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Command and Control: An Introduction

by

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ABSTRACT

The authors present an introduction to command and control (C^2) and establish a foundation for understanding the complex nature of C^2 and the C^2 process. A historical perspective is presented which demonstrates the importance of effective C^2 to national, military, and political objectives. The command and control process is described, and the basic characteristics of a C^2 system are specified. The command and control structure of the United States military organization is presented. An introduction to the architecture of C^2 systems is described, and a conceptual architecture of the C^2 process is developed. The authors describe the U.S. strategic nuclear command and control structure and provide a basic description of the tactical warfighting doctrines and C^2 structures of the U.S. Armed Forces including the wartime operations of the Coast Guard. The authors conclude with a fundamental approach to the process involving the evaluation of complex command and control systems.

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I. INTRODUCTION

A. BACKGROUND

The physical manifestation of command and control (C^2) is often difficult to quantify. Effective C^2 is the net result of the successful interaction of a complex architecture that is comprised of people, procedures, and equipment. This architecture may be transparent to the various users (both commanders and the forces to be commanded) in that as long as data may be conveyed to the decision makers and orders may be conveyed back to appropriate units, the users easily forget about the complexity of the process that has just transpired. [Ref. 1:p. 55] Sadly, serious attention to the C^2 process seems to come to light only on the occasion of catastrophic C^2 failure. Perhaps the most infamous such failure in modern military history is the gross mishandling of intercepted Japanese diplomatic message traffic that could have served to alert the U.S. Pacific Fleet and prevent the tremendous losses that were sustained on that day at Pearl Harbor. Three further examples of C^2 failures reveal the dire consequences that poor C^2 may have.

1. USS Liberty (AGTR-5)

At the time of the outbreak of hostilities between Israel and the United Arab Republic on 5 June 1967, USS

Liberty was under the operational command of Commander in Chief Europe. At 0001 7 June, USS Liberty came under the control of Commander, 6th Fleet. At the time of her operational control transfer, USS Liberty was directed to remain at least 12.5 nautical miles from the United Arab Republic coast and 6.5 nautical miles from Israel. Following the outbreak of hostilities, standing orders for all ships assigned to 6th Fleet had been modified to forbid approaches of less than 100 nautical miles from either country. The error in USS Liberty's positioning was noticed in the afternoon of 7 June and the Joint Chiefs of Staff (JCS) transmitted the first of five messages ordering the repositioning of the ship. At 1210 8 June, USS Liberty, still having received none of the warning messages, was attacked by Israeli aircraft. Shortly afterwards she was torpedoed by Israeli surface units. In all, 34 men were killed and 75 were wounded. The ship was so severely damaged that repair was impossible. [Ref. 1:p. 6010-A-14]

A Naval Court of Inquiry was convened to investigate the attack on USS Liberty and, among several findings, stated the following:

> Liberty's position at the time of the attack had been previously ordered changed farther to seaward by the JCS; however, the messages relating to these changes were not known to the ship before the attack took place; and
>
> The combination and compounding of many delayed communication deliveries related to the Liberty incident denied the ship the benefit of command decisions actually made prior to the attack which,

among other things, would have caused the ship, as a minimum, to be heading further off shore from her 1200 8 June actual position. [Ref. 1:p. 6010-A-15]

2. USS Pueblo (AGER-2)

USS Pueblo was a U.S. Navy "auxiliary general environmental research vessel utilized for intelligence collection." [Ref. 1:p. 6010-A-15] On 23 January 1968, the Pueblo was off the coast of North Korea when it was approached by a North Korean vessel. Through flag hoist communications the North Korean vessel instructed Pueblo "heave to or I will fire." USS Pueblo transmitted a flash precedence message to inform the JCS of her situation. The message was received by the JCS two hours, 34 minutes later. Continuing delays slowed the second flash transmission from Pueblo which informed the JCS that she had been seized by the North Korean forces. This second message reached the JCS one hour, 39 minutes after its transmission from Pueblo. These inexcusably slow transmissions were via the Defense Communications System. Additionally, parallel transmission was initiated for both messