control and direct the application of force or tactical use of combat support assets but refer more to the definitions in chapter 1 than the doctrinal concepts.[18]

As noted earlier, the source of the JFACC's flexibility in employing airpower is his enormous span of nearly direct control.[19] The JFACC exercises this command through the JAOC to implement the air strategy he desires. A JAOC director is in charge of the JAOC and directs its subordinate organizations like combat plans, combat operations, and intelligence. Within these organizations, the planning and execution processes are well defined, so the JFACC's primary concern (working through the JAOC director) is to ensure that the hundreds of people running these processes make good decisions for both strategy options and support. A majority of the personnel in the JAOC are usually augmentees with whom the JFACC and his permanent staff may have no prior working relationship, so this task is a challenge. This task is further complicated within a CAOC, where previous working relationships are almost assuredly nonexistent.

Between the JFACC/JAOC and the forces in theater, the JAOC represents a specialized, parallel chain of command and control with the single purpose of centrally planning and directing air operations when combat is possible or already under way. AOCs do not normally direct peacetime flying operations. Flying wing, group, and squadron commanders thus have no formal combat tasking authority for their units in the sense that they exert only ad hoc influence on the planning or direction of strategy through the ATO. The combat role of these commanders is to generate sorties, repair aircraft, and provide sustainment or support to those who do the same—and perhaps fly a combat sortie from time to time.

The order used by the JFACC to direct his forces is naturally the ATO, plus his authority delegated to combat operations working through real-time control assets. The ATO is the primary reflection of air strategy and represents the majority of the JAOC's strategy effort.

Chapter 2 describes a mission order as a task and a purpose, where the task states the mission but not how to do it and the purpose states the commander's intent. The opposite of a mission order is a detailed order that describes not only what to do but also how to do it. Detailed orders do not generally need a purpose (intent) statement, since they direct the unit to execute the tasks precisely as described. There is a gradient of detail between mission and detailed orders, and the ATO as normally distributed leans more towards the detailed order.[20] The ATO loosely resembles a mission order in that it specifies a target and weapon but little of the tactical detail planned at the wing level or below. The resemblance of the ATO to a mission order goes no further.

Functionally, the ATO is much more like a detailed order because it specifies targets rather than desired effects and the commander's intent in achieving those effects. For the majority of surface attack missions, the ATO remains an "order" to attack a target even though it includes a theaterwide commander's intent statement that might be useful to combat operations and real-time control elements. The intent statement serves little purpose to frontline units because there is little ambiguity about delivering a specific weapon to a certain target (coordinates and photo provided) at a certain time. Commander's intent in an ATO in no way delegates to an aircrew the authority to change a target to better achieve a certain effect. The absence of a means to deconflict targets and aircraft, coordinate support, and assess effects at any level below the JAOC in near real time prevents the delegation of the authority traditionally implied by a commander's intent statement in a mission order. Without approval from JAOC-level agencies, a mission commander's authority extends only to canceling a mission for good cause (aircraft system failure, bad weather, loss of support), attacking an approved alternate target, or maneuvering in self-defense.

Although traditional commander's intent has little practical utility for the wing level and below other than providing "nice to know" insight into the broader purpose of air operations, the JFACC uses a form of commander's intent mentioned earlier called JFACC's daily guidance to communicate to his JAOC, even though he approves the ATO and indirectly supervises combat operations.[21] Combat plans uses this guidance to devise and refine strategy, while combat operations uses it to compensate for the numerous real-time changes in a manner coherent with the planned strategy. As noted earlier, it is nearly impossible to infer the underlying strategy represented in an ATO without intent statements, but these are rarely provided at the sortie, flight, and package levels. The more "why?" the JFACC and combat plans provide, the better combat operations can adjust the ATO in light of changing conditions, yet this would have the unfortunate effect of making ATOs even longer than their current excessive length.

Leadership in Centralized Command and Control

As with command, this topic also has three parts due to the normal structure of a JAOC-controlled air component—the leadership relationship between the JFACC and his JAOC, between the JFACC/JAOC combination and the fighting forces in theater, and within the fighting forces themselves. This section describes leadership vision, team building, and motivation for each of these relationships.

The direct leadership relationship between JFACC and his JAOC is generally a daily event reinforced by the JFACC's presence at the meetings and approval functions involved in the planning and execution cycle. In additional to his role as an advisor to the JFC, the JFACC's role in the planning and execution processes within the JAOC require him to be accessible to it. In the past, accessibility equated to physical presence, but modern communications have the potential to decrease this requirement while still allowing him to carry out his normal leadership and supervision tasks.

In terms of the JAOC, the primary leadership challenge to the JFACC (through the JAOC director) lies in forging a mutually cooperative, usually ad hoc team composed of several categories of personnel. The largest single group on the AOC team is likely to be the core staff of the NAF, an air operations group, or joint headquarters who have a previously established working relationship with each other and the JFACC. While this group may be the largest, it will likely be a minority of the personnel in the operating JAOC. Next are the numerous augmentees and liaisons from staffs and operational units, to include other services and countries. Finally, there are individuals and small teams of specialists and experts who arrive only when a real contingency is at hand. The team building task the JFACC faces is to energize his "regulars," to incorporate the augmentees into the JAOC's goals and processes, and to exploit the specialists without creating internal resentment. The JFACC builds this team during a real-world contingency with a group of people that has probably never been to war, even as members of a JAOC staff. A secondary leadership challenge for the JFACC is to integrate the real-time control assets, rarely collocated with the JAOC, into the JAOC team as direct extensions of combat operations. Once the JFACC has successfully forged a cooperating team within the JAOC, motivating the group towards his vision of strategy is a straightforward function of direct and often face-to-face leadership and a shared sense of urgency to get it right.

There is a large potential leadership disconnect between the JFACC/JAOC combination and the theater forces they lead. The peacetime NAF commander does not command the same forces he commands as a JFACC in wartime, so there are leadership relationships that the JFACC must forge with his wing commanders. Unfortunately, it is difficult to build a leadership relationship through an electronically transmitted ATO that takes hours to decode into useful information at the wing level. For an ATO to work, the JAOC must expect full obedience and compliance in carrying out its taskings. The campaign would grind to a halt if every squadron called the JAOC to repeatedly negotiate the terms of its assigned missions. Fortunately, the leadership in theater is not as tightly reined and inflexible as a centralized ATO would suggest, largely because most Air Force leaders do not lead in this fashion in peacetime. It is common for mission planning cells and wing commanders to call combat operations to clarify or fix problems on the ATO.

Team building beyond the JFACC/JAOC carries over directly from peacetime squadron, group, and wing operations, with the added likelihood of normally diverse peacetime units operating together as provisional or expeditionary wings from the same airfields. Cooperative operations among several squadrons and groups is painless and exercised frequently in peacetime during the Red or Blue Flag exercises and the like. Motivating the team is likewise not usually a problem since most operators and maintainers relish the opportunity to put their finely honed skills to the test in combat, but there is an added motivational dimension.

As noted in the command discussion earlier, the JAOC is a war-mobilized combat C^2 organization that takes sortie tasking authority away from squadron, group, and wing commanders and locates it in the JAOC, the nexus of the information, planning, and execution systems necessary for combat tasking. Because the commanders below the JFACC/JAOC level have neither the authority (command) nor the ability (control) to direct the flow of combat in the campaign, their roles focus on sortie production, tactical mission planning, logistics, and support instead of strategy.[22] If these commanders receive enough of the JFACC's intent to explain it to their personnel, they will have a stronger leadership role in terms of motivating the campaign vision to their people, but they still only echo the JFACC and JAOC vision of combat.[23] Commander's intent statements in the ATO would solve part of the problem, as noted earlier, commander's intent without corresponding authority to modify tasks is not the original idea behind commander's intent.

The Role of Doctrine in Centralized Command and Control

Interest in aerospace operational art and doctrine climbed in the Air Force during the last decade, punctuated by *The Air Campaign*,[24] the Gulf War, the end of the cold war, Strategic Air Command, and Tactical Air Command as organizing features of airpower, and an operationally oriented version of AFM 1-1 (1992). Operational Air Force doctrine (AFDD 2-series) is in its infancy as most documents are still in draft, it is possible to make a few observations regarding doctrine in the centralized C^2 system.[25] The two pertinent categories of doctrine are C^2 doctrine AFDD 2-5.6 and operational war-fighting doctrine AFDD 2 and the AFDD 2-1 series.

The first draft of Air Force C^2 doctrine concisely describes and illustrates the centralized structure of theater command and control via a JAOC, then discusses the technical (systems) features of the C^2 system.[26] In broad terms, the structure of the TACS with the JAOC as the central directing organ does not change, and accordingly, doctrine has no reason to describe alternate structures. As noted in the organization section, the flexibility of the JAOC comes from the assets connected to it and the processes embedded in it. These processes are more complicated and are described by operational war-fighting doctrine.

The operational level of air warfare exists entirely within the JAOC. On a situational basis, the JAOC also touches on strategic issues, these are usually the domain of the National Command Authorities (NCA), JFC, and perhaps the component commanders.[27] The detail of the ATO as normally transmitted also shows that the JAOC's responsibilities extend to the tactical level of warfare. The result is that the JAOC spans an awesome conceptual distance from the near strategic to tactical levels of war, a span that completely includes the operational level of air warfare.

Because the JAOC completely subsumes the operational level of war and some of the tactical level, there is little practical reason for forces controlled by the JAOC to understand operational doctrine or warfare. Wings, groups, and squadrons employ at the tactical level and need only understand tactical doctrine. An understanding of operational level doctrine, while certainly a good idea from a professional standpoint, has little use when executing the ATO. The use of mission orders is an exception, such as the arrangement with JTF Proven Force in the Gulf War. The official USAF doctrine during Desert Storm included the 1984 version of AFM 1-1, a 1969 version of AFM 2-1, *Tactical Air Operations*, and tactical doctrine in the form of the 3-series manuals that are updated every year or two. AFM 1-1 and AFM 2-1 were not heavily referenced documents during the conflict, while the 3-series accurately reflected the character of tactical combat operations and accompanied most deploying units to the theater.

There are one positive and two adverse doctrinal observations from concentrating the operational level of air warfare at the JAOC. On the positive side, if operational doctrine is not adequate for a conflict, or some theater contingency requires a quick response that employs airpower in an entirely new manner, the centralized JAOC may be able to more quickly formulate a plan and direct its execution.

On the negative side, the group of personnel who have a practical need to know and use operational doctrine is small. This group consists of the NAF commanders (JFACC) and their strategy cells, academic and doctrine center personnel, and a few major command (MAJCOM) and headquarters USAF staffs.[28] Missing from this group are forces and commanders at the wing level and below. Centralization of operational air warfare stifles air mindedness above the tactical level of warfare in the largest part of the forces.[29] As a result, the JAOC becomes the de facto realm of the operational thinkers, while the wings become the realm of the tactical doers.

The second adverse doctrinal implication for the centralized JAOC is that for most missions, the language of airpower is the language of the ATO: sorties, targets, weapons, and timing, not effects. Without a jointly understood language to precisely describe airpower effects, there can be no initiative beyond the JAOC to achieve them and joint coordination becomes a more difficult, detailed task. For example, US Army doctrinal publications such as FM 100-5, FM 100-15, *Corps Operations*, and FM 101-5-1, *Operational Terms and Symbols*, precisely define the effects the army creates at nearly any level of combat, distinguishing between terms such as defeat and destroy. Without a language for airpower effects more specific than the general discussions contained in Air Force doctrine, both lateral and vertical communications are trapped at the tactical level of detail.

Training for Centralized Command and Control

Peacetime flying training is not centrally planned in detail, so this discussion addresses the training of the C^2 system itself. JAOCs have no peacetime function other than to train themselves and participate in C^2 exercises. Although associated with a NAF, the JAOC plays no role in the training of the forces assigned to the NAF in peacetime. Due to the same challenges of team building discussed in the leadership section, training a JAOC to accomplish its wartime C^2 mission is a difficult task. Many of the problems are due to the fact that the JAOC is a very large organization built specifically to support a unique force mix responding to a particular situation. A JAOC grows to its full and unique size and structure only during a real conflict.

Because the JAOC has no peacetime C^2 function, it is minimally manned, consisting of a cadre of staff personnel assigned to a NAF. Training and exercises must pull in a large number of temporary duty augmentees for periods of one to two weeks. The expense of temporary duty and the fact that augmentees have other job responsibilities at their home station limit the frequency and duration of training. Additionally, the group of augmentees is not constant from exercise to exercise. The decision to send a particular person to augment JAOC training is usually based more on the sending unit's needs and preferences than the experience or training that augmentee may possess to accomplish a JAOC role.[30]

The length of a typical exercise makes it difficult to execute all aspects of the C^2 process, from basic strategy formulation through ATO generation and then to execution and assessment to close the loop. Realism is also a challenge. Most exercises do not control real aircraft in a training scenario with real-world, real-time inputs, and it is difficult to simulate the intensity or coordination involved in a near-simultaneous launch of 500 or more aircraft. There are a few specialized joint exercises that include command and control of live aircraft sorties and offer the rare opportunity for more realistic training.

The challenges of training a JAOC both realistically and frequently make it difficult for the organization (even the cadre) to collectively retain past lessons.[31] For communications and computer systems operators, the problems are acute. Learning to operate and maintain the equipment takes up to two years, but the typical three-year assignment undercuts the payoff of this training.

At the wing level and below, a more stable complement of assigned personnel plus daily training and periodic flag (or similar exercises) and operational readiness exercises provide realistic experience in reading ATOs, mission planning, and tactically employing airpower. Training opportunities are not always evenly distributed and remain subject to high post-cold-war operational demands and tempos, but the mission planning and exercise process at the wing level and below is sound.

Education Support to Centralized Command and Control

Air Force professional military education (PME) plays a number of roles that directly support centralized command and control in addition to the greater goal of producing officers with a deeper understanding of their profession. First, PME must educate the strategists who will support the JFACC and work in the JAOC in wartime. Second, through historical research, education assists in the process of formulating doctrine that supports both command and control and operational war fighting. Third, educational research contributes new ideas for the organization, development, and employment of airpower.

The split between the operational level of warfare embodied in the JAOC and the tactical level of warfare in the wings and below permits little diffusion of operational art into the tactical world.[32] Tactical operators have little insight into the operational level of war before PME teaches it to them or a JAOC- or staff-related billet teaches them on the job. This causes two effects. First, advancement in rank and the associated PME is based on the potential to assume greater responsibilities, presumably at higher levels of warfare. Commanders must judge officer potential based on tactical ability, work ethic, and a general assessment of intellectual aptitude, with little opportunity to assess operational war-fighting aptitude or interest. Second, the operational education of the officer takes place in large, concentrated doses of PME that remains primarily associated with rank advancement.[33] While such education may lead to a more permanent pursuit of operational art, the educational method does not reflect the "life-long, open ended, continuing process for all personnel," that Air Force PME seeks to instill.[34]

Systems Support for Centralized Command and Control

Communications and computer systems support the relationships on the organizational chart and the processes in each functional area. There are again three areas to examine—systems within the JAOC, systems that connect the JAOC to operational units and real-time control elements, and systems that support the forces the JAOC directs.

There is a constant effort to streamline the ATO process. The goal of these systems is to increase speed, reduce paper (any essential work done outside the system), and improve reliability, robustness, and connectivity. The core system is the Contingency TACS Automated Planning System (CTAPS), the primary software used to generate and disseminate the ATO. A number of other software packages show promise to automate various parts of the ATO processes and integrate them into CTAPS. Increasing speed and reducing paperwork go hand in hand. Using networks and on-line working environments, passing targets, guidance, and other data from cell to cell within the JAOC becomes easier and faster, and facilitates planning ATOs with large numbers of sorties. In fact, a new generation of systems may free the ATO from the time-incremental (usually 24-hour) cycle, permitting continuous transmission of mission assignments as soon as they are ready in combat plans.[35]

Robustness and reliability of the computer systems in the JAOC continue to be critically important. If the whole system or any part of it should "dump," physically fail, lose its power supply, or come under attack, the air campaign is in jeopardy because there is very little strategy to task planning conducted outside the JAOC.

Systems improvements will simplify the administration and supervision of campaign planning, but it is unlikely that computer systems will soon substitute for the judgment of human planners. There are many tasks that computer systems accomplish exceedingly well. For example, expert systems store logical rules and guidelines based on historical cases and programmable expert human knowledge, and permit the operator to perform a search to rapidly locate rules or combinations of rules that may apply to a particular situation. Expert systems are valuable aids and streamline parts of the research process for developing an air campaign plan, but they require a skilled operator to properly interpret their output and cannot substitute for human reasoning, judgment, or intuition. Other systems like distributed planning networks facilitate rapid, structured interaction between numerous human users, and hold great promise in permitting human collaboration that might not otherwise be possible due to time or geographic constraints. Therefore, it is possible to streamline the largely administrative aspects of the ATO production process, but it is unlikely (even undesirable) that the required number of expert human planners and strategists as a function of the dynamic complexity of an air campaign will decrease any time soon.[36]

Reducing the footprint of the JAOC in theater is another high priority that systems improvements are poised to satisfy. As previously mentioned, the reachback concept garrisons the bulk of a JAOC's personnel and systems in a safe location outside the theater. High bandwidth communications link the garrisoned JAOC to a smaller element, the JAOC forward, which includes the JFACC, a much smaller quantity of equipment, and a small staff. Reachback both reduces the physical vulnerability of the JAOC and avoids most of the deployment hassle with little loss of functionality. As a result, the JAOC can plan the campaign instead of worrying about deployment and beddown. The major vulnerability posed by reachback is the robustness and bandwidth of communications channels to the theater.[37]

Systems interoperability is the key to connecting the JAOC to the other components, wings, and real-time control elements. In the past, systems interoperability was minimal and strained due to stand alone stovepipe systems not designed to work together. As a result, human operators ended up serving the systems by hand carrying and converting data from one system to another. Today, new systems must comply with computer and communications standards. The defense information infrastructure (DII) common operating environment (COE) provides connectivity throughout the joint force, plus the ability to connect older "legacy" systems that migrate to the COE.[38] Ultimately, the JAOC will connect digitally and seamlessly in real or near real time to everything that is a factor to the theater.

For a frontline unit, the most important communications link for combat execution is the vertical link that delivers the ATO from the JAOC. Without the current ATO, a unit does not participate in theater combat or participates only in a severely degraded backup mode. Because of its size and detail, ATO reception requires high bandwidth vertical connectivity to the JAOC, usually via at least two independent means.[39] Lateral connectivity among units at the wing level and below is of secondary importance, first because the centrally planned ATO usually provides the necessary coordination and second, because it is a low communications priority in theater.[40] It is possible to communicate from wing to wing through CTAPS, however these communications pass through the JAOC.[41]

At the wing level and below, local networks are already a part of deployed operations.[42] Automation is also revolutionizing wing operations, permitting more rapid extraction of pertinent data from the ATO and the planning of appropriate details through mission support and intelligence systems. In the future, the planning processes within the JAOC may extend to the wings, providing them with a more formal input to the planning process than the current arrangement of messages, phone calls, liaisons, and duty officers.

One last issue concerns information and communications security. There is an inherent security dilemma in all communications networks. In order to use a network, a computer must connect to it, yet this connection provides a path for the latest virus, program glitch, or breach of security. There is no "front" or theater for this problem. It exists whether the system is garrisoned in the USA or forward deployed. The challenge is to build the desired level of security into a networked system without slowing it down or making it too inconvenient to use. New encryption technologies have the capability to meet this challenge on a theoretical basis since they are effectively unbreakable.[43] When JAOC systems and the ATO distribution network routinely use the newest algorithms to block unauthorized access to either nodes or communication channels, there will remain only two ways to deny systems to the JFACC: physical denial through destructive or nondestructive effects or human compromise. The centralized JAOC may work best to defend against human compromise, but it then creates a problem for physical security.

The explosion of communications and computer technologies has great potential to streamline processes and ensure the connectivity the JAOC needs to operate at its best, provided reliability and security issues are part of the solutions. With the interoperability promised by DIICOE and similar concepts, systems will become increasingly transparent to command and control. These advances provide the JFACC with the information he needs and the ability to direct forces with less concern about the underlying systems that support these tasks.

Conclusion

This chapter describes the current practice of airpower command and control at the component level and below using the eight categories of the theoretical framework. This generic description does not apply to a specific theater and does not examine the categories in great depth. Instead, it describes the archetypal image of centralized command and control of airpower as practiced according to current USAF and joint doctrine so as to show the interrelated characteristics across the eight subjects. Chapter 4 takes an entirely different approach in applying complexity theory to the same theoretical framework to derive a similarly interrelated vision of predominantly decentralized command and control.

Notes

1. Joint operations include forces from more than one US service. Combined operations include the forces of another country.

2. For example, standing AOCs include the HTACC at Osan, Korea (effectively still a war zone), the AOC at Howard AFB, Panama, and the CAOC at Vicenza, Italy, which directs operations in Bosnia.

3. The AOCs associated with Eighth, Ninth, and Twelfth Air Forces mobilize and deploy to fight.

4. The normal exceptions are Army helicopters, Naval fleet defense, and Marine Corps aviation.

5. Col Scott M. Britten, "Reachback Operations for Improved Air Campaign Planning and Control" (paper, Air War College, Maxwell AFB, Ala., 1997); and Arthur F. Huber et al., *The Virtual Air Combat Staff: The Promise of Information Technologies* (Santa Monica, Calif.: RAND, 1996).

6. See Britten, 26; and Maj David Wessner et al., "Joint Air Operations Center: C^4I Structure Study" (paper, Air Command and Staff College, Maxwell AFB, Ala., 1995), 41.

7. In combined operations (most notably NATO), the ATO is called an "air tasking message (ATM)," because one country does not traditionally command or "order" another country's forces.

8. Adapted from Joint Pub 3-56.1, *Command and Control for Joint Air Operations*, 14 November 1994, chap. 3, and from Col Maris "Buster" McCrabb, "Air Campaign Planning" (paper, ACC/DR-SMO-V, Langley AFB, Va., 1996).

9. Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey (GWAPS) Summary Report* (Washington, D.C.: Government Printing Office [GPO], 1995), 149. See also Alan D. Campen, ed., *The First Information War*: *The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War* (Fairfax, Va.: AFCEA International Press, 1992), 43.

10. Lt Col Maris "Buster" McCrabb, "Air Campaign Planning," *Airpower Journal* 7, no. 2 (Summer 1993): 11–22.

11. Combat operations generally sends a representative to the MAAP meeting.

12. *GWAPS Summary Report*, 51. "Push CAS" is an example. Fighters cycled through a specific area every few minutes. If not tasked by the ground commanders after a certain period of time, they proceed to planned targets.

13. Lt Col J. Taylor Sink, *Rethinking the Air Operations Center: Air Force Command and Control in Conventional War* (Maxwell AFB, Ala.: Air University Press, 1994), 33.

14. The OODA loop concept comes from Col John R. Boyd, "Organic Design for Command and Control," unpublished briefing slides, May 1987.

15. Eliot A. Cohen, "The Mystique of US Air Power," *Foreign Affairs* 74, no. 1 (January/February 1994): 113; and Daniel R. Gonzales, *Evolution of the Air Campaign Planning Process and the Contingency Theater Automated Planning System (CTAPS)* (Santa Monica, Calif.: RAND, 1996), 20.

16. JSTARS provides radar detection and tracking for surface vehicles much like AWACS provides for aircraft. There is currently a doctrinal debate concerning the control aspects of JSTARS. In the Gulf War, JSTARS was employed not only as a sensor platform but also as a control platform under the JFACC. The Air Force would like to preserve this arrangement in doctrine. Under current doctrine, JSTARS is only a sensor platform.

17. Maj P. Mason Carpenter, *Joint Operations in the Gulf War: An Allison Analysis* (Maxwell AFB, Ala.: Air University Press, 1995), 66.

18. Joint Pub 0-2, *Unified Action Armed Forces (UNAAF)*, 1995, III-9, 10.

19. AFDD 2-5.6, "Command and Control (C^2) and Command, Control, Communications, and Computer (C^4) Systems" (first draft), 31 January 1997, 28, discusses increasing span of control while dramatically decreasing decision time as a function of systems, not campaign complexity.

20. The normal ATO is a list of units, sorties, targets, weapons, support arrangements, and so forth. Although the ATO could distribute mission orders, the current format is a joint and combined document. Changing it would require approval from all appropriate agencies, which would take a long time. Moreover, the ability of wings to plan and execute based on mission orders is extremely limited. The exceptions are composite wings able to employ primarily organic assets with established planning procedures and information

systems. JTF Proven Force during the Gulf War built this capability and operated with de facto mission orders. The 366th and 347th Wings at Mountain Home AFB, Idaho, and Moody AFB, Georgia, respectively, and US Navy carrier air wings are the only standing forces with similar capabilities.

21. The first draft of AFDD 2-5.6 briefly includes the commander's intent in the planning process without defining it or explaining how it applies to airpower directed through an ATO.

22. Tasks accomplished in the wing mission planning cells are usually delegated to junior officers who are more current with the intricacies of the weapons systems and mission planning. Chap. 4 argues that modern communications and computer networks make it possible to give commanders both the ability and authority to plan and execute appropriate portions of an air campaign but only when supported by organization, doctrine, training, education, and command and leadership philosophies.

23. See Richard E. Simpkin, *Race to the Swift: Thoughts on Twenty-First Century Warfare* (London: Brassey's Defence Publishers, 1985), 232–40. This corresponds to the "2-up, 2-down" concept associated with mission orders. Personnel must understand the commander's intent two levels of command higher and ensure the intent for their level of command is understood at two levels lower. This serves as a motivational tool since personnel better understand how they fit into the overall campaign.

24. Col John A. Warden III, *The Air Campaign* (Washington, D.C.: Pergamon-Brassey's, 1988). This book is one of the very few that directly addresses the operational level of air warfare.

25. As of this writing (June 1997), only a few of the AFDD 2-series documents are beyond the draft stage.

26. AFDD 2-5.6, 31 January 1997.

27. For example, coalition airpower's efforts to target Iraqi Scud launchers and missiles targeted at Israel were key to keeping Israel out of the Gulf War and preserving coalition unity, a strategic issue.

28. The School of Advanced Airpower Studies regards the strategy billets on numbered air force staffs (which become the strategy cell in a JAOC) as the job which most typifies the educational goals of the school.

29. Sink, 42.

30. Observations from visits and discussions with Eighth Air Force and Twelfth Air Force personnel during Blue Flag exercises.

31. A stateside AOC typically participates in four to six Blue Flags per year (five days long) and perhaps four more "in house" exercises conducted at the home base without augmentees. Exercises are training-event driven to provide systems operators with basic equipment proficiency.

32. Col Edward C. Mann, *Thunder and Lightning: Desert Storm and the Airpower Debates* (Maxwell AFB, Ala.: Air University Press, 1995), 190. Colonel Mann observed that squadron aircrews threw away their shrink-wrapped copies of AFM 1-1 when the new version was distributed in 1992 and suggested that this was due to anti-intellectualism and a lack of commitment to the profession of arms. While this may be partly true, it could also be true that the doctrine had little practical use based on the war-fighting organization and environment of the Air Force. In comparison, tactical doctrine as embodied in the 3-1 series manuals is vibrant, intellectually challenging, and reflects deep commitment by those who write and refine it on a yearly cycle. The challenge is to create the same environment at operational and strategic levels.

33. In addition, masters degree programs need not be related to the profession of arms.

34. Lt Col Richard L. Davis and Lt Col Frank P. Donnini, *Professional Military Education for Air Force Officers: Comments and Criticisms* (Maxwell AFB, Ala.: Air University Press, 1991), 100.

35. Air Force Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century, Summary Volume* (Washington, D.C.: GPO, 1995), 26.

36. The Information Technology Volume of the Air Force Scientific Advisory Boards *New World Vistas* sounds an appropriate warning regarding software described as intelligent: "In the development of agents there may be a propensity to ascribe human attributes to a program as its functionality increases . . . But care must be given in not misleading users as to the reasoning power and adaptability software programs like agents actually have."

37. Britten, 50.

38. Defense Information Systems Agency (DISA), "Defense Information Infrastructure Master Plan Executive Summary" (Arlington, Va.: DISA, 28 July 1995), 5 and 10.

39. Discussion with communications specialists, Eighth Air Force Blue Flag/Unified Endeavor, Barksdale AFB, La., 18–21 December 1996.

40. According to Joint Pub 6-0, *Doctrine for Command, Control, Communications, and Computer (C^4) Systems Support to Joint Operations*, 30 May 1995, VI-4 through VI-6, Global Command and Control System (GCCS) connectivity priorities start at the top and work downward, namely, the NCA, JTF commanders and headquarters, component commanders, then tactical units. Lateral coordination at the wing level and below is low in priority.

41. Using Kauffman's N-K construct, the JAOC has numerous nodes (2,000 or more personnel) that are intensely interconnected and has the potential to become chaotic during highly dynamic situations. Due to the general lack lateral connections, the field units have main connections (K = 1 or 2) to the JAOC through which they receive the ATO. Accordingly, their ability to exhibit adaptive behavior is minimal, and they remain an ordered behavioral regime.

42. Local networks accompanied the rapidly deployed Air Expeditionary Force to Jordan commanded by Brig Gen William Looney III (described during visit to the School of Advanced Airpower Studies, 3 March 1997).

43. Algorithms include triple digital encryption, public key encryption using the RSA algorithm, and new methods using quantum encryption techniques. These techniques pose mathematical problems that are and will remain numerically intractable. See Martin C. Libicki, *What Is Information Warfare?* (Washington, D.C.: NDU Press, 1995), 31–34, or Air Force Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century, Information Technology Volume* (Washington, D.C.: GPO, 1995), 92.

Chapter 4

Applying Complexity Theory to Decentralize Airpower Command and Control

"If the Air Force really wants the JFACC to be a theater air commander, then it should release the JFACC from daily tactical control over all fixed-wing aircraft operations and concentrate instead on the theater air battle fought by all air and space assets."[1] This chapter proposes a C^2 system that combines the ability to achieve a specified objective with the benefits of complex adaptive behavior. To achieve this goal, the proposed system is not purely decentralized as described by the definitions in chapter 1, but it is predominantly decentralized and more decentralized than the system described in chapter 3.

There are two characteristics inherent in the following proposal, but it is difficult to distinguish between them in the discussion. First, this proposal describes a system that will allow increased adaptive behavior throughout the organization, a kind of infrastructure for adaptability and organizational learning. Second, this proposal suggests beginning methods and processes that will serve to initialize the system and provide insight into its operation. Ideally, once an adaptive infrastructure is in place, the initial methods and processes embedded in that infrastructure, and even the infrastructure itself, will evolve towards more fit possibilities that incorporate newer, more effective ideas.

Because complexity is a young and interdisciplinary science, concepts from other fields that are compatible with the theory rarely carry an explicit complexity theory label. For example, Adam Smith's well-known description of the "invisible hand" in economics is a classic discussion of emergent behavior written more than 200 years before the advent of complexity theory. In constructing the following proposal, the author depends upon deductive reasoning to apply ideas from several disciplines to decentralize airpower command and control. Through this process, the resulting C^2 system may offer the potential to exploit adaptability, better allocate decisions, use resources with agility, and ameliorate the JAOC vulnerability problem to provide effective airpower in either traditional or new scenarios.

The Predominantly Decentralized Organization

In the field of organizational design, a pervasive theme is the central role of decision making as a variable that determines the structure of the organization. Such an approach is particularly germane to this study because it defines the principal object of command in terms of purposeful decision instead of its logical mirror image, the management of uncertainty. Organization design theorist Butler framed the design problem in terms of the "Principle of Requisite Decision-Making Capacity." According to this principle, the central problem in organization design lies in constructing a structure that has a decision-making capacity equal to the decision-making requirements based on the level of uncertainty in both the ends and means of the organization. He associated the spectrum of uncertainty with the terms of *crisp* and *fuzzy* to describe organizations and their processes.[2]

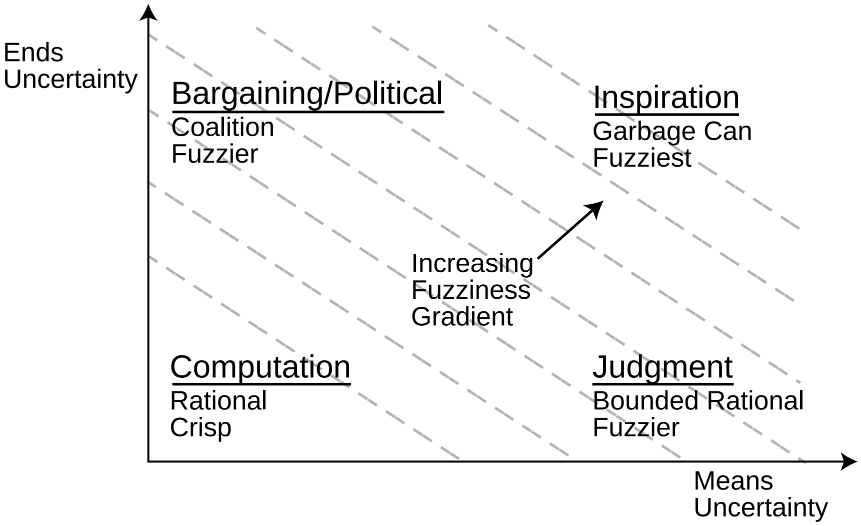
A crisp organization is formal, with precisely demarcated areas of responsibility, little decision latitude, and firm control. Interactions are based on defined parameters and remain within the limits set by those parameters. Analysis is the basis for decisions and analytic rules, decision boundaries, and interaction parameters are centrally formulated. Each individual functional area ideally makes decisions based on the rules and parameters established by the central authority so that the overall system will exhibit the efficiency and reliability of clockwork. Accordingly, any change of rules, parameters, or responsibilities must occur through the centralized authority, or breakdown of the entire system may occur. Crisp structures are mechanical and suitable for stable, unvarying tasks and environments.[3]

On the other hand, fuzzy organizations have an implicit structure that is more interactive and decentralized. Responsibilities may be differentiated, but not rigidly so. Decisions result from collective organizational activity as problems, solutions, participants, and opportunities constantly vary within a flexible network infrastructure.[4] Fuzzy structures are organic and suitable for unstable or varying environments, tasks, and methods. By using the N-K network model in crisp organizations, K (number of connections per node) is small relative to N (number of nodes) signifying little connectivity, while in fuzzier organizations, K is larger relative to N.

Low uncertainty permits routine procedures employed by crisp structures to improve efficiency. High uncertainty implies an environment that has little routine and requires fuzzy structures to achieve the adaptability necessary to cope with changing circumstances. The problem is to design an organization sufficiently crisp to minimize decision-making costs (maximizing efficiency), yet sufficiently fuzzy to achieve adaptability (maximizing effectiveness). Succinctly stated by Butler, "Fuzziness is needed to cope with indeterminateness."[5] Since no organization is purely fuzzy or crisp, the objective is to design organizational zones of fuzziness and crispness to maintain the proper balance between adaptability and efficiency.[6]

US Army Pamphlet 600-80, *Executive Leadership*, expresses similar concepts in its discussion of control. "Control and decision latitude (or initiative-building) are reciprocals. The more control there is, the less decision latitude there can be and the more slowly thinking and decision skills will mature throughout the organization."[7] "There is an optimum level and type of control for each level of operational complexity. In general, we overestimate the ability of senior levels of command to deal effectively with operational matters at subordinate levels."[8]

The first quote is interesting not only because it identifies the relationship between control and decisions but it also connects control with thinking and decision skills. The second quote is similar to Butler's principle but stated in control rather than command (decision) terms.[9] Butler combined the Principle of Requisite Decision-Making Capacity with a contingency model of decision making that includes several other decision models, namely, the rational, bounded rational, political, and garbage can decision models.[10] Figure 6 depicts the contingency model with two axes defined by uncertainty in means and ends.



Source: Adapted from Richard Butler, *Designing Organizations: A Decision-Making Perspective* (New York: Routledge, 1991), 59.

Figure 6. The Contingencies of Organizational Decision Making

This model provides a useful tool for understanding the relationships among several decision-making models, a basis to assess the organizational structure described in chapter 3, and a pointer towards an appropriate decentralized structure.

The JAOC is the central authority in a doctrinally crisp theater C^2 organization operating in the "computation" quadrant of the contingency model of decision making. The planning, execution, assessment processes (the 5-phase theater analysis process and 6-step ATO cycle) conducted within the JAOC are nominally rational, crisp processes.[11] Together, they ostensibly create an optimal match of available resources to priority targets based on theater strategy. Although combat operations directs real-time changes to the ATO, these processes function best in an environment that changes more slowly than the duration of the ATO cycle. The JAOC is the lone doctrinal agent above the tactical level of warfare and conducts all planning to support the JFC/JFACC concepts of operations from the strategic level down to tactical level packaging and sorties. There is correspondingly little decision lattitude at the receiving end of the ATO beyond a narrow range of tactical tasks. Primarily communications is vertically oriented as each executing unit depends on the central authority for direction.

Based on Butler's organizational design principles and executive leadership doctrine, the decision capacity of a C^2 system needs to increase to survive in a dynamic environment. The organization must become fuzzier. The NCA, JFC, and component commanders largely resolve the uncertainty in operational level "ends" (what to do). Operational "means" uncertainty (how to do it) becomes the primary problem for the JFACC and the C^2 system below him. This orients the decision vector away from the computation quadrant towards judgment vice political bargaining. In this case, fuzzier structures imply more interactivity to solve problems that do not lend themselves to planned solutions.

From the complexity theory perspective, enabling complex adaptive macro-behaviors requires more operational-level, rule-based agents with an appropriate dynamic communications infrastructure. Even though hierarchical structures are not by definition complex, complex self-organization commonly produces hierarchical structures, so the wing-group-squadron organization is viable if the appropriate micro-characteristics are present to give it adaptability. Under these circumstances, predominantly decentralizing the functions of the JAOC suggests that logical first places to locate decision authority lies in the wing, group, and squadron commanders (and their staffs) where such authority already exists during normal peacetime operations.[12]

Aligning decision authority appropriate to the combat demands and resources at each echelon increases the number of agents (commanders and their staffs) in the theater C^2 system, but there are several other requirements to increase adaptability based on complexity theory and organization design. The first of these is a communications or interaction infrastructure—the lines on an organization chart. If wing, group, and squadron commanders collectively assume the responsibilities of a JAOC, they must be able to communicate freely with each other and have the requisite information in order to execute these tasks. Based on the N-K model, the density of connections, K, must rise as N rises to preserve or enable adaptability.[13] These requirements suggest a network among commanders (and their staffs) at each echelon of the organization to support collaborative efforts in spite of geographic separation. As wing commanders execute their combat command authority, they must communicate taskings to the group commanders below them. The same applies for group and squadron commanders. These communications requirements suggest a wartime organization that combines the traditional hierarchical command structure, including combat tasking authority, with a network among commanders and their staffs at each level of command. For ease of comparison, figure 7 depicts the simplified command arrangements under the JAOC showing split lines of command authority and little lateral networking.

The JFACC and the AFFOR (Air Force commander) are usually but not necessarily the same individual, depending on which service provides the preponderance of airpower assets. Figure 8 depicts the decentralized organization structure.

The dual system of organization, hierarchy combined with a network as depicted in figure 8, occurs in a wide variety of professional organizations. Charles Handy, a social philosopher with broad academic and business

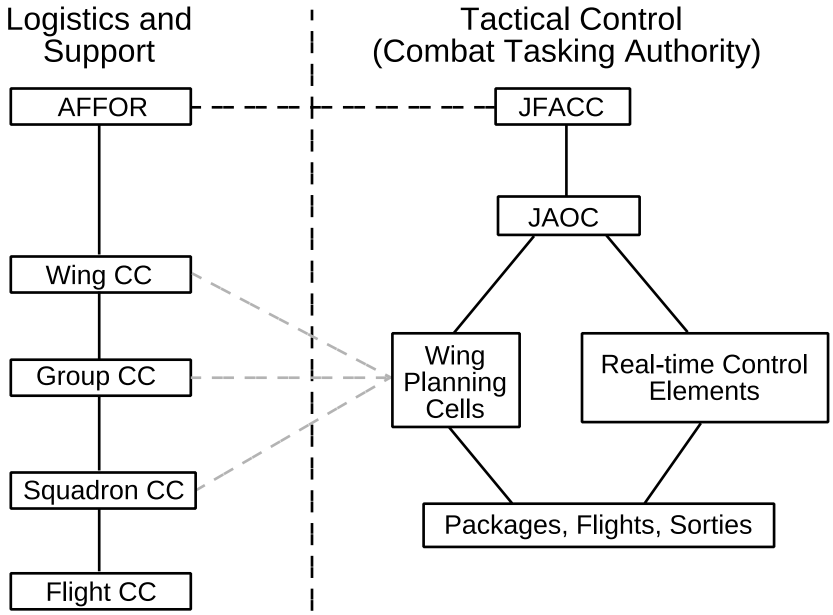


Figure 7. Split Lines of Tactical Control, Logistics, and Support

credentials, calls the system of "twin hierarchies" both necessary and useful.[14] Twin hierarchies marry the seniority hierarchy of an organization, based on knowledge, experience, and longevity, with interdependence at the work group level, where disparate skills must work together, often with one particular skill area taking the lead depending on the specific situation. The skill-based hierarchy is a dynamic network that matches expertise with the task at hand, providing a self-organizing quality to the organization.[15]

Dual hierarchy is not another version of the traditional matrixed organization that establishes two lines of authority, one for products and one for processes. Instead, this structure combines a traditional hierarchical line of command authority with a networked arrangement for emergent control. In figure 8, chain of command authority is unified and aligned with commanders at all levels, but the different capabilities of forces they command requires lateral cooperation to assign, plan, and execute missions.

Composite wings and forces attending flag (and similar) exercises regularly cooperate in this manner, although they enjoy the luxury of collocation that this organization does not assume, and wing and group commanders have little role in the strategy process. Within this lateral arrangement, the situational expertise and key personnel required for combat planning and execution are unlikely to be the same from contingency to contingency. The primacy of command combined with dynamic situations and organizations prevents the political forces that typically cause process versus product conflicts in static matrixed organizations.[16]

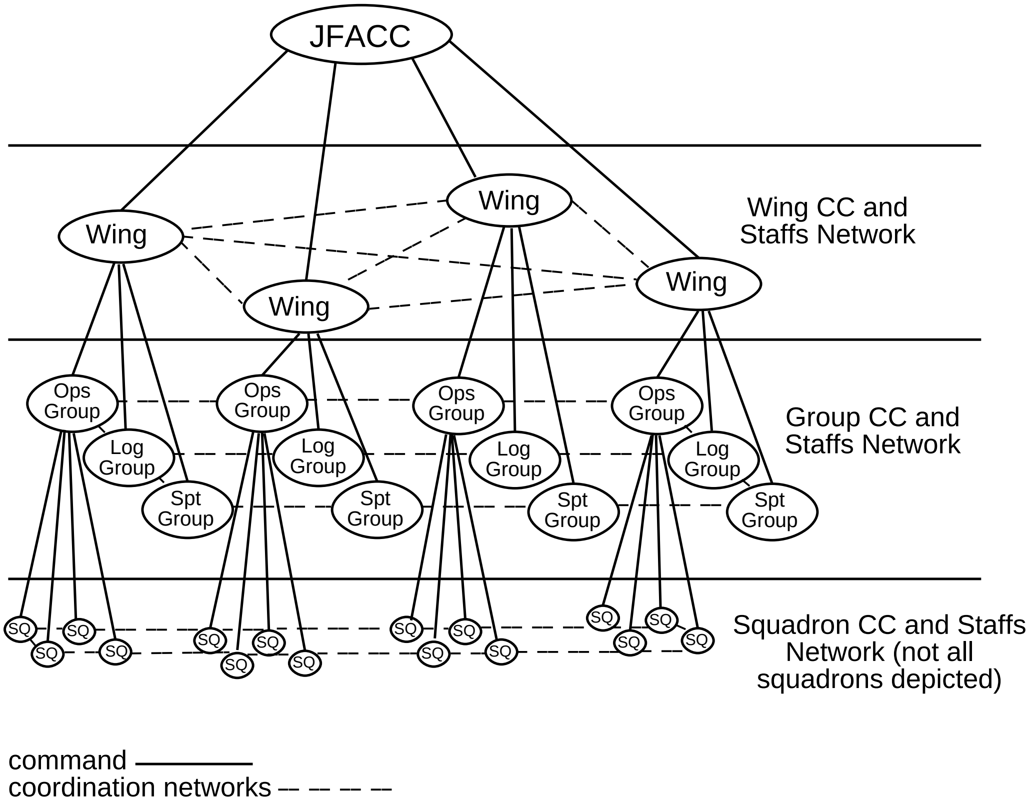


Figure 8. Decentralized Organization Structure

Based on the definitions of command and control, it is important to reiterate why an unrestricted networked organization of some kind is not a preferred option for decentralization. An important result of complexity theory is that it is not currently possible to design a purely decentralized system with a given emergent behavior. Employing a pure, unstructured network to implement a desired emergent strategy is likewise impossible. The proposed organization marries the characteristic responsiveness and adaptability of a network with a hierarchical structure commanded by the JFACC to guide the organization's purpose towards a desired end. This structure is similar to the structure that the peacetime Air Force uses, except that it is more highly networked laterally, and there are new imbedded processes to support wartime operations. Although the wartime structure is topologically identical, specific squadrons, groups, and wings chop to the theater forces based on the nature of the contingency, just as they do under centralized command and control. Each commander has a small networked staff to carry out functions peculiar to that level of command, control, and employment.

This predominantly decentralized organization identifies agents and a rudimentary infrastructure. The next section describes how it works, and subsequent sections slowly build the remaining micro-characteristics—rules, decisions, competition, and fitness judgment—which provide adaptability.

Predominantly Decentralized Operations

Combat operations are the ultimate series of fitness tests for the theater air component. These operations naturally build on doctrinal, training, and educational preparation. In the absence of a JAOC, planning, executing, and assessing combat operations takes place much differently.

Planning

Predominantly decentralized planning tasks align with the echelons of the hierarchical organization, layered so that the refinement and detail of the air campaign from the strategic to the tactical levels increases from JFACC to wing, group, and squadron. Campaign planning processes define a normal locus of decisions for each commander that is commensurate with assigned resources, experience, and ability. Commanders use mission orders to provide the subordinates commanders with flexibility to plan and execute in any doctrinally suitable manner. Should a commander need to provide detailed orders to a subordinate commander for any reason, it is transparent to the system.

Mission orders consist of a task and a purpose, and the purpose or commander's intent is the more important part. Intent speaks in terms of effects and desired end-state. Subordinates must understand the intent of the commanders above them, and likewise, subordinate commanders' intent statements must conceptually nest within their senior commander's intent. Intent provides the basis for subordinates to exercise initiative when unanticipated opportunities arise or the original task no longer applies. Commander's intent as practiced by the Germans included both intent and "intents," and both senses of the concept are useful for airpower mission orders.[17] Intent applies to the overall organization, while intents are part of a concept of operations and apply to each subordinate unit in the organization.

Mission orders for airpower must accommodate fundamental differences in air and land warfare. First, missions on a two-dimensional battlefield normally take place within defined geographic zones (areas of operations) with forward boundaries, lateral boundaries to deconflict neighboring operations, and rear boundaries to interface with supporting forces. Geographic deconfliction of surface combat operations is straightforward (at least theoretically) as is coordination with neighboring and supporting forces, but deconfliction in this manner unnecessarily restricts airpower. Such a deconfliction scheme would effectively require composite wings with perfect aircraft mixes in a route package system with predefined routings between bases and targets. This is clearly impossible as well as unacceptable, and even if possible, specific mixes of aircraft would not serve all phases of a campaign equally well. Although a JFACC may deploy specific mixes of aircraft to certain bases for a number of reasons, but to require any specific arrangement only ties the JFACC's hands.[18] Theater airpower must be able to strike any target within the theater while operating with any mix of aircraft from bases distributed throughout or outside a theater, whether marshaled on the ground or after airborne. Geographic boundaries applied as they are in surface warfare only restrict flexibility. Airpower mission orders for decentralized air campaign planning must provide a suitable mechanism for force packaging and deconfliction.

Second, support relationships have a different meaning when there is no specific area of operations with a rear boundary. In an ideal planning system, any support asset should be able to support any combat asset within the physical capabilities of the two systems, regardless of home base or target. Furthermore, since support will not usually be organic to the combat air forces, there must be a clear means to prioritize support assets when supply is less than demand. Mission orders in the airpower context must provide the means to identify, coordinate, and prioritize support relationships among forces.

Planning within each echelon of the hierarchy uses a distributed collaborative real-time planning system and takes place in parallel. For example, once the wing commanders in theater receive orders from the JFACC, they conduct a networked planning effort, supported by their staffs, to collaboratively formulate group level taskings that support the JFACC's orders and transmit them downward. Distributed collaborative planning (DCP) systems are already part of the joint deliberate planning process and are accelerating planning processes by enabling them to take place in parallel or concurrently at several locations.[19] Migrating such systems to a deployed execution environment with real-time or near-real-time capabilities will provide this capability. Although the organization emphasizes a vertical hierarchical structure with lateral networking within each echelon, the planning system should not deny diagonal connections to higher or lower echelons for special situations. Most normal planning takes place laterally and in parallel after receiving mission orders from the next higher level.

Given a layered campaign planning concept for mission orders to pass information between layers and collaborative parallel planning within layers, figure 9 outlines a division of planning tasks and target development by echelon.

JFACC Tasks	
JAOP Level Planning	For Each Campaign Phase:
Campaign Orientation	Objectives, Tasks by Wing, Operational Effect (Purpose)
Wing CC Tasks	
MAAP Level Planning	Air Base Integration— Operations, Logistics, Support
Phase Orientation	Link Operational Effects to Tactical/System Effects
	Within Each Phase Provide Operational Effect, System, Tactical Effect, Forces (Ops Groups), Missions
Group CC Tasks	
Mission Level Planning	Forces Integration—Attack, Enhancement, Control, Support
System/Battle Orientation	Preliminary Airspace Deconfliction/Coordination
	System, Tactical Effect, Target, Time, Weapon, Squadron/Sorties, Support
Squadron CC Tasks	
Sortie/Package Planning	Detailed Mission Planning
Daily Orientation	Final Airspace Deconfliction/Coordination
	Sorties, Takeoff, Refueling, Route, Deliveries, Mission CC, Remarks
	Upload Sortie/Mission Plan to Execution Network

Figure 9. Outline of Key Responsibilities for Decentralized Employment Planning

These tasks are flexible and evolve with the organization structure and commander based on training, real-world experience, and the particular nature of the contingency. For the wing, group, and squadron commanders, the following discussion emphasizes the new planning roles due to combat tasking authority—the roles they assume because there is no JAOC, and these commanders and their staffs assume the variety of functions the JAOC accomplishes. Command logistics and support roles also decentralize to the extent that such roles take place in the JAOC.

The JFACC retains most of the same responsibilities, except his decisions remain at the theater level. He has a small staff of strategists, logisticians, support specialists, communications support, and perhaps a technical specialist from a particular unique asset. As in centralized operations, the JFACC advises the JFC and integrates airpower into the joint campaign. He selects forces, mobilizes and deploys them to the theater (if required), and organizes them into wings and groups based on squadron and detachment building blocks. He devises an overall air campaign concept, phasing and objectives within the campaign, and conducts theater-level analysis of the enemy to determine what effects will achieve the objectives of each phase. He assesses the enemy in relation to theater-level limiting factors, namely, operations and airfields, logistics and support, and political/economic limits on strategy for rules of engagement. He determines critical limiting factors in all areas and devises options in the event friendly forces operate near or beyond recognized limits. The JFACC maintains a campaign-level orientation and provides the wing commanders with the JFC intent, JFACC objectives, theater-level COG, airpower effects by phase and wing, and JFACC intent for joint operations below the component level. The JFACC essentially provides JAOP-level planning (but without tactical detail) to his wing commanders and other supporting agencies instead of a JAOC.

The wing commander roles change appreciably because they exercise combat command of their forces in addition to integrating logistics and support at the base level. Wing commanders must understand, plan, and direct the use of every airpower asset under their command to contribute to theater objectives.[20] While the JFACC maintains a campaign-level orientation, wing commanders maintain a phase and theater (operational) effects orientation. Wing commanders and their staffs conduct tactical level COG analysis so as to connect operational effects to tactical effects on individual enemy systems and assign them to operations groups most appropriate to attacking the identified systems. For support assets, wing commanders identify and integrate supporting effects with the other friendly assets. Wing commanders also integrate base-level logistics and support with the specific forces that wing provides. Wing commanders accomplish these tasks collaboratively and in parallel through networked staffs to plan at the campaign-phase level of detail. Wing commanders also coordinate directly with remote assets to be employed in theater and with their counterparts in other components (corps and division commanders and carrier battle groups) in joint operations. Wing-level mission orders describe the tactical effects, timing, systems, forces, and lateral coordination operations groups that will require them to achieve stated operational effects, thus providing the critical link from the operational to the tactical level of war. They also coordinate theaterwide airspace control measures and identification procedures. Wing commanders effectively provide the MAAP level of detail to their operations groups but without detailed sortie assignments.

Group commanders are oriented to the battle level of detail—achieving tactical effects against specific enemy systems and supporting effects for friendly forces.[21] Group planners use the tactical effects, systems, and forces guidance from the wing commander to select specific targets and timing and to arrange force enhancement, support, and assessment. With the timing, targets, and support arrangements, groups provide coarse deconfliction among assets over a period of several days to a week. For example, operations groups have a general idea of the density of operations in space and time based on the targets they identify and a rough estimate of force required to attack them. This information is adequate for coarse deconfliction. Using collaborative planning among the commanders and their staffs, operations groups deliver near ATO detail to their squadrons for mission planning.

Squadrons operate much like they do today, except that they control the number of sorties they schedule to attack the targets specified by the operations group. Squadrons focus on combat success at the engagement level, and they refine deconfliction for specific missions. They coordinate directly with other squadrons to plan mission details, select weapons, generate cockpit-usable mission data, brief, and fly the missions.

Based on these planning tasks, the applicable time frame of orders varies according to the echelons involved and the level at which dynamic enemy activity takes place. Once the JFACC states the campaign objectives and phasing in the concept of operations, it is conceivable he would amend orders only to identify significant branches or sequels or to react to an enemy surprise at the strategic or theater levels. JFACC orders may change on the scale of weeks to months. A large miscalculation or significant enemy action on friendly forces could be grounds for a new concept of operations and provoke a more immediate response. With their campaign phase focus, the wing commanders typically issue orders several times during each phase, depending on the battlefield activity as tactical effects on the enemy combine or accumulate to create operational effects. Group orders occur on an even shorter time scale, from one to several days, oriented towards the timing of tactical effects on specific enemy systems. Finally, squadron taskings fluctuate daily, though squadron mission planning using group level information may extend several days in advance.

Without assuming composite wings or geographical deconfliction, the mission orders and distributed planning processes described here depend completely on decentralized, networked communications and computer systems. These systems are discussed later in more detail, but the functions they assume in facilitating functional decentralization away from the JAOC and ATO is such an important part of planning and operations that they are also briefly discussed here. Figure 10 illustrates the three functional requirements: a collaborative planning network, a real-time execution network, and an assessment/effects development network.[22] The planning systems are time-keyed, networked databases. Time keyed

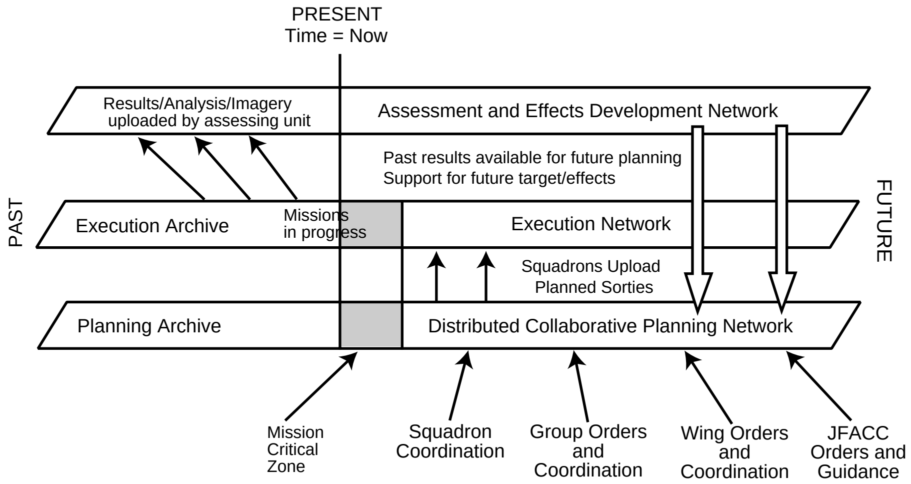


Figure 10. Three Real-Time Networks Supporting Decentralized Planning, Execution, and Assessment

implies that all data in the system has a time (relative with respect to another event or absolute) associated with it and the system has a universal clock. The network supports future planning that eventually moves into execution and then becomes archived as a record of past operations. The foundation planning system is near real time and functions similarly at all echelons even though the content provided at each level of the hierarchy and by each weapons system is different. The system is both a messaging system and planning system, and all participants in the system can normally observe the activity of any other (selected) part of the system. There is the possibility to "rope off" part of the system for planning restricted access operations, but too many restrictions destroy the collaborative aspect of the system. Commanders transmit orders through the system and coordinate laterally to fulfill their responsibilities, and the orders and coordination of all units are accessible by any unit on the system. Even as lateral coordination occurs a level or two higher, subordinate planners could observe the flow of information to get an indication of likely taskings, anticipate target development bottlenecks, and even make inputs if the situation warrants.

The networks operate in a combination of a supply-push and demand-pull modes of exchanging information. Between echelons, commanders push mission orders to subordinate units, but because they are mission orders and not detailed orders, this is a limited quantity of data. Certain information, such as prearranged mission assessments, would also be pushed to the appropriate units automatically. Within echelons, units operate on a demand-pull basis by coordinating with a limited number of units (identified in the mission orders) to plan and execute a mission that satisfies the senior commander's intent. This limitation in the lateral information flow prevent the bandwidth requirements of the network from skyrocketing, much like the predominant demand-pull nature of the Internet.[23]

The JFACC makes inputs into the system first, entering his campaign concept, taskings for the wing commanders and, when he is directed, associating it with an execution time. The entire planning process can take place with a relative D day, and when the real (absolute) D day is established, it ripples through the system to set the plan in motion. Similar advance planning could take place for important branches and sequels. The JFACC's order is a template for planning all operations so that they support the theater objectives, as indicated in figure 9. Based on the JFACC's air operations plan and previous theater research, intelligence authorities gather information to support the phase objectives the JFACC identifies. The wing commanders and their staffs add the next level of detail, connecting theater effects with tactical effects on enemy systems and the specific forces to achieve them. Wings continue working with the appropriate intelligence, surveillance, and reconnaissance (ISR) agencies through the effects development network to request products to support COG analysis and to identify tactical effects linked to the JFACC's operational effects. Based on effects, the same ISR agencies plan postattack assessment requirements and provide guidance to groups and wings on possible ways to achieve certain effects, if they have such information. Groups pull specific imagery from the effects development network, identify and measure targets, assign them to squadrons, and coordinate for mission support. Finally, the squadrons use group information to finish detailed planning, whereupon they upload planned sorties into the execution system. The process of uploading a completely planned sortie into the execution system is the equivalent of filing a flight plan, except that the sortie data is much more detailed, including weapons, delivery, and target information, as well as the links to expected effects, enhancement, support, and assessment assets. Sorties depending on the planning of missions in other squadrons, such as tanker support or defense suppression, are flagged by the system until all linked supporting sorties are also uploaded and synchronized. Synchronization mechanically checks linked mission plans to ensure takeoff times, cruise speeds, fuel offloads, and so forth broadly agree in time and space to ensure the expected synergism can occur.

The execution database is "real time" because all missions are time tagged, and there is a moving time pointer representing current operations in progress. There is no restriction on how far in advance missions can be loaded into the system, although there are minimum time restrictions, especially if a mission is linked to other assets that need specific planning, launch, or cruise times. Commanders and planners at any level have the capability to "fly" future missions loaded into the execution system at several times real speed on a visual display of the theater. This capability permits them to visualize future combat plans to monitor planning activity below them, or fly a future plan while suppressing or adding assets to test robustness, or try unplanned options.

Once a senior commander completes his orders and finalizes them on the planning network, he and his staff monitor the planning activity of the subordinate level to ensure it is on schedule, meets the commander's intent, and to catch potential problems. Frictional problems will arise in both strategy and resources, and in both cases, commanders must understand the possible behaviors of the network below them to know when to make inputs and what kind of inputs to make. In terms of strategy, a senior commander may observe planning that he feels is not appropriate or well advised in light of superior options. Another type of conflict arises when two subordinate commanders disagree on a course of action, but both believe their plan best achieves the commander's intent. If subordinate commanders do not solve problems on their own, the senior commander makes timely, direct inputs to rectify the situation or revise his intent statement if the problem occurs on a widespread basis. If limited resources (e.g., tankers or reconnaissance assets) cause a conflict that subordinates cannot resolve, there are a number of possibilities. First, the senior commander suggests a solution that subordinates overlooked. Second, the commander provides more resources to relax the limitation, if he can arrange for them, or modifies the tasking if it was overconstrained to begin with. Third, in the absence of more resources, the commander prioritizes to give the resources to one subordinate and then the other instead of both simultaneously. Finally, if the senior commander cannot prioritize within the mission and intent he himself must meet, he appeals to his superior for assistance. Ideally, direct inputs to solve either strategy or resource conflicts would be a rare exception rather than the rule.

Besides differences in strategy and resource limitations, there are other more common emergent network behaviors and friction that senior commanders handle on a proactive basis. There will be critical planning paths in which a planning delay by a single unit delays the planning by many others. There will also be units that have difficulty committing to a given plan as they continually adjust their intentions based on other inputs, or because they are trying to meet constraints that are too great, but they do not know it. Such changes and the resulting dithering will propagate across the planning network and prevent or delay convergence on an acceptable plan for combat. Finally, there is the possibility of grossly unsatisfactory planning due to a misapplication or misunderstanding of commander's intent. It is a weakness of mission orders that misunderstood commander's intent has potentially much more grave ramifications than an operation directed with detailed orders. Because the connectivity (K) is higher relative to the number of units (N), errors can ripple more readily through the networks, but the command hierarchy must provide the counterbalancing force as a check against chaos. Misunderstandings of intent can result from a training problem that impacts the "common operational outlook" and mutual trust required for mission orders, but this should be rare in a professional air component where commanders are career officers. Given that the network distributes the planning workload across more commanders and their staffs and permits monitoring of both planning and future execution, there may be a higher probability of detecting and correcting this situation through a decentralized network system than there is in a centralized JAOC. When a commander or his staff recognizes network problems, the goal is to influence the planning process either directly or indirectly to solve the problems with the minimum impact on subordinate decision authority.

In this monitoring role, senior commanders and their staffs use the network and personal presence as a directed telescope, suggested by Martin van Creveld as a key aspect of successful decentralized operations since Napoléon's time.[24] The directed telescope allows a senior commander to focus attention on a subordinate's activity without requiring a large mass of regular reporting (supply-push style), or curtailing or questioning subordinate initiative. A particularly valuable aspect of the system is the ability for senior commanders to selectively monitor subordinate planning, to include "flying out" missions uploaded onto the execution network to visualize future combat. Through planning and coordination at the senior staff level, commanders will understand and anticipate the critical strategy and resource areas and be better prepared to respond to friction in the ways discussed earlier. At the same time, senior commanders avoid direct involvement after issuing orders to permit their subordinates maximum flexibility and initiative to solve highly constrained problems in new and perhaps surprisingly innovative ways. Organization-wide initiative within appropriate decision latitudes is a primary benefit of decentralization, but the networks unobtrusively provide commanders with aspects of the directed telescope function they need to guide planning and execution.

The layering of planning tasks and decision authority provides another valuable benefit to the planning process: straightforward airpower war gaming. It is virtually impossible to quickly war game several airpower courses of action because the computational requirements to recreate current ATO processes and fly a strategy at the sortie level within a reasonable period of time are prohibitive. Furthermore, the ability to make quick modifications to test variants on a game plan is equally complicated, as can be the process of linking sortie level outcomes back to theater objectives. By limiting the locus of decision authority and focusing on critical limiting factors and the behavior of forces near these limits, it becomes cognitively possible to war game courses of action on paper, or using drastically simplified computational tools. For example, a wing-level war game uses the JFACC's JAOP as the primary input (including the JFACC if he were able to be present) to identify candidate enemy systems for each operational effect, identify the tactical effects against those systems, and determine synchronization requirements. Subsequently, different assignments of effects to operations groups combined with support, enhancement, and assessment requirements and base-level logistics and support completes the exercise. Such a war game does not require a massive sortie and target simulation using workstations, yet it provides commanders with a conceptual framework to assess different plans. Wing commanders and their staffs conduct such a war game either in person or through the distributed planning network, and groups observe the interaction. Once a course of action is selected, it is published on the network (as an order) to facilitate the next level of planning. Although computers may still assist the war-gaming process, there is a world of computational difference between war gaming for understanding and insight versus war gaming for numerical results.

Predominantly Decentralized Execution and Assessment

When a squadron uploads a sortie onto the execution system, it has accomplished the coordination necessary for that sortie to execute even though other squadrons may not have uploaded supporting sorties. Supporting links remain highlighted until all of the required sorties are uploaded and their synchronization verified. It is possible to add further changes to a sortie after it has been uploaded into the execution system, but if those changes cause a connection to another sortie to change, then the squadron on the receiving end of the change must agree to it. Such short-notice coordination takes time and introduces friction into the system, but the coordination is direct (squadron to squadron). If the original planning was not robust or the situation changes rapidly, a squadron may download a sortie from the system if it is incapable of flying it or the sortie no longer makes sense. In this event, units who depend upon that sortie for their own execution decide whether it is possible to proceed without it, whether they can find another squadron to work with, or failing that, appeal to the canceling squadron or their group commander to fly the sortie for a secondary or tertiary purpose. Therefore, uploaded sorties may continue to change, but changes are limited when they affect other units and missions. Ideally, drastic changes to uploaded sorties should be infrequent, because such planning should take place on the planning system, not the execution system.

As execution time approaches, sorties and missions enter an execution critical window. This window is different for each weapons system, is determined by groups and squadrons, and approximates the period of time before takeoff that the parameters of the mission must be stable to permit proper planning and aircraft configuration. Mission changes that affect other units will generally not occur within this window, and other units know when supporting assets enter this window because it is part of the uploaded sortie information and they can see it displayed on the network. Some aircraft have long critical windows due to weapons loading or mission planning times (perhaps as long as 12 hours), while other aircraft, such as those on alert status, have little or no critical window (five minutes). Likewise, aircraft will have different critical windows for different missions, and some units may need longer critical windows due to local operations tempo or planning limitations than other similar units need. Critical windows allow every squadron to communicate planning and launch constraints to other squadrons and groups who will support them (or get their support) in future operations.

Real-time control elements such as AWACS, JSTARS, and ground units integrate into the operations hierarchy just like any other squadron, group, or wing. They execute the missions assigned by senior commanders to support combat missions and joint operations and fulfill command intent like all other units. They have no command or control role as an extension of a JAOC. They gather and broadcast battle-space information throughout the theater through the execution network to add to the information available to commanders on a real-time theater battle-space display.[25] Control elements providing direction and monitoring (as in ground control intercept) to airborne assets on primary or support missions coordinate directly with those units or operate through standard operating procedures as they do today. These assets are not hierarchically superior to combat and support assets, but execute as a team to achieve the intent of their senior commanders.

The combination of on-board sensors and real-time cockpit displays of the execution system for a limited geographical area provides the deconfliction mechanism that permits individual initiative up to the moment a weapon is released. This system operates like the joint tactical information distribution system (JTIDS), but on an expanded scale. It displays both current operations and permits aircrew access (both display and inputs) to future operations to support mission adjustments after launch. Providing a mechanism for sortie-level deconfliction enables mission initiative, but the other benefit of the system is the increase in mission effectiveness due to higher situation awareness. Air-to-air engagements employing JTIDS consistently enjoy superior results versus adversaries without the system.[26] If a real-time cockpit link is too intense for the workload, real-time links to control aircraft and ground stations provide the same capability one level removed from the aircraft commander.[27]

Squadrons and groups determine flying schedules, subject only to the required support coordination, deconfliction with other units, and the mission and intent statements from higher command levels. Squadrons and groups decide if targets need to be reattacked to achieve or maintain a desired effect based on assessments and analysis arranged during mission planning. Such decisions take place at lower levels in the organization whether the desired effects occur from a single mission or an accumulation of the results of sequential or simultaneous missions. Likewise, every command understands its senior commander's intent and upon encountering a fleeting opportunity to achieve an effect economically has the means to exploit the situation or quickly communicate the opportunity to another unit. Squadrons, groups, and wings have normal operations tempos but can surge, perhaps doubling their sortie production for a short period to exploit such opportunities. Based upon their feel for the campaign and ability to coordinate support, commanders decide when, where, and how to employ the ability to conduct surge operations.

In terms of cycle time, activity on the planning and execution networks is real time but asynchronous and has no "speed limit" other than the minimum mission critical zones identified by the squadrons and planning time constraints expressed as part of a commander's intent.[28] The networks support many different OODA cycles operating simultaneously as squadrons, groups, and wings interact to plan, execute, and assess missions as quickly or as slowly as the theater objectives require, each adding their part to the whole while using or coordinating only what they need to accomplish their missions.

Once a mission is complete, the execution system archives the time-history of the mission for future reference. Assessment operations for every mission are arranged in advance and collect and disseminate mission information directly to the unit ultimately responsible for the effect sought. Collectors simultaneously post imagery and analysis on the assessment network for other units to use as necessary (on a demand-pull basis), and this information links to the execution archive. Final assessment of effects takes place at the squadron, group, or wing responsible for achieving them, regardless of the nature of the effect. Commanders have ultimate responsibility to accomplish missions that achieve effects at all levels, as stated in the definition of command in chapter 1.

As noted in chapter 3, the major challenge to the centralized command and control lies in speeding up its processes and ensuring high bandwidth vertical connectivity and interoperability to improve responsiveness. In contrast, lateral connectivity and interoperability are most important in the decentralized system, and high bandwidth communications to higher level commanders is less important than medium to low bandwidth communications (relatively speaking) both laterally and vertically within the decentralized organization. Bandwidth is not as much an issue for the decentralized system due to a vastly decreased quantity of supply-push information and much more demand-pull activity. Speed of response (nominal decision times) improves since the OODA cycles do not extend from the top to the bottom of the organization and the majority of decisions take place lower in the organization. The primary challenge for the decentralized system will instead be an understanding of commander's intent and reliability of action that comes through a common doctrinal, training, and educational outlook to air warfare at all echelons. Only through the common outlook and reliability of action will the decentralized system exhibit the hallmarks of vertical and lateral trust between units that is the key to its success.[29]

Before discussing joint considerations, two final concerns in decentralized operations are synchronization and mass. Decentralized operations have no explicit centralized control authority like the JAOC to guarantee synchronization or mass. Instead, the responsibility to achieve mission synchronization and mass where necessary falls directly on the shoulders of the commanders and their planning staffs. For mission orders, intent statements must communicate effects and the tasks within the concept of operations indicate the expected level of effort and timing necessary to achieve that effect. If hostilities begin suddenly after a long period of planning (such as the Gulf War), then the refinement of timing and mass will naturally increase, perhaps motivated by higher-level command guidance. If the JFACC or wing commanders do not have confidence in the group commanders and the distributed collaborative planning processes to generate the mass or synchronization necessary for a particular effect, they should centralize the planning of that portion of the campaign.

Joint Considerations for Predominantly Decentralized Operations

Planning and executing joint operations takes place at any level in the decentralized organization, ideally at the lowest level commensurate with the synergies that are expected from the joint operations. In decentralized operations, it is not doctrinally forbidden to chop combat command of a squadron, group, or wing to another component for a certain mission, objective, or period of time, although the commander that ceded command retains the authority operational control (OPCON) to pull the unit back if events or orders change. Such command arrangements do not work without a doctrinal foundation and peacetime training and education to develop the same trust and reliability of action between components that one would expect to find within a component.

Joint planning and execution requires interoperability with the planning and execution networks that is not conceptually different than the requirements already envisioned for future systems. It is likely that the liaison requirements between components would decrease due to increased peacetime training and education and the ability to directly coordinate between units instead of coordinating indirectly up and down a chain of command to reach a unit at the same echelon in a different component.

Joint interoperability on the planning and execution networks would facilitate more flexible joint employment and coordination options than currently exist. For example, different components would be able to operate more freely in what would today be considered each other's areas of responsibility because the coordination and deconfliction mechanisms are advanced enough to avoid the necessity to deconflict geographically, like the fire support coordination line (FSCL) or temporally, except as a backup. With advanced coordination and the training to support it, the need for areas of responsibility as joint deconfliction measures ultimately disappears.

Finally, using the same C^2 structure in both daily peacetime operations and real-world contingencies encourages a wider variety of joint employment concepts to develop at all levels of service and component organizations. Specific unit-to-unit relationships may build unique synergistic relationships that provide a much greater operational advantage than randomly pairing units from different services.[30]

The preceding organization and operations discussions do not cover every nuance of decentralized command and control. They have hopefully established a consistent conceptual picture to set the stage for the remaining subjects of command, leadership, doctrine, training, education, and last, systems.

Commanding the Predominantly Decentralized Organization

The decentralized organization and operations described earlier establish the agents in this complex system and provide them with a flexible, loosely structured interactive medium to plan and execute an air campaign. As noted in the definitions in chapter 1, command is difficult to reconcile with decentralization because military command is ultimately centralized in the NCA and the JFC. The reconciliation of this apparent paradox lies not in the decentralization of the formulation of the objectives of the military force (the "ends" of the contingency model of decision making) because objectives properly lie in the political domain. Instead, decentralization of command lies in the formulation of the means for employing military force. In commanding the military means, command authority and responsibility flow from the JFC through the JFACC to subordinate commanders to plan and execute a campaign that supports the politically determined objectives of the contingency. In short, as implied by a mission-order command system, objectives and effects are centralized at high levels and progressively "nested" at subordinate levels, but decisions concerning the means to achieve those objectives are decentralized.

There are many more dynamic command relationships in the decentralized organization than in the centralized one. Instead of a centralized organization (the JAOC) with a huge locus of decision authority from strategic to the tactical level, the locus of decentralized decision making is layered according to echelon of command. Layering keeps the demands at any command or staff position within cognitive limits and focuses commanders on those tasks most suited to their experience, resources, and abilities. Furthermore, commanders go to war with most of the same staff they have in peacetime, and those personnel from units chopped to the organization are experienced staff workers because they work on a similar staff at a similar echelon at their home base.

The basis for decentralizing decision authority into layers is subsidiarity. Subsidiarity places decision authority as low as possible in an organization, not because senior leadership is in some way empowering lower commanders to make certain decisions, but because the decisions properly belong at the lower level to begin with.[31] To quote Pamphlet 600-80 again, "There is an optimum level and type of control for each level of operational complexity." Stated more directly, it is wrong to make a decision for a subordinate that he should make for himself. Subsidiarity requires training, education, doctrine, and advice to help subordinates learn to make good decisions. Only in the event substantial organizational damage or an absence of requisite training and education should a senior commander intervene.[32] Continuous intervention of senior commanders into lower level issues not only risks detrimental neglect of their proper responsibilities, it deconditions subordinate commands from exercising the initiative they will need to cope with dynamic circumstances.

To complement the vertical division of decision authority, there are the lateral cooperative relationships within each level as wings, groups, and squadrons coordinate to achieve the intent of their superior commanders. The networked planning system is critical to enabling such coordination independent of theater geography or specific deployed unit locations. Because any part of the network can be accessed from any node, senior commanders have much more mobility to visit and command from the front lines.

The decentralized hierarchy unifies command and control in wings, groups, and squadrons. Command of the noncombat forces is no longer separated from the command of the combat forces. Instead, command is unified at each level, and in joint operations, command takes place at the point of synergy between two subordinate units. The lines of authority and responsibility are clear.

Decentralized command depends strongly on mission orders for subordinates, and mission requests for coordination among peers. Mission orders require a strong doctrinal foundation, precise and concise mission descriptions, and skilled use of commander's intent and "intents."[33] Mission orders depend on low volume, high-quality communication between senior and subordinate commanders. Control mechanisms associated with command typically pass to subordinate commanders and their staffs, providing an image of control from the bottom of the organization to the top.[34] These staffs conduct the higher volume (still demand-pull), routine internal and external planning and coordination that adds the detailed "how?" to the intent of the senior commander and helps the subordinate commander reformulate the mission and intent for the next echelon down. This command style is called command by influence because it consists of broad guidance appropriate to the level of command rather than labored detail.[35]

Leadership in Predominantly Decentralized Command and Control

Decentralized command and control closely parallels the leadership tasks suggested by stratified systems theory for large organizations. Stratified systems theory describes the increase in complexity of job requirements from low to high levels in an organization.[36] This theory is one of the principal constituents of the Strategic Leader Development Inventory used by the National Defense University.[37] The decentralized planning and execution processes described above progressively organize the cognitive complexity (not detail complexity) of leadership tasks based on strategic, operational, and tactical orientations and the time and resources associated with each. The richness and variety of leadership relationships in the decentralized organization match those of the command relationships previously described and are reflected in the primary leadership tasks of vision, team building, and motivation.

Each commander transmits his vision through mission orders, and his staff's primary duty is to help him formulate that vision, whether it is the end-state of an engagement, battle, or campaign. The theaterwide planning, execution, and assessment networks not only facilitate coordination and communication but also provide commanders with the situation awareness they need to formulate a vision of future operations. A common picture and networked coordination provides more immediate understanding of very complex patterns and simplifies leadership and coordination tasks at all levels.

There are two classes of team-building challenges for deployed commanders. The first challenge lies in creating mutually supportive wing and group teams from collocated units that may or may not employ together in combat. There is great value to combat operations in face-to-face leadership and coordination in composite wings, but composite wings are not always possible. In the worst case, the JFACC deploys and organizes wings, groups, and squadrons from disparate peacetime organizations—all of which contribute personnel to the group and wing staffs. It could be the case that the core of the wing and groups (and their associated staffs) at a particular base might consist of the personnel from a primary deploying unit that has worked as a team before, but there will inevitably be additional personnel from other peacetime units posted to the same base for the duration of the conflict. There will be those assets operating from bases outside the theater that chop to a group or wing commander. In this event, a liaison officer from the noncollocated unit may participate in the appropriate staff to supplement the networks. The team-building challenge for the wing and group commanders lies in forging competent and unified staffs from the units deploying to their base while seamlessly integrating noncollocated assets into the team. One positive aspect of this situation is that deployed personnel will be well trained in their roles, familiar with the equipment, and accustomed to working cooperatively with others at the same level of command because they accomplish identical tasks in peacetime. This familiarity, plus the fact that the staffs themselves are not very large, makes wing and group commander's jobs less of a challenge than the alternative task of leading a deployed JAOC with hundreds of augmentees who have rarely worked together and infrequently trained for their wartime roles.

The second team-building challenge comes from coordinating laterally among units with different commanders. Many authors, Martin van Creveld among them, assert that self-contained units are best for successful decentralization in most situations.[38] While self-contained, independent units may facilitate decentralized command and control, especially in land warfare, they pose a severe flexibility problem for airpower. Self-contained units cannot possess any and every capability and must therefore organize with respect to a specific concept of operations or some external limiting factor, such as ramp space or logistics. In the absence of theater and global networking capabilities, self-contained, collocated, and perhaps organizationally flexible units were probably the only way to achieve the critical level of lateral interconnectivity that mission orders require. While networks do not imply that collocation and self-containment have lost all value, such requirements are less important, especially if the forces have thoroughly trained and exercised with the system. Networks with sufficient bandwidth (and compression technology) also permit routine videoconferencing for face-to-face collaboration and better communications between geographically separated units. As demonstrated by the Joint Training, Analysis, and Simulation Center's video briefing and debriefing system used to link geographically distributed headquarters in real time, such capabilities, once they mature, will provide powerful tools for decentralized leadership.

In lieu of self-contained units, the leadership challenge is to combine command and coordination to arrange for the right combination of assets to do the right job at the right time, reflecting a "lean" approach to both operations and organization.[39] Leadership throughout deployed wings, groups, and squadrons forms the lateral glue for mission requests which, combined with mutual understandings of senior command intent, makes such an arrangement possible and reliable. In addition to vertical trust and mutual respect between higher and lower echelons, the same lateral trust and respect is required among units at the same echelon. Such trust already exists in the Air Force due to decentralized peacetime training, but it would develop further as wings, groups, and squadrons train together in a decentralized system intended for wartime employment, as demonstrated in composite wings. In any event, leadership sets the conditions for such relationships to develop as the collective organization learns to collaborate effectively in the absence of a centralized, detailed ATO.

The third leadership task is motivation. Aligning combat command with the other deployed tasks of squadron, group, and wing commanders makes motivation more direct in the decentralized system. In terms of vertical motivation, all commanders task their own forces and are responsible for all aspects of their performance, to include their contribution to strategy at all levels. This component exists in peacetime but is missing in the centralized wartime command and control as currently practiced. Unless one works in a JAOC, planning and leading an operational mission is currently the ultimate combat task for a captain, and it remains the ultimate task for almost all other operational commanders short of the JFACC. Decentralizing combat command and tasking to wings, groups, and squadrons provides junior officers with examples of senior leaders as skilled practitioners of higher level tactical and operational tasks of air warfare as well as vertical and horizontal leadership. Simultaneously, the same junior officers have the initiative and freedom to understand and meet command intent with the expectation that proficiency as well as potential will be rewarded with the opportunity to command. Aligning the tasks of command with the skills necessary to achieve command closes the fitness assessment and credit assignment loops to provide continuous leadership improvement in the officer corps.

Laterally, the motivation to maintain good working relationships with other units on the same echelon hinges on the mutual benefits of teamwork and a unit reputation for clear communication, cooperation in stressful circumstances, and reliability.[40] If a unit is consistently unable to deliver the missions it commits to, there is probably a leadership problem within the unit itself. While there is always the potential to invoke the hierarchical chain of command to force action from lateral units, such an arrangement should be rare.

As alluded to in the operations section, unexpected leadership situations will certainly arise within the decentralized organization, and senior leaders must understand network behavior to develop an instinct for those situations in which a detailed order is necessary to supplement mission orders. If increased detail is necessary because lower echelons are not trained to effectively plan the operation, then decentralized command and control is an improper approach to begin with. The commander should centralize planning for the operation in question and fix the training problem after the contingency is resolved.[41] If poor planning takes place due to a leadership or staff vision problems at lower levels, then provide detail or change the leadership. Finally, there is the possibility that increased direction takes place not because subordinate planning is a problem but because the senior commander is prone to micromanagement. In this situation, subordinate frustration or confusion could compromise planning or execution effectiveness, the more critical problem lies in the senior commander. While micromanaging his subordinates, he ignores more important responsibilities that properly fall within his decision authority regardless of any apparent employment success which may result from micromanagement. The potential of unattended higher level responsibilities to adversely impact the organization is much greater than the possibility of mistakes at a lower level.

Regarding leadership in learning organizations, Peter Senge writes that there are two views of leadership.[42] The traditional view sees the leader as the heroic captain of a large, complicated ship at sea. Another view sees a leadership role for the designer of the ship, a more quiet, behind the scenes leadership that probably has a greater influence on the success of a voyage than the skill of the captain. These roles correspond to the transactional and transformational leadership styles identified by James MacGregor Burns in 1978. Transactional leadership works within existing structures while transformational leadership assesses, designs, and adapts.[43] The decentralized leader has a strong "leader as designer" element in that he builds and commands staff, operations, logistics, and support teams at the base while forging dynamic teams among lateral units to accomplish missions. The leader with heroic ambitions is not likely to facilitate smooth operations in the decentralized system.

The Role of Doctrine in Predominantly Decentralized Command and Control

Decentralized doctrine must fill three roles. Two roles are traditional, one is not. First, doctrine is traditionally a set of principles that guides action and is authoritative but requires judgment in application.[44] In a complex adaptive system, doctrine is equivalent to the set of rules that govern the micro-level behavior of each agent. Doctrinal rules preserve past experience, govern internal processes, and permit an agent to anticipate future events based on patterns of observations, the orientation part of the OODA loop. Modern military doctrine is usually codified—written down and officially sanctioned—although there are other ways to transmit doctrine. Second, doctrine traditionally establishes a common outlook and language to facilitate communications.[45] This role is particularly important to decentralized command and control due to the dynamic, highly interconnected communications infrastructure that must function even as the internal rules of each node vary. Communication must be both physically possible and effective in terms of content to enable adaptive behavior in a decentralized system. Third, the less traditional role of decentralized doctrine guides how a system organizes and reorganizes based on the mission and environment. Such an organization could emerge purely from the system itself, but in the airpower context, the JFACC and wing commanders (or their equivalents) also shape the organization of the air component.

Organization-Oriented Doctrine

For this discussion, organization doctrine does not refer to high-level command relationships that extend from a supreme theater commander through a JFC and coalition commanders and finally to component commanders. National and senior military leaders arrange these quasi-political commands and coalitions. Decentralized organization doctrine refers to the arrangement of forces at and below the component level to suit the needs of particular campaigns, campaign phases, and missions.

The organization in figure 8 illustrates a system in which every node is effectively connected to every other node (if indirectly), even though the underlying physical network infrastructure would have a different structure. For this organization, doctrine specifies nodal relationships to provide structure for the interactions between squadrons, groups, and wings and to prevent such a highly interconnected system from devolving into uncoordinated chaos. The JFACC and wing commanders use organizational doctrine to adapt proven arrangements of forces, logistics, and support for the requirements of any contingency. Due to the master tenet of airpower, neither operational doctrine nor C^2 doctrine considers the idea of topologically altering a JAOC-centered organization to meet the specific needs of a contingency.[46] The strength of the decentralized organization lies in the fact that if a communications network can physically connect any two nodes via hardware, then the software or doctrine of the system ultimately establishes structure and decision-making capacity by activating connections and specifying relationships. Such a system reconfigures at will to fit the needs of any situation.

Highly flexible organizations are a proven concept in business, where Motorola Corporation, Sun Microsystems, and Lockheed Martin Corporation (among others) have used similar processes to become the most competitive corporations in their business segments. According to the Lockheed Martin CEO, the corporation effectively redesigns itself for each major program the company targets. Complementary skills tailored to a project's specific requirements are assembled from throughout the entire organization.[47] In a similar manner, organization doctrine addresses the process by which diverse resources adaptively organize to provide the foundation for theater advantage in combat.

Decentralized organizational doctrine must define the relationships between echelons and within echelons by specifying the format and content of mission orders and mission requests. Likewise, the doctrine must define the joint relationships with units from other services and components. The doctrine must also be flexible, so the structure in figure 8 is only one possible starting point from which more refined situational structures evolve through training and experience. Using the N-K network model, organization doctrine could be thought of as the way a unit (and the organization as a whole) tunes its own connectivity based on past experience.

The critical parts of a mission order include the overall task, commander's intent, and a concept of operations that includes commander intents for each unit in the order. These elements conveniently align with the traditional 5-paragraph order at the JFACC and wing levels and should take a prominent position in the networked planning software and templates at group and squadron levels.[48] Within the same echelon of the hierarchy, units coordinate based upon relationships established by senior commanders. These relationships parallel the joint command relationships described in Joint Pub 0-2, *Unified Action Armed Forces*, but they apply at a lower level in the component organization. There are four basic relationships between different units, and variants within each may also apply as in Joint Pub 0-2: supporting, supported, synergistic, and independent.[49] A supporting unit renders a defined effect onto another friendly (supported) unit. A supported unit could itself be a supporting unit, or it could be at the "end of the line" and render an effect on an enemy system. Two or more synergistic units operate together to render an effect on an enemy or friendly system that neither alone could achieve. Finally, independent units have no synergistic interaction in producing effects, but the effects they create may interact synergistically due to timing, geography, or accumulation. Mission orders may specify several simultaneous relationships with a number of other units, to include operations, logistics, and support arrangements. For mission requests, doctrine describes supporting effects, supporting capabilities, synergistic relationships, and independent operations for the same circumstances.

Communications-Oriented Doctrine

To facilitate communications and permit such a layering of detail and locus of decision, there must be clear terminology to describe airpower effects, and it must be understood throughout the organization both vertically and horizontally. In the absence of such a terminology, it is impossible to communicate in terms other than targets, sorties, and specific weapons, all of which are inherently tactical terms—the equivalent specifying every bullet fired by an infantry company. Meaningful levels of abstraction above the target/sortie level provide commanders with the ability to both discuss and employ combat airpower without having to micromanage it. Abstractions as suggested in the operations section may blur the lines between the tactical and operational levels of war. If there is a compelling reason beyond logistics and support to organize airpower into wings and groups, then there must be a theater concept of operations that gives commanders strategy and tasking authority at an appropriate level.

A language for effects at the operational and tactical levels refines traditional airpower missions to make the effects they achieve both understandable and measurable. Doctrine must precisely define airpower effects to give them meaning when used in command intent statements. General doctrinal discussions do not accomplish this task and set the stage for detailed orders that cannot describe the "what" and therefore must describe the "how." Here is a short subset of the air interdiction effects from a draft of AFDD 2-1.3, "Counterland Operations," which have no specific definition:

- Delay accumulation of enemy materiel—ground forces not in contact.
- Destroy enemy materiel in rear area.
- Prevent or force movement of enemy forces in rear area.
- Isolate a friendly area of operations from enemy forces.
- Canalize enemy forces.
- Divide enemy forces to prevent mutual support.
- Exhaust enemy forces through combined ground contact and aerial delay/destruction.
- Disrupt enemy command and control.

There are many more interdiction effects than these. Some effects terminology will become almost rigid in its meaning due to repeated use and broad application, while other terminology will be created to describe new or very specific situations. In addition to defining an effect, effects terminology and orders should specify three additional parameters: the magnitude of the effect (if not inherent in its definition), how soon the effect must occur, how long it must last, and why it will work. Refining the types of airpower effects, their magnitude, timing, duration, and purpose makes it possible to plan and employ airpower in terms other than target coordinates and sorties.[50]

Doctrine must also provide a language for two-way communication during joint operations at every level. Any wing, group, or squadron could be tasked with any of the lateral relationships described above (support, supported, synergistic) in a joint operation. Airmen and commanders must understand the doctrinal terminology of other components, and other components must understand airpower terminology, once it is created, so commanders can communicate at doctrinally and hierarchically compatible levels. A corps commander should not be required to pass target coordinates to a squadron as the only means of communication, nor should a wing commander ponder the details of company-level air base security operations. The language for effects must be flexible to permit the addition of new employment concepts, but without such a higher-level language, little communication can occur.

Process-Oriented Doctrine

Within each node, doctrine describes specific planning and execution procedures. In terms of complexity, this doctrine is the set of rules in each agent, a required micro-characteristic for adaptive behavior. This doctrine supports processes that are broad and conceptual at high levels and become more specific and customized at low levels. If process doctrine is too authoritative, the ability for the decentralized organization to innovate and adapt will be lost. Inflexible process doctrine, which specifies detailed procedures to follow at all levels, provides for centralized command with distributed control instead of a truly decentralized system. In this situation, orders specify the task and the checklist to use, a concept foreign to mission orders, but applicable in certain situations. To evolve and devise solutions for specific problems in a dynamic situation, wings, groups, and squadrons must have the doctrinal flexibility to experiment. There must be bounds, akin to training rules that balance the potential for effective training with the risk of a mishap, the bounds must include enough latitude to encourage initiative and creativity.

Doctrine is traditionally a distillation of accumulated experience, but it also serves an anticipatory role as a roadmap for organizational change. In either situation, the formulation of doctrine begins with the study of history and campaigns and reflection on the changing nature of the military. After vetting in academia and staffs, doctrinal concepts move to wargaming and exercises for further testing and refinement. The interplay between successive tests and revisions of doctrine in academia and real-world training provides the fitness judgments and interactions that are critical to adaptability and improvement. Guided by senior leadership, adaptive doctrinal processes at all levels in the organization maximize organizational learning and combat effectiveness.

Training for Predominantly Decentralized Command and Control

From the complexity theory standpoint, training serves several purposes. First, it provides a medium to disseminate and practice the doctrinal rules that govern behavior at all levels of warfare to all appropriate agents—individuals, squadrons, groups, and wings. Second, training provides a practical opportunity for generating new rules, since many procedure and strategy improvements are invented on the spot, or during the after-action process, if it becomes clear that current techniques do not satisfy the objectives at hand. Finally, because realistic training mirrors the environment of war, it normally includes competitive interaction and adaptability in an environment tolerant of error as a means to prepare for more deadly challenges.

Decentralized training addresses the C^2 system itself and the task-oriented training of wings, groups, and squadrons. Additionally, there must be some kind of organizational training to test, evaluate, and refine new structural concepts in a variety of realistic situations and challenge the ability of a multi-wing organization to adapt. While organizational training would more easily take place in war games at the JFACC and wing commander levels, the option to exercise organizational flexibility at the wing level and below must be vetted during training and exercises prior to combat.

Command and Control System Training

The planning, execution, and assessment networks function nearly identically in both peacetime and wartime. Peacetime command and control of combat assets is already hierarchically decentralized, and such networks would enhance scheduling and messaging processes that already occur at squadrons, groups, and wings. Certain processes in the decentralized C^2 system will change during wartime, but in peacetime each echelon routinely uses the networked tasking structure and processes that ultimately produce an executable flying schedule. The C^2 processes would also have the benefit of local exercises, deployments and flag exercises, and inspections to provide familiarity with the wartime-specific aspects of the system. No wing, group, or squadron conducts any operation without using the C^2 system at some level.

There are great benefits to deploying and employing with the same C^2 system used on a daily basis in peacetime. Daily reinforced peacetime proficiency directly benefits war planning and execution, and unit commanders and staffs have a direct stake in ensuring that their people are trained and systems function properly, the same way they care about aircrews, maintainers, and aircraft. The systems section discusses a number of other requirements, but daily training is crucial to the wartime reliability of the decentralized C^2 system.

Task-Oriented Training

Task training remains largely the same at the individual, squadron, and group levels. One major difference lies in the increase in potential training options and the concurrent capability to exercise the C^2 system at the same time. Streamlined, accessible planning and execution networks for coordination between squadrons, groups, wings, and units from other services permit more frequent large (or small) live-fly exercises to project airpower into any training range that can accommodate the aircraft and surface forces desired. Although there are numerous additional issues, it is extremely valuable to transparently plan, execute, and assess training that integrates a variety of capabilities without expensive deployments, and to do it in a way that also replicates the wartime C^2 process.

If large-scale, live-fly exercises are limited for reasons beyond the C^2 system, the limited locus of decision authority at each level of the hierarchical organization permits network-based war gaming without influencing the real-world operations of organizations above, below, or laterally. Although war gaming would certainly involve a commander's staff, the requirement to gather a large and inconsistent group of augmentees for a JAOC exercise would disappear except to specifically train for centralized control.[51] Even when practicing centralized command and control, networks enable the war-gamed *processes* to be centralized as software options even though the system itself is geographically distributed. The only reason to travel to a JAOC site is to accomplish collaborative processes that are impossible through the network. In this mode of operations, the networks constitute a virtual JAOC.[52] War gaming at higher levels of command requires the networks for collaboration but does not require numerous high-powered workstations because the locus and detail of decisions are limited. Commanders at all levels would devote their attention to the cognitive aspects of command and coordination appropriate to their level of command rather than micromanaging targets and sorties.

Direct coordination of training opportunities between Air Force and other units at all levels provides a fertile environment for employing new joint force combinations and enhancing traditional operations concepts.[53] Promising employment arrangements at any level would enjoy rapid dissemination to forces worldwide for potential use and further refinement. Ultimately, the networks accelerate evolution of standard operating procedures and more rapid adoption of them. There must be a balance between practicing standard procedures to gain proficiency and trying new ideas, but integrated training provides more opportunities for both.

Organizational Training

Organizational training has two facets, practicing operations in a variety of structures and maintaining flexibility. An organization that changes its structure based on a mission, campaign phase, or objective must still exercise specific structures in peacetime. This aspect of organizational training is straightforward to war game, but live-fly exercises and training ensure that subordinate units and personnel maintain the flexibility to rapidly adapt to new structures, understand relationships, and operate within those arrangements. Training is the only way to practically build the common outlook, trust, and reliability of action that decentralized systems require. Training with flexible organizations also keeps all personnel focused on the totality of airpower employment in terms of effects, support, and assessment. Isolated training environments where weapons systems become stovepiped or destructively compete with other systems would be an artifact of the past. The benefits of routine integrated training already take place in the 366th Wing (composite) at Mountain Home AFB, Idaho, where teams of flights from different squadrons and weapons systems participate in wing competitions instead of squadron or weapons system-based competitions.[54] Similar opportunities exist at flag exercises and in competitions like Long Arrow, but such opportunities tend to be the exception, not the rule, for normal unit training.[55]

The message for decentralized training is that a judicious combination of decentralized command, doctrine, and networking creates an organization that learns at many different levels, and the results of that learning translate directly into wartime capability. In order for learning to occur, training must specifically challenge the adaptability of the organization in addition to its C^2 system and mission-oriented tasks. Daily use of the C^2 system facilitates more frequent training opportunities that allow organizational learning to take place more quickly.

Education Support for Predominantly Decentralized Command and Control

Extending complexity theory into education reveals several functions that roughly parallel training but vary in context. Like training, education provides a medium for rule (doctrine) dissemination. Education also provides the opportunity for theoretical rule discovery or doctrine formulation, an added dimension to the practical rule generation that takes place during training. The added value of rule generation during education is the broader historical context that is possible versus the more specific applied context of training or exercises. Concomitantly, there is also the danger of misapplying historical lessons or misinterpreting context and formulating misguided or inapplicable doctrine.

Another aspect of decentralized education beyond the individual is the learning organization. All of the complexity theory discussion about agents, rules, interaction, and fitness judgments unravels if there are no "decision authorities" in those agents. The decision authorities, whether vested with formal command or not, are educated personnel. In order for the decentralized organization to learn and function as a whole, there must be operationally educated people in every part of the organization, not only in a strategy department or headquarters but also in the JAOC. The other elements of the decentralized framework provide an organizational structure that supports learning for both individuals and organizations.

One possibility for tying theoretical doctrinal propositions to the practical ability to test them for relevance and effectiveness lies in cooperative arrangements between PME institutions and operational units. In the civilian sector, universities and businesses have long collaborated in cooperative or "industrial practice" programs. These programs infuse business with the latest ideas from laboratories while providing universities with direct feedback (through their students) on the relevance of their research. The resulting win-win-win situation for business, universities, and students may provide a model for decentralized education to increase the frequency and quality of crossfeed between PME institutions, operations, and staff organizations. Such interaction would introduce new ideas to the field more rapidly while providing a moderating influence on the doctrinal proposals and other research at PME institutions. One chief executive officer whose corporation participates in an industrial cooperative stated, "The rate at which organizations learn may become the only sustainable source of competitive advantage, especially in knowledge-intensive businesses."[56] Command and control in warfare may be the supreme manifestation of a "knowledge intensive business." PME has a role to play not only in individual learning but also in decentralized organizational learning through cooperative doctrine development, especially at the group and wing levels of command.

Another promising possibility for organizational learning suggested by the interdisciplinary nature of complexity theory is interdisciplinary benchmarking.[57] The quality movement incorporates benchmarking to identify and spread best practices from one unit to another. Benchmarking is straightforward when units compare themselves to other units with approximately the same mission, equipment, or procedures, but this form of benchmarking does not realize its full potential. Interdisciplinary benchmarking seeks lessons from functional parallels between disciplines that may be so different that a comparison may seem ludicrous at first. For example, a recent RAND study, *The Virtual Combat Air Staff*, used the organization of a Rolling Stones concert tour as a case study.[58] In another example, the US Marine Corps recently sent 22 officers to experience the decision-making action of traders in a commodities market. The Marines found the nonlinear relationships, high tempo, and quick decisions of the market paralleled the circumstances of command during maneuver warfare.[59] There are certain processes that are unique to the military, but most military activities are similar or identical to practices conducted in other organizations. There are a host of legal issues involved in direct benchmarking between military and business organizations, but it is worth the effort to solve them. With their relative freedom when compared to operations and staff units, PME institutions may be the best forum to seek such relationships.[60]

Systems Support for Predominantly Decentralized Command and Control

One of airpower's greatest strengths is the ability to rapidly project power from anywhere, to anywhere. Unfortunately, behind this strength lies a weakness in the challenge of command and control to coordinate the projection and targeting of a geographically distributed force. Surface forces have the benefit of a more geographically bounded distribution of forces that the air component cannot assume. The C^2 problem seems somewhat more tenable when there is a geographically centralized planning and execution command authority in the form of a JAOC. For the centralized system to function, a unit's most important communications link is the one to the JAOC. In the decentralized case, demands on communications and computers systems are in some ways much greater and in other ways not as severe, but they are critical to this form of command and control. Without them, it is impossible for geographically distributed units to pass the orders and accomplish the necessary coordination and planning.

From the complexity theory viewpoint, the communications and computers in a decentralized system provide the primary medium for interactions between agents. Without them, few interactions are possible, and the concept of a complex adaptive system breaks down rapidly. There are other interaction possibilities, especially at the base level, but the greatest volume of coordination takes place laterally between units and commanders at the same echelon within and among different bases. Because any two nodes can communicate directly with each other (although the message may pass through several different nodes along the way) the moderating influence on the potentially chaotic coordination process lies in mission orders transmitted through the hierarchically organized command structure.

As discussed in the operations section above, there are three functions that the communications and computer networks must provide for the decentralized C^2 system. First, the planning network must provide the ability to pass orders and coordinate with other units involved on any particular task. The planning network, properly supported by the other elements in the C^2 framework, takes the place of combat plans in the JAOC to enable near-real-time coordination and planning. Planning networks of this type are already beginning to arrive in mainstream applications. There is a new family of planning systems that operate in the Global Command and Control System (GCCS) under the auspices of the Distributed Collaborative Planning Initiative, a program that began in the Advanced Research Projects Agency in 1993. These planning systems support both deliberate and crisis action planning on joint staffs and enable extremely rapid planning through parallel collaborative effort.[61] Additionally, the recent RAND study on virtual air combat staffs addresses most of the technological issues inherent in networked, mobile (wireless), distributed collaborative planning.[62]

The second function is the execution system. This network serves two purposes as it provides aircrews, commanders, and staffs with the real-time friendly execution picture and an inquiry-based depiction of known enemy forces. First, aircrews and commanders low in the hierarchy have the information necessary to assess a favorable situation and exercise initiative within the limits of the senior commander’s intent. Second, the system provides the same personnel with the ability to deconflict changes in operations as they exercise this initiative. Only the combination of these two functions at the lowest levels in the theater air component makes a predominantly decentralized C^2 architecture for theater airpower viable in its most general application.

The third and last function is the assessment and effects development network. Through this network, data from sensors theaterwide pass to the appropriate analysts (along with the questions they should answer using the data), who pass completed products back to commanders and staffs to serve as inputs for planning. This network would also serve as the mission-debriefing medium for missions involving assets from more than one base. The network should be near real time, however the limitation on speed will not come from the network itself but from the ability of human analysts to process data into information and knowledge useful to the commander. A clear doctrinal language for system and operational effects will significantly enhance the ability to specify the right data to collect and focus the efforts of analysts to glean the desired information rapidly from that data. Once such information is available, posting it on the assessment network for theaterwide use as well as prompting the unit responsible for the effect is straightforward.

Given communications and computer networks that support these three functions, the characteristics of such a system differ from a centralized system in several ways. Regarding bandwidth, the centralized system needs its greatest bandwidth to feed data to the JAOC, and after that, within the JAOC to process and fuse the data into information. Additionally, there is a large but temporary bandwidth requirement—based on the size of the theater operation—to distribute the ATO to units in a timely manner. The decentralized system has low bandwidth requirements between echelons and moderate bandwidth requirements within echelons. (Of the three networks, the assessment and effects development network would be likely to have the highest bandwidth requirements due to the quantity of data typically collected by a variety of sensors.) The strength of the decentralized system lies more in connections—lateral, wireless, secure, near-real-time connections. Each unit in an echelon coordinates only with those it must, though it can get any information from any other unit at will. In the event higher bandwidth is needed between any two nodes, the numerous paths between them can provide it. Another way to save bandwidth lies in compression techniques, especially for images and video transmitted through the network.[63]

Security in a decentralized system could pose a problem because of the physical distribution of the system and the large number of access points. This will be a problem only until the widespread use of the latest encryption technologies catches up with the ability to network computers. Digital communications combined with several theoretically unbreakable algorithms will provide secure and unspoofable communications once these systems become commonplace and routine.[64] Routine use of encryption techniques will also enable the military to contract with commercial satellite constellations for operational communications. An important organization task for the theater commanders will be to determine the network security structure using these algorithms to establish which units can access and alter what information and to isolate the wartime networks from routine peacetime operations.

Survivability in a decentralized system is enhanced by the absence of a centralized command node or geographic collocation of most of the systems necessary to plan and execute the campaign. The networks would ideally be configured to include the ability to access or input information from any node systemwide, providing excellent flexibility and built-in redundancy. Software and hardware for operating large, complex, distributed, real-time systems are mature in many military and civilian applications.[65] Such systems present to an enemy a truly amorphous C^2 targeting problem provided the underlying communications system does not have bottlenecks or critical nodes functionally invisible to the C^2 system. The JFACC and a small staff are free to go where their personal presence would most contribute. One important vulnerability would be the wireless communications requirements for deployability, mobility, and airborne access, but this vulnerability is not exclusively a decentralized problem.

Interoperability for single service and joint functions hinges on the ability to connect to the network, much like the ability to access the Internet. Once a connection is possible, standards like the defense information infrastructure common operating environment will enable users to access software and data in any part of the network. The ability to share and use software systems developed for different purposes will further enhance the speed of evolution across the network. In order for this to occur, there must be flexibility to permit communications and data formats to evolve.

One last feature of upcoming computer networks is desktop video-teleconferencing (VTC) on demand. VTC enables personnel at two or more nodes on the network to establish a real-time, high-fidelity video-link for collaboration during planning, execution, and assessment. Simultaneous data sharing and common note taking, like a virtual white board, are also possible. Desktop VTC has the potential to put the human element back into the distributed and decentralized leadership and command relationships. While such capabilities would not be the same as physical presence during communications, they would certainly provide clearer communications between and within echelons.[66]

The continuous rapid evolution of computers and communications networks indicates that these systems do not limit the decentralization of command and control and in many ways encourage it. Changing the human elements of the C^2 system will take longer than fielding the appropriate supporting systems. On the other hand, modern systems will also provide the ability to radically centralize command, control, and execution. The commercial trend points towards decentralization, but the decision to centralize or decentralize lies with senior airpower commanders. There is a potential problem posed by decentralized communications and computer systems when the choice is to centralize command authority. Colonel Allard noted that "[networks] could provide situation awareness independent of the limitation of standard hierarchical information flows. Ultimately, the proliferation of these distributed data systems could even involve considerable organizational stresses should command and information lines, once firmly welded together, begin to diverge."[67] Modern information systems make much more information available to many more people much more rapidly. The flow of information will cause emergent organizational behavior whether it is desired or not. This chapter described a C^2 structure that offers the possibility to reintegrate command and information lines while preserving the ability to operate effectively, preemptively solving the organizational stresses Colonel Allard warns of.

Conclusion

This chapter used complexity theory and related sources to construct a predominantly decentralized airpower C^2 system in its most general case. Such a C^2 system must overcome geographic distribution of friendly forces and enemy systems, enable the numerous synergistic relationships among friendly forces, and deconflict friend from enemy as well as current and future operations. By applying complexity theory across the C^2 framework, this chapter described the broad challenges such a change to C^2 poses and provided an appreciation of how these challenges interrelate. Designing the micro-characteristics of complex adaptive systems into the eight subjects of the framework serves two additional purposes. First, it provides airpower commanders with an additional C^2 option. Second, the increase in complex adaptive potential brought about by decentralization and applied micro-characteristics may improve the effectiveness of airpower in dynamic situations.

Chapters 3 and 4 have now described two approaches to airpower command and control. Chapter 5 compares and contrasts these systems to derive a set of guidelines a commander would use, given that both options and a spectrum between them are available, to determine the best manner to employ.

Notes

1. Lt Col Stephen McNamara, *Air Power's Gordian Knot: Centralized versus Organic Control* (Maxwell AFB, Ala.: Air University Press, 1994), 154.

2. Richard Butler, *Designing Organizations: A Decision-Making Perspective* (London: Routledge, 1991), 57.

3. Ibid., 43–44.

4. Ibid., 53–56.

5. Ibid., 57.

6. Ibid., xiv.

7. Army Pamphlet 600-80, *Executive Leadership* (Washington, D.C.: Government Printing Office [GPO], 1987), 39.

8. Ibid., 40. Complexity in this quote does not refer to complexity theory, but complexity in the colloquial sense.

9. Butler, 58. Another useful concept related to the locus of decision authority is that of "patch size" from Kauffman. From an organizational perspective, a patch is the locus of command and control authority of a given functional area. The size of a patch reflects the degree to which an organization is divided into parts for the purpose of solving a complex problem. For any problem, there is a range of patch sizes that will drive the system into a complex adaptive regime. Fewer than the requisite numbers will force the system into an ordered regime (centralized) that equates to Butler's discussion of decision undercapacity, while more than the ideal number of patches throws the system into a chaotic regime in which there are many agents influencing many others that no solution ever emerges, equivalent to Butler's decision overcapacity. The ideal patch size could be considered the ideal organizational structure in terms of agents, differentiation, and interactions so that the system is as adaptive as possible. Stuart Kauffman, *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity* (New York: Oxford University Press, 1995), 252–67.

10. The contingency model originated with J. D. Thompson and A. Tuden, "Strategies, Structures and Processes of Organizational Decision" in J. D. Thompson, *Comparative Studies in Administration* (Pittsburgh, Penn.: University of Pittsburgh Press, 1956), 195–216.

11. Col Maris "Buster" McCrabb, "A Normative Theory of Air and Space Power Command and Control" (paper, SAAS, Maxwell AFB, Ala., Course 643, Campaign Planning, 1997), 9. McCrabb states that the decision-making theory that underlies modern US Air Force C^2 is the rational actor model. Graham T. Allison, *The Essence of Decision: Explaining the Cuban Missile Crisis* (New York: HarperCollins, 1971). Allison explains this model as a process of gathering information on alternatives, valuing them in a cost-benefit fashion, and selecting the best alternative with the least cost. This is a very common model used by all military services to some extent. The US Navy has examined another

model called the temporal model or colloquially, the "garbage can model," which more closely associates the time factor into decisions. This model "assumes that problems, solutions, decision makers, and choice opportunities are independent streams flowing through a system," linked primarily by their simultaneity. James G. March and Roger Weissinger-Baylong, *Ambiguity and Command: Organizational Perspectives on Military Decision Making* (Marshfield, Mass.: Pitman Publishing Co., 1986), 17 and 311–36. The US Marine Corps conducts operations with decentralized command and control and acknowledges a number of other theories, among them Col John R. Boyd's "Organic Command and Control" concept (unpublished briefing, 1987) and Gary Klein's theory of "recognition primed decision-making." Recognition-primed decision making describes a commander's intuitive judgment of a situation and "satisficing" (instead of optimizing) decisions based on matching experience, training, and study to the situation. Gary A. Klein, "Strategies of Decision Making," *Military Review*, May 1989, 56–64. Also MCDP 6, *Command and Control*, October 1996, 101–2.

12. This proposal retains wings, groups, and squadrons as organizational subunits. Many information age suggestions completely discard hierarchical organizations as outmoded artifacts of industrial age and Newtonian thinking, as chap. 6 points out. Even the Internet is hierarchically organized as reflected in the structure of the addresses. It is important to remember that hierarchy is a desirable macro-level behavior of complex systems, but hierarchies are not necessarily adaptive. Hierarchies that emerge in complex adaptive organizations will function effectively in fuzzy environments.

13. The N-K model is used for illustrative purposes only, not to suggest that there is any numerical result that directly applies to a C^2 organization, a much more complex system.

14. Charles Handy, *Beyond Certainty: The Changing Worlds of Organizations* (Boston, Mass.: Harvard Business School Press, 1996), 53.

15. Ibid.

16. Butler, 165–70. Especially see pages 168–69 for a description of the failures of matrixed organizations.

17. Maj John C. Coleman, "Comprehension of Confusion: Commander's Intent in the AirLand Battle" (master's thesis, School of Advanced Military Studies, Fort Leavenworth, Kans., 1990). Major Coleman provides an excellent doctrinal discussion of the theoretical and historical underpinnings of the various incarnations of commanders intent. Suffice it to say that the concept is used in a number of ways, but its fundamental strength as a tool for decentralization is beyond dispute.

18. In the limiting case, if mission planning and coordination of airpower were completely transparent to geographical considerations, it would make the most sense to base aircraft so as to minimize logistical requirements.

19. "Distributed Collaborative Planning," US European Command Homepage, Classified SIPR Net (via the Global Command Control System); on-line, SIPR Net, 28 March 1997, available from http://www.eucom.smil.mil, but only on the SIPR Net.

20. Wing commanders may still be associated with certain broad mission areas based on their experience (e.g., air superiority, fighter attack, CAS, or heavy bomber operations). The ideal is that all wing commanders are capable of commanding all kinds of forces at the level described here, namely, effects, systems, and matched forces. Specific wing commander expertise would certainly be a factor in the JFACC's selection of commanders and deployment of forces.

21. The doctrine section in this chapter discusses effects in greater depth.

22. For functional clarity, the networks are described as separate systems, but how they are actually implemented is another matter. They could be three parts that operate on a common network.

23. Bandwidth can still rise due to the type of information passed rather than the number of discrete communications events. See James P. Kahan, D. Robert Worley, and Cathleen Stasz, *Understanding Commanders' Information Needs* (Santa Monica, Calif.: RAND, 1989), 36–44. Supply-push is the traditional mode of pipelined intelligence information and reports. A wide variety of data is regularly provided to units without their request and with no specific relationship between the information content and unit situation. Demand-pull is an inquiry-based approach to search for information and coordination. The value of information exchange in a demand-pull system directly depends on the expertise of the commander.

24. Martin van Creveld, *Command in War* (Cambridge, Mass.: Harvard University Press, 1985), 272. See also Maj Gary B. Griffin, "The Directed Telescope: A Traditional Element of Effective Command" (Fort Leavenworth, Kans.: Combat Studies Institute, US Army Command and General Staff College, 1985) for an excellent historical survey of the directed telescope.

25. This system is similar to the capability provided by the global command and control system, but it is available at all command levels in the theater and includes adaptations for cockpit use.

26. C. Kenneth Allard, *Command, Control, and the Common Defense*, rev. ed. (Washington, D.C.: National Defense University [NDU] Press, 1996), 217–18.

27. The execution network described here provides friendly deconfliction for both current and those future operations loaded into the system by squadrons. There are less general deconfliction systems with the potential to operate more simply, such as advanced IFF (identify friend or foe) systems that deconflict current operations but have no future deconfliction capability, that is, they cannot tell the aircrew that a "pop-up" target they detect is the primary target for another aircraft arriving in 10 minutes.

28. When time is critical, one planning guideline used by the US Army is to identify the planning time available and use one-third of it at a senior staff and leave two-thirds of the time for subordinate planning. Within the planning network described here, a subordinate staff can monitor a senior staffs planning activity and begin conceptualizing likely missions before the mission order arrives. Monitoring could take place spontaneously or as a result of a "heads up" by the senior commander. In any case, a superior commander can impose planning time constraints in his mission orders if he feels it necessary.

29. See Richard Simpkin, *Race to the Swift: Thoughts on Twenty-First Century Warfare* (London: Brassey's, 1985), 241–55.

30. The breakdown of stovepiped thinking, improved synergistic employment, and the concurrent rise in trust and confidence in units from other services has been demonstrated at composite wings such as the 347th Wing at Moody AFB. The 347th Wing combines a variety of airpower assets and operates in concert with the US Army's 24th Infantry Division at Fort Stewart, Georgia. See G. Larry Thompson, "The QRAF [Quick Response Airpower Force]: Decisive Expeditionary Airpower for the Future" (master's thesis, SAAS, Maxwell AFB, Ala., 1996), 25–26.

31. Handy, 41. Handy notes that the Catholic Church is a long-standing institution that incorporates subsidiarity into its moral doctrine.

32. Ibid.

33. See Coleman, "Comprehension of Confusion: Commander's Intent in the AirLand Battle," 19. It is especially interesting that a German army officer, Lt Col Walter von Lossow, writing on the subject of mission orders, cited General Washington's command of Hessian troops and militias during the American Revolution as the original source of the concept. Such orders migrated back to Europe and became the basis of von Moltke's (the Elder) reforms in the German army a century later. See Lt Col Walter von Lossow, Federal Republic of Germany Army, "Mission-Type Tactics versus Order-Type Tactics," *Military Review*, June 1977, 87–91.

34. MCDP 6, October 1996, 41.

35. Ibid., 109.

36. Elliott Jaques and Stephen D. Clement, *Executive Leadership: A Practical Guide to Managing Complexity* (Oxford: Basil Blackwell Company Publishers, 1991), 91–100.

37. *A Guide to the Strategic Leader Development Inventory*, National Defense University and Industrial College of the Armed Forces, Department of Strategy (Washington, D.C.: GPO, 1994), 5.

38. Van Creveld, 269; and Fischer, 61.

39. "Lean" in this context borrows from the concept of "lean production" as a replacement for mass production techniques. For an excellent description of lean production in the auto industry, see James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine That Changed the World* (New York: Rawson Associates, 1990). Lean techniques integrate large organizations into highly responsive producers and include "just in time" deliveries, minimal warehousing, exceptional quality, and high worker initiative among their major characteristics.

40. Toyota of Japan (a lean auto producer) demonstrated just how reliable lateral cooperation can be when, on 1 February 1997, a fire destroyed the company's sole-source

brake valve supplier, shutting down Toyota's production lines. Experts believed Toyota would take weeks to recover, but 150 subcontractors quickly and competitively adapted to provide 50 different production lines making small batches of the brake valves, permitting full auto production to resume after five days. Valerie Reitman, "Toyota's Fast Rebound after Fire at Supplier Shows Why It Is Tough," *Wall Street Journal* 229, 8 May 1997.

41. Chap. 5 describes how this centralization takes place.

42. Peter M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday Currency, 1990), 341.

43. John W. Gardner, *On Leadership* (New York: Free Press, 1990), 122.

44. See Dr. Harold R. Winton, "A Black Hole in the Wild Blue Yonder: The Need for a Comprehensive Theory of Air Power," *Air Power History*, Winter 1992, 32–42. According to Dr. Winton, doctrine is "sanctioned theory" that connects general theory to actual practice.

45. AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*, March 1992, vol. 1, vii.

46. "Topologically" in this sense refers to the mathematics of topology, which studies the structure of objects in terms of lines, loops, trees, knots, networks, and so forth. For example, adding an extra branch to a tree structure changes how it looks and functions but does not change its structure in a topological sense. With a JAOC as a dominant central node, changing the assets that link to it changes its capabilities but not its topological arrangement.

47. Anthony L. Velocci Jr., "'Virtual' Enterprise: A Plus for Lockheed Martin," *Aviation Week and Space Technology* 146, no. 6 (10 February 1997): 86–87.

48. For a succinct explanation of the five paragraph order and its history, including commander's intent and intents, see Clayton R. Newell, *The Framework of Opertional Art* (New York: Routledge, 1991), 162–73.

49. Joint Pub 0-2, *Unified Action Armed Forces*, 24 February 1995, chap. 3.

50. Maj William F. Crain, USA, describes a similar problem the US Army faced regarding precision in mission and task language in his paper, "The Mission: The Dilemma of Specified Task and Implied Commander's Intent" (Fort Leavenworth, Kans.: School of Advanced Military Studies, 1990), 17.

51. As a reminder, this study does not propose to eliminate centralized command and control, but to add decentralized command and control as an option. Even if a system were normally decentralized as described in this chapter, there would still be the requirement to exercise centralized control in the event a situation would dictate it. When to use centralized versus decentralized control is the subject of chap. 5.

52. See Arthur F. Huber et al., *The Virtual Combat Air Staff: The Promise of Information Technologies* (Santa Monica, Calif.: RAND, 1996).

53. VAdm Robert J. Spane, former commander, Naval Air Forces Pacific, sponsored several workshops in 1995 to provide a freewheeling forum for pilots, sailors, SEALs, and Marines to experiment with integrated air-surface littoral operations. The effort resulted in the creation of a "Jaeger Squadron" to continue the experimental philosophy, but it has also caused debate since it is a "bottom up" philosophy of hands-on innovation that operates outside the normal "top down" development, test, and evaluation channels. See Jaeger Group X-ray, "Jaeger Squadron (X)," *Marine Corps Gazette*, May 1996, 63–65. Also Majors Robert L. Gardner and James S. Robertson, "A Review of Jaeger Air," *Marine Corps Gazette*, June 1996, 36–38, and Cmdr Daniel E. Moore Jr., "A Response to 'A Review of Jaeger Air,'" *Marine Corps Gazette*, September 1996, 66.

54. Thompson, 27.

55. Long Arrow is an annual Air Combat Command competition that tasks packages of aircraft from noncollocated units in a long-range power projection mission.

56. Ray Stata of Analog Devices Corporation, a company with a cooperative connection to the MIT, as quoted in Senge, 349.

57. Handy, 135.

58. Huber et al., 32–33.

59. F. J. West, "War in the Pits: Marine-Future Traders Wargame," *National Defense University Strategic Forum* 61 (February 1996): 1–4.

60. The US Marine Corps Combat Development Command, Quantico, Va., is negotiating to participate in a consortium regarding the application of complexity to management led by the Boston-based consulting corporation Ernst & Young, Inc. See Thomas Petzinger

Jr., "How Creativity Can Take Wing at Edge of Chaos," *Wall Street Journal,* 24 October 1996, B1.

61. US European Command is in the third year (1997) of a five-year program to implement distributed collaborative planning systems. Experience to date has demonstrated that supporting plans have been completed before the primary operations plan is published.

62. See Huber et al.

63. Several studies, *New World Vistas* among them, indicate that although bandwidth requirements currently seem to outstrip our systems capabilities, the trend is for bandwidth to become increasingly plentiful and decreasingly expensive. *New World Vistas* recommended that the Air Force terminate basic development of communications systems providing bandwidth into and within a theater because commercial capabilities are evolving rapidly enough to provide such services economically. *New World Vistas Summary Volume,* 62–63.

64. *New World Vistas Information Technology Volume,* 92, and Martin C. Libicki, *What Is Information Warfare?* (Washington, D.C.: NDU Press, 1995), 32–33.

65. See *Decentralized Computing Technology for Fault-Tolerant Survivable* C^3*I Systems,* Final Technical Report RADC-TR-90-101, 3 vols., Carnegie-Mellon University for Rome Air Development Center, June 1990. This project and others demonstrate that rapid progress in this area took place under the auspices of the Strategic Defense Initiative. Many software and hardware techniques have spun off to other military and civilian programs.

66. The five main topics discussed in the previous paragraphs—bandwidth and connections, security, survivability, interoperability, and desktop videoteleconferencing—are all technologies that the private sector leads in developing, challenging the military to adapt commercial technology and, to some extent, commercial practices. See *New World Vistas Summary Volume,* 63–64, for a concise description of related policy recommendations.

67. Allard, 245.

Chapter 5

Adaptive Command and Control

Chapters 3 and 4 describe two forms of airpower command and control that lie on opposite sides of the centralized-decentralized spectrum presented in chapter 1. If the JFACC wanted the option to be able to operate anywhere on this spectrum, then he either needs to have two separate C^2 systems (uneconomical), or he needs a single C^2 architecture that offers the flexibility to operate at either end of the spectrum or anywhere in between. Given that the JFACC has a spectrum of C^2 options, then choosing where to operate on the spectrum must be part of both the early and ongoing planning of an operation. This decision may favor centralization or decentralization or use a combination of modes simultaneously or sequentially. After determining the C^2 plan, the JFACC communicates this decision to the air component. Finally, the forces must adapt (change the system architecture) to operate in the mode or modes that the JFACC desires. This chapter discusses these issues. First, the considerations, which guide the JFACC's C^2 decision, will serve as a vehicle to compare and contrast chapters 3 and 4. Second, this chapter discusses the JFACC's "intent for command" as the means to communicate his C^2 decision. Finally, this chapter discusses the architecture and mechanism by which an air component transitions between predominantly centralized and predominantly decentralized command and control.

Considerations for Adapting Command and Control

A real-world contingency is a deadly, interactive competition waged between opposing groups and forces at all levels of conflict from strategic to tactical. Adaptive command and control asks what echelon within the air component has the ability and resources to achieve appropriately matched objectives without further guidance. If the ability to achieve objectives is not in question, a secondary consideration is the cost to achieve those objectives. Based on Butler's Principle of Requisite Decision Capacity, a contingency could be viewed as a flow of decisions through a pipeline that empties onto the C^2 system. In a stable situation, the decision flow is even and regular, enabling centrally coordinated decisions to maximize efficiency. In a complex or dynamic contingency, the decision flow has extreme, unpredictable fluctuations that may exceed the decision capacity of a centralized organization. The appropriate response is to decentralize decision authority to improve responsiveness and effectiveness.[1] The challenge for the JFACC is to design a C^2 system that can cope with the magnitude and fluctuations in the flow of decisions by providing human decision makers at the appropriate echelons with the authority and information to make them. He wants to provide some margin of excess decision capacity to cope with uncertainty, but he does not want too much capacity if the cost of decisions is important.

Every subject in the C^2 framework has a bearing on the most appropriate configuration of the C^2 system. Comparing an organization to the models in chapters 3 and 4 provides general guidance on whether to centralize or decentralize, but an extreme deficiency in any particular area easily throws the decision one way or another. For example, the lack of a coordination and deconfliction mechanism in a general theater situation without composite wings or geographic areas of responsibility makes decentralization impossible. Even if composite wings or geographic deconfliction exist, the absence of coordination or overall command authority still dooms decentralization.

Instead of revisiting each framework subject, this chapter selects four primary considerations: systems, people, situation, and the commander. Comparing the information from chapters 3 and 4 in these areas provides a succinct basis to guide the C^2 decision.

The Systems

No quantity of technology can drastically reduce the number of human decisions required to plan and execute an air campaign, but technology significantly enhances the ability and flexibility of decision makers to get information and disseminate decisions. The fundamental geographic dispersion of an air component combined with the detailed coordination necessary for an air campaign dictates advanced communications and computer systems as a part of any force regardless of the arrangement of command and control. In centralized operations, the JAOC is a command (supply-push) organization that requires great processing power (and internal bandwidth) and high-bandwidth vertical communications to every unit that collects information, plans and executes ATO-directed missions, or controls the execution. Decentralized operations orient the organization around an inquiry-based demand-pull architecture that requires lower bandwidth vertical connections between commanders and lateral connections between units on each echelon. Each unit requires the requisite computing power and bandwidth for its own processes plus an additional overhead requirement to support the network.

As currently organized, the centralized (JAOC) C^2 system has a minimal peacetime role except to exercise, so in peacetime the associated systems are largely unused.[2] Continuing improvements to JAOC processing and communications since the Gulf War will certainly provide better performance in a future conflict, but the human training problems associated with the system are unlikely to change. On the other hand, decentralized command and control has the potential to train during peacetime operations in the same manner and frequency, and with the same systems, employed in wartime. Provided with the requisite lateral networking capability, training in the United States can more realistically simulate large-scale wartime employment, including command and control. For example, overlaying a map of Kuwait, Saudi Arabia, and Iraq on the United States shows the great dispersion of coalition forces during the Persian Gulf War and the large distances involved in launching, marshaling, ingressing, and recovering these forces during combat missions. Forces are similarly dispersed at their home bases in the United States, as are the training ranges, refueling tracks, and other specialized airspace. Streamlined coordination through a network to enable synergistic airpower projection in addition to Red Flag training (a temporary composite wing) or increasingly expensive squadron deployments will provide frequent, realistic training opportunities both for operational units and the C^2 system. Large-scale exercises would not take place immediately. The system would start simply, substituting networking for telephone coordination on basic training and support missions, integrating the group and wing roles into the planning process. Deconfliction through standard training rules and specific coordination would suffice until improved real-time systems become available. Wings would build experience and lessons learned to gradually develop more complex scenarios that project greater power and provide more realistic training.

For the C^2 decision, systems are therefore a fundamental driving force. If well-trained lateral coordination and all-echelon battle space picture distribution do not exist or cannot be used, then operations must favor centralized command and control. If lateral coordination and battle space pictures exist, then the remaining factors such as airmen, the situation, and the commander become more important to the decision whether to centralize or decentralize.

The Airmen

In discussing the requirements for mission orders, Richard Simpkin cites the requirement for “a chain of trust and mutual respect running unbroken” from the top to the bottom of an organization provided by reflective human experience.[3] In conjunction with this idea is the “acknowledgment and unreserved acceptance of mutual dependence.”[4] These concepts describe the prerequisite of vertical and horizontal trust and respect required in organizations that decentralize command and control. If a commander does not believe that his subordinates can achieve the objectives he sets in an acceptable manner without detailed instructions, then mission orders and decentralization are foolhardy. Likewise, if units operating under mission orders cannot depend on lateral forces to deliver mutually coordinated support or effects, then the ability to coordinate laterally becomes meaningless.

The trust and respect necessary to facilitate effective vertical and horizontal operations do not arise spontaneously but come from doctrine, training, and education. Doctrine is a very powerful means to provide a common outlook and approach to problem solving at every level in the organization, if it is known, understood, and applied. For decentralized operations, doctrine must reach beyond the military specialties to include communications and organizational flexibility. Doctrine for decentralized operations provides common language for understanding effects both within the component and outside the component, thus facilitating implicit and informal communications. Organization doctrine describes the variety of ways to organize both joint and component forces according to specific situations to maximize the synergistic effects they deliver. Doctrine that does not provide a language for communicating effects and guidelines for organizational flexibility cannot support decentralized operations.

Training reinforces and refines doctrine, connecting specific abstract concepts communicated during planning and coordination into specific actions during execution. Repeating the connection between concept, coordination, and execution is the process that builds trust and respect, both within the air component and jointly. Reinforcing the common outlook and building a reputation for reliability of action and doctrinal coherence enables cooperation in potentially deadly situations. Education also contributes to the common outlook, developing the requisite professional knowledge and cognitive abilities to enhance the understanding of airpower in its broadest sense. Without a broad understanding of airpower or a common outlook that extends beyond the limits of a certain specialty, a force cannot build the trust and mutual respect necessary for decentralized operations.

Returning to the C^2 decision, the commander must decide whether he trusts his subordinates to do the job, and moreover, he must judge whether his subordinates trust each other. This decision occurs at every command level in the hierarchy, and ideally, efforts to build trust and mutual respect occur well before a real contingency arises. For a commander, the C^2 decision is intuitive, situational, and based on the specific personalities of his subordinates, but the relationship of doctrine, training, and education to the specific situation provides a rationale to support the commander's judgment.

The Situation

It may come late, but the enemy in fact plays a role in this study. The enemy determines how dynamic and complex the campaign is likely to be, which influences the requisite decision capacity the C^2 system must have during the conflict—how many decisions must be made at what level and tempo. In general, the more dynamic a situation, the more decentralized the command structure should be to accommodate it. It is conceivable that the decision capacity of a centralized JAOC could be large enough that no enemy could be dynamic enough to require decentralization to increase that capacity by delegating more decisions throughout the organization. This is the same as saying that effectiveness is not in doubt. If this is true, then leaning towards centralization will provide better efficiency. Although this may be the situation facing American airpower in the post-cold-war era, to assume it will always be the case, as with the great Scud hunt, is dangerous.

The situation and enemy also play a role in the command decision if the objectives are clear but the means to achieve them is uncertain. In this case, more interaction and involvement (at the component level and below) to interpret the problem and propose courses of action increases the likelihood that effective solutions will be both proposed and adopted. Such interaction also takes place within a JAOC and to the extent that it has the highest situation awareness of any node in theater, solutions will be effective. However, group dynamics play a role in JAOC strategy deliberations, the number of people in the strategy cell is limited, and the situation awareness available through a communications channel is rarely as good or complete as being there in person. Decentralized command may offer advantages of multiple perspectives when facing uncertainty.

Finally, knowledge of the enemy influences how theater objectives translate to appropriate supporting operational and tactical effects. In the decentralized system proposed in chapter 4, wing commanders and their staffs have the role of connecting operational effects identified by the JFACC to tactical effects on enemy systems and the forces that will achieve those effects. If the nature of the campaign-level objectives or effects pose a doctrinal or training problem that prevents commanders from deriving appropriate supporting effects, the JFACC, in consultation with the requisite experts, may have to centralize this particular role of wing commanders. This centralization could extend down to the squadron level, or it may only bypass the specific identification of tactical effects normally accomplished by the wing commanders. In the best case, the JFACC takes only as much authority from lower level commanders as he judges proper to get the job done.

The Commander

Finally, the personal preferences and judgment of the commander play perhaps the greatest role in the command decision. From the definition in chapter 1, commanders accept responsibility for outcomes along with the authority to make decisions. In accepting this responsibility, it is just as grave an error to decentralize command in an instance requiring centralization as it is to centralize command when the situation demands decentralization. Unfortunately, a commander who centralizes and fails can claim he did everything in his power. The commander who decentralizes and fails is judged to have abdicated his responsibilities as a commander.[5] Fortunately, the professional officers who rise to command are rarely concerned with their own fate should they fail. The ultimate measure of leadership, training, education, and doctrine lies in the trust a senior commander demonstrates by accepting responsibility for the initiative and results of his subordinates. The Prussian Gen Helmuth von Moltke, who brought missions orders to the German army in the latter 1800s, wrote, that "the advantages, moreover, which the commander believes to achieve through continuous personal intervention, is mostly only an apparent one. He thereby takes over functions for whose fulfillment other persons are designated. He more or less denigrates their ability and increases his own duties to such a degree that he can no longer fulfill them completely. . . . It is far more important that the high commander retain a clear perspective of the entire state of affairs than that any detail is carried out in any particular way or another."[6]

The ability to accept responsibility for subordinate decisions is heavily influenced by the balance between robustness and error tolerance. Delegating decisions downwards builds a more responsive and robust organization, but it increases the potential for unpredictability and error. If unpredictability and error are not acceptable, as could be argued for limited raids or strikes, then centralized command is appropriate. On the other hand, an air component engaged in an extended major regional contingency versus a peer competitor in terms of people, training, and equipment, needs robustness and higher decision capacity more than detailed predictability and perfection.

The following chart summarizes the preceding discussion of the considerations for centralizing and decentralizing command.

Factors Favoring Centralization		Factors Favoring Decentralization
Vertical networks	Systems	Lateral and vertical networks
Efficiency first priority		Effectiveness first priority
Specialized doctrine, training	Airmen	Common outlook, doctrine, training
Directed cooperation		Trusted cooperation
Formal communications		Implicit communications
Expertise focused at the top		Distributed expertise and education
Focused operations	Situation	Flexible operations
Relatively simple, stable		Relatively complex, unstable
Routine, repetitive environment		Nonroutine environment
Doctrinally incompatible situations		Doctrinally compatible situations
Low tolerance of error	Commander	Some tolerance of error
High predictability		High robustness
Personal judgment		Personal judgment

Communicating the Decision—Commander's "Intent for Command"

Once the JFC and JFACC have established the joint air component, the JFACC's intent for command tells his wing commanders (or equivalent) whether to act immediately on his guidance or continue general preparations while awaiting more detailed instructions. Wing commanders translate the JFACC's intent into appropriate guidance for their groups. The proper place to specify the command arrangements is in the decentralized version of the joint air operations plan, effectively the order the JFACC provides to his wing commanders.[7] The JFACC may specify several intents for command based on different phases of battle described in the concept of operations. For example, the JFACC may want to exercise tighter control during the first few days of a major regional contingency to ensure certain critical enabling objectives are met on a specific timeline, after which mission orders would facilitate direct interoperability with other components. The same criteria may apply to major branches in the operations plan or specific effects or mission requiring special focus. Planning for such branches still takes place through the networks, but the JFACC and his staff provide specific guidance on effects or targets and approve lower echelon plans before granting authorization to execute.

The JFACC's initial command structure decision takes place during Phase 3 of the joint air operations planning process, the strategy identification phase (fig. 4). During this phase, the JFACC first associates forces and capabilities with JFC objectives, and the concept of forces must include a tentative organizational structure and intent for command. The JFACC has the flexibility to alter either the structure or intent for the command in consultation with the wing commanders he selects for the operation.

Implementing the Decision

There is an important fundamental asymmetry regarding the centralization and decentralization of command and control: A C^2 system able to normally operate in a decentralized manner can centralize its operations at will. A centralized system cannot necessarily decentralize as easily. Succinctly, decentralized C^2 infrastructures support centralized operations, but not vice versa. Figure 11 illustrates this relationship. The networked hierarchy is a horizontally and vertically connected network where every node can communicate with every other node either directly or through an intermediate node. A traditional hierarchy removes the lateral connectivity in the networked hierarchy and is more centralized than the networked hierarchy. Centralized organization is the limit of centralization, where there is no intermediate command authority, no low-level lateral network, and the central authority "A" directly commands and controls the actions of each "C." Beginning with the networked hierarchy, it is possible to create the organization in the traditional hierarchy by simply removing (disabling or choosing not to use) the lateral links at each echelon. Likewise, it is possible to create the centralized organization from the traditional hierarchy by removing the decision authority in the B nodes. It is much easier to remove structures or authority that already exist for some specific, temporary purpose than it is to create something from nothing. This becomes evident beginning with the centralized organization and working backwards. Moving from it to traditional hierarchy requires training three new intermediate commanders and a small amount of connectivity to the structure. Moving from centralized organization to networked hierarchy organization requires not only more commanders and more connectivity but also an entirely new command philosophy that emphasizes initiative and lateral cooperation. Such changes do not develop at a moment's notice if the infrastructure and outlook do not already exist.

There are two ways to centralize a decentralized C^2 system. There is the trust-based method that assumes that commanders will discern and

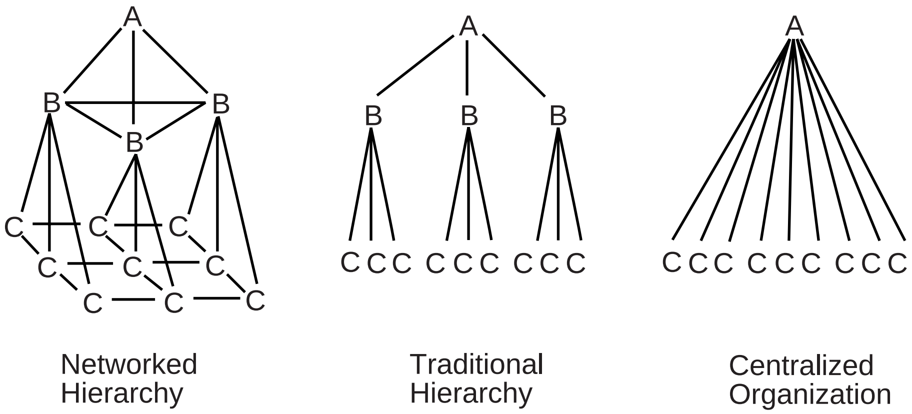


Figure 11. Centralizing a Decentralized Organization

understand the difference between mission orders and detailed orders, and that they will in turn exercise a similar level of control over their subordinates. In other words, the people are disciplined enough to understand when initiative is expected and when it is not. The second method is a proactive approach that expects anything to go wrong that can go wrong. Using this method, the JFACC and his staff prevent lower level units from making inputs to (or perhaps seeing) specific parts of the planning and execution networks by imposing passwords to access or "rope off" the portion of the network conducting theater planning until it is appropriate for lower level units to become involved. In the extreme case, senior commanders, by imposing passwords throughout the system, could selectively disable any or all lateral networking to prevent any inadvertent activity during highly sensitive operations.

During centralized operations, there is a need to provide the JFACC with a larger staff and more equipment to handle the planning load, but even this may not always be required. Centralizing a normally decentralized system can apply to the processes only, without necessarily pulling equipment and personnel to a central location.[8] Centralized control with geographic distribution thus maintains the survivability benefits of the decentralized system. While the operation is under centralized control, the enemy's challenge is to find and target the central controlling node, assuming the enemy is even aware that the operation is centralized. Regardless of which centralization method is used, the entire system could again be released at will through orders or password removal to restart decentralized operations.

Adaptive Command and Control

Returning to a phrase at the beginning of this chapter, "If the JFACC has a spectrum of command and control options . . ." then the JFACC's application of this spectrum to a theater situation constitutes adaptive command and control. There may be instances when a JAOC is best, and there may be cases where a decentralized approach provides a more effective use of airpower, much as it did in the Southwest Pacific in World War II.

In order to have the option to use predominantly decentralized command and control, significant change must take place in all of the framework areas discussed in chapters 3 and 4. To conclude this study, chapter 6 discusses the development of decentralized command methods as well as the value and benefits of adding decentralized command and control to the airpower arsenal.

Notes

1. It is sometimes difficult to distinguish between efficiency and effectiveness. As discussed in chap. 4, in organization design literature, centralization of common tasks is normally associated with a desire for increased efficiency in more stable environments. Decentralization of nonroutine and varying tasks is associated with a desire for increased effectiveness in unstable and dynamic environments. This is the sense of the terms as used in this study.

2. There are exceptions in the standing AOCs directing operations in high-threat and other real-world contingencies.

3. Richard Simpkin, *Race to the Swift: Thoughts on Twenty-First Century Warfare* (London: Brassey's, 1985), 241.

4. Ibid., 243.

5. This was exactly J. F. C. Fuller's criticism of Gen Helmuth von Moltke's style of command. Moltke had a decentralized command philosophy and is commonly associated with the operational employment of *Auftragstaktik* or mission orders. Daniel J. Hughes, *Moltke on the Art of War* (Novato, Calif.: Presidio Press, 1993), 13.

6. Hughes, 184.

7. The decentralized version of the joint air operations plan, as described in chap. 4, is very similar to the plan described in current joint publications, but its detail does not extend to tactical effects. The orientation remains strategic and operational.

8. *The Virtual Combat Air Staff* study by RAND makes no assumptions regarding the centralization or decentralization of the processes.

Chapter 6

Conclusion—A Cultural Shift

We say, "Flexibility is the key to air operations," and this is a fundamental truth. But we also enshrine in doctrine the notion of "centralized control and decentralized execution." What I'm suggesting is that centralized "control," as now practiced, may be robbing us of one of our most important operational virtues—flexibility. There is much more to maneuver warfare than the ability to undertake centrally planned, centrally directed, methodical operations. . . But, just maybe we can make it part of a cultural shift from a system featuring centralized, inward-focused, imposed discipline to a decentralized, outward-focused (on the enemy and situation), innovative, self-disciplined approach. Warm regards.

—Gen Merrill A. McPeak
Message to HQ ACC/CC
23 November 1992

This study's development of C^2 conflicts with the master tenet of airpower as practiced by the USAF. While the master tenet speaks more in terms of control, not command, the system in chapter 4 decentralizes command to some extent and control to a great extent. The JFACC as the single airmen responsible for the air component remains unchanged, although his normal command authority focuses exclusively on strategic and operational issues. The command authority the JFACC delegates to subordinates must carefully nest within and support his intent to ensure unity of effort. Delegating this combat tasking authority to subordinate wing, group, and squadron commanders decentralizes command relative to the JAOC system. The JFACC's control mechanism changes even more dramatically, moving lower in the organization to match the command authority exercised at each echelon. The JAOC as a requisite control mechanism for airpower disappears. For these reasons, the decentralized C^2 system proposed here is not doctrinally compatible with the master tenet of airpower.

This conclusion will tie together the ideas presented in chapters 1 through 5. First, it argues that airpower benefits from more than one approach to command and control. The master tenet of airpower and decentralized command and control need to coexist. Second, they must coexist because the best approach to command and control depends on the theater situation that cannot be predicted. It is important to ensure that the C^2 system can operate in a mode best matched to the challenge, whether it is effectiveness, efficiency, or a combination of the two. Third, in order to develop a spectrum of C^2 options, there are specific requirements across a number of subject areas (the framework) to develop decentralized methods as viable alternatives. Though there are some systems requirements, the effort to develop decentralization is not a question of technically oriented, high-cost systems. Most of the effort lies in organization, doctrine, training, and operational styles and will not change *what* is done as much as *how* it is done. Fourth, the effort to develop decentralization may provide numerous benefits beyond more flexible command and control. Finally, the post-cold-war strength of US airpower relative to potential threats provides an opportunity to develop decentralized methods during a period of relatively low vulnerability.

The Value of Options

There is a benefit to having more than one C^2 concept for airpower. The JAOC has flexible capabilities based on the sources of information it accesses and the forces it controls, but the organizational topology of a JAOC-controlled air component builds limitations into its capabilities. Decentralization changes the organizational topology of the C^2 system, providing it with the ability to have varied structures that are task- and performance-oriented combined with a parallel command structure that is purpose-oriented. The specific requirements of an air campaign in meeting the joint force commander's objectives—whether it is efficiency, effectiveness, robustness, low error tolerance, initiative, predictability, or some other requirement—determine the best C^2 approach.

Flexibility and versatility are considered birthrights of airpower, yet it is the C^2 system that ultimately makes these qualities useful to a theater campaign in all circumstances. A flexible C^2 system is a logical partner to flexible airpower.

The Role of the Scenario

As discussed in chapter 5, the combination of systems, friendly forces, the enemy, theater objectives, and commander determine the best C^2 arrangement for a given campaign. It is impossible to predict the demands that a scenario will place on the C^2 system, and it is also impossible to predict the extent to which those demands will impact the tactical, operational, and strategic levels of warfare. During the Gulf War, Iraq consistently demonstrated the ability to operate inside the OODA loop of the coalition C^2 system when it launched Scud missiles, even after the coalition did its best to adapt to the situation. The coalition was fortunate that the Scuds were not more accurate and did not carry more deadly warheads. The problem was that the coalition OODA loop had to operate not faster than the Iraqi OODA loop, but faster than just one part of it—the "A" (act) part.

The increasing power and connectivity of systems will certainly speed up the C^2 process, but attempting to build a centralized C^2 loop that can engage a random action anywhere in theater is a losing race. Even with instantaneous computation and communications, human decisions will be the slowest part of the cycle and made even slower by the small numbers of people making them. Delegating decisions to those who are closer to the "action" while ensuring strategic coordination and coherence provides a way to win the responsiveness race.

Developing Decentralized Methods

The framework derivation in chapter 2 and the material in chapters 3 and 4 demonstrate that decentralized command and control requires a coordinated effort across many disciplines to properly develop. Paying attention to one or two areas while ignoring the others has been historically counterproductive. Creating conditions for change in all areas simultaneously realizes the goal to evolve a control system that exhibits adaptive behavior while command provides a moderating influence to avoid chaos. The main effort comes at the micro-level, not at the macro-level, the modern incarnation of General von Moltke's "system of expedients within a pattern of thought."[1] By ensuring that the micro-level characteristics of the system are present and functioning properly, adaptive macro-behaviors will emerge, molded by the intent of the commander. Providing the low-level mechanisms for adaptability is the only way to transition to decentralized operations. In many areas of the framework, these mechanisms are straightforward and have historically succeeded in other services and disciplines. In the area of systems, however, it may be the ability to provide theaterwide networking and information systems that only now makes decentralized command and control of complex air operations truly conceivable.

There is great potential in complexity research and in the lessons from other disciplines that have successfully incorporated adaptive fundamentals into their operations. The organization and management methods that enable adaptability are not corporate secrets locked away in a vault, such as a new technology or manufacturing technique. These methods enhance competitiveness, reduce costs, and flexibly leverage the assets of large corporations while pressing innovation to its limits. In developing decentralized methods, casting the net widely, rather than focusing inwardly, will yield the most useful results.

The variety of sources available both in and beyond military disciplines demands an open-minded but prudent approach to developing decentralized methods for military operations. For example, the inability to design a decentralized system with a specific emergent behavior motivated the dual hierarchy discussed in chapter 4 to combine a traditional command system with the advantages of a network. It is easy to become enamored with networks and forget that their behavior can be unpredictable or counterproductive when, as Allard observed, the command and information lines diverge.[2] The following citations illustrate the confusion that arises when discussing decentralization. "Decision-making is most effective in a flattened hierarchical organization. Eliminating layers of command provides the means to operate at a higher tempo." "The Air Force must reexamine the doctrine of 'centralized control, decentralized execution' against an information-age adversary. The JFACC and ATO concepts are a product of hierarchical organizations and centralized control, perhaps the last vestiges of excessive concern over [Air Force] 'independence.' "[3]

Regarding the first quotation, flatness of the organization is only one factor in effectiveness and tempo. If an organization is flat and there is no lateral coordination capability or protocols, then the effectiveness of the organization plummets unless the commander of the flatness coordinates everything, much like a JFACC does through the JAOC. Likewise, high tempo is no problem through any number of command layers if the situation does not change very rapidly, a concept proven by World War I, or if the locus of decisions at each layer is appropriate to the task and dynamics. Concerning the second quote, the current JFACC/JAOC/ATO system is in fact one of the flattest, least hierarchical C^2 systems ever devised. The JAOC spans the strategic level of war down to the tactical level of war and gives the JFACC direct control over every sortie of the forces assigned to him. It is hard to get any flatter than this.

The above quotes also misunderstand hierarchy. Hierarchy is a natural, emergent, self-organizing macro-behavior of complex adaptive systems. Although hierarchy is an extremely important organizational feature, it can be pathological. Inflexible hierarchy without the requisite micro-characteristics becomes a rigid control device that is all too familiar in many "sick" organizations, organizations whose survival is threatened by their inability to learn and adapt.[4] On the other hand, adaptive hierarchy takes advantage of networking and information by matching inherent task complexity and dynamics with the echelons of an organization. By matching task complexity to experience and judgment, hierarchy prevents chaos in an otherwise unrestricted organizational network.

There is much to gain at very little risk in developing predominantly decentralized C^2 methods. As explained in chapter 5, a decentralized system can be recentralized at will to fit the requirements of the situation and commander, but in the absence of a decentralized infrastructure, the reverse is not true. Unfortunately, the road to decentralization will be uncomfortable due to self-imposed requirements of near-perfect predictability and no error combined with organizational inertia and the human instinct to be "in control." While in the words of General McPeak, there is much cultural shifting to do, the building blocks to experiment with systems, organization, doctrine, training, and operations are already available. Today, hardwired communications networks facilitate new relationships and employment flexibility, connecting operational units regardless of location and service. Although these networks cannot yet deploy to a theater with the same level of functionality, they can serve as an infrastructure to evolve new cooperative methods that will carry directly to the theater when (and if) deployable, wireless, secure networks and the supporting software become widely available in the military.

Benefits of Decentralization

There are benefits beyond theater command and control that will accrue from developing decentralized methods. First, decentralization strengthens command in the more general sense. The Air Force reorganization in 1991 strengthened peacetime command under the "one wing, one base, one boss" concept that placed all aircraft, operations, and agencies at one base under one wing organization, commanded by the wing commander.[5] Unfortunately, this command concept only partially applies in wartime. The wing commander at a deployed base fighting a theater contingency commands all aspects of the base except the combat tasking of the forces that launch from it. Combat tasking is controlled by the JAOC located elsewhere or even garrisoned in a secure location outside the theater (reachback). In the predominantly decentralized concept proposed in chapter 4, wing, group, and squadron commanders *command* in both peace and war.

Second, there are two approaches to "doing more with less." One way is to group all similar activities into one functional area which then learns to accomplish that activity very efficiently. The second method is to ensure no effort is wasted on unnecessary activity that has no bearing on the situation at hand. The former leads to centralization (for efficiency) and the latter leads to decentralization (for effectiveness). It is hard to do more with less without the appropriate authority and guidance to decide and focus on the most important tasks. Decentralization therefore offers an alternative approach to reducing costs, manpower, and tempo by conducting effective operations with fewer assets, especially in dynamic situations.

Third, decentralization generates more synergism between different specialties, the kind of synergism that cannot be predicted and planned in advance by a staff of experts and specialists.[6] This synergism is the product of human initiative in a system that fully trains and educates airmen and provides them with the planning, execution, and assessment mechanisms to use mission orders. The process of receiving a task and purpose, planning a solution, executing the plan, and assessing the results is extraordinarily motivating, and tends to increase future initiative at every echelon. The combination of synergism and initiative in decentralized operations therefore builds cohesion and morale, two rarely discussed but critical factors to airpower success.

Finally, decentralization plays a large role in closing the gap in airmindedness that currently exists between the tactical level of airpower and the operational and strategic levels. Providing more airmen with the practical motivation to think about, plan, execute, and assess the application of airpower across the broad spectrum of its capabilities will promote operational and strategic innovation. Such thinking breaks down internal Air Force stovepipes and also opens doors to improved joint operations.

A Window of Opportunity

In 1982, Gen David C. Jones, former chairman of the Joint Chiefs of Staff, noted a disconcerting historical pattern in American military operations:

- unpreparedness at the onset of each new crisis or war,
- initial failures,
- reorganizing while fighting,
- building our defenses as we cranked up our industrial base, and
- prevailing by wearing down the enemy—by being bigger, not smarter.[7]

Although General Jones referenced the defense establishment in general, he concluded that organization, not military funding, people, or forces was the cause of this pattern. Allard made a related observation concerning organizations in the conclusion of his book, *Command, Control, and the Common Defense*. "The major implication . . . for command and control is that the American military establishment does not naturally create the institutions necessary to evolve the 'system of systems' demanded by warfare in the information age."[8]

Both authors cite problems with the ability of organizations to adapt. The failure to adapt in turn leads to failure during crises or wars and gross inefficiency and poor defense value and preparedness in peacetime. The moral is that organization should be the most important military issue during the peaceful interludes between major military operations.

The United States currently enjoys a period of low vulnerability to serious national threats. Even though its physical size is shrinking, the strength of US airpower is still probably greater than the rest of the world combined, and there are no looming threats to change this situation any time soon. Yet this precise combination of circumstances is perhaps the greatest threat US airpower has faced in the twentieth century. By feeling secure in the afterglow of the Gulf War and cold war while applying airpower to peripheral national interests, there is no compelling reason to maintain the force structure and personnel associated with American air power for the last 50 years. As the force shrinks and grooms a smaller corps of professional airmen, there is a window of opportunity to build decentralized operations from the ground up. Adding predominantly decentralized operations to the C^2 playbook will configure American airpower to aggressively adapt to the future.

Notes

1. Daniel J. Hughes, *Moltke on the Art of War* (Novato, Calif.: Presidio Press, 1993), 9. Moltke referred to strategy as a "system of expedients" rather than a series of rules and procedures to be performed in all circumstances. Hughes remarked "Moltke's statements should be taken against the background of the detailed systems of the eighteenth century and may be seen as a rejection of such systems."

2. C. Kenneth Allard, *Command, Control, and the Common Defense*, rev. ed. (Washington, D.C.: NDU Press, 1996), 245.

3. Lt Col Gregory A. Roman, "The Command or Control Dilemma: When Technology and Organizational Orientation Collide" (Maxwell AFB, Ala.: Air War College, 1996), 41. This paper won distinguished essay honors in the 1996 Chairman, Joint Chiefs of Staff, Essay Competition.

4. Charles Handy, *Beyond Certainty: The Changing Worlds of Organizations* (Boston, Mass.: Harvard Business School Press, 1996), 113.

5. Gen Merrill A. McPeak, USAF, *Selected Works: 1990–1994* (Maxwell AFB, Ala.: Air University Press, 1995), 103–4.

6. Joint Pub 3-56.1, *Command and Control for Joint Air Operations*, November 1994, III-2 lists 21 different experts and specialists which form the staff to help the JFACC devise the joint air operations plan. Wing, group, or squadron commanders are not part of the list.

7. Gen David C. Jones, "What's Wrong with Our Defence Establishment," *Joint Force Quarterly* 13 (Autumn 1996): 24.

8. Allard, 243. The "system of systems" refers to Adm William A. Owens, "The Emerging System of Systems," *Proceedings* 121 (May 1995): 34–39.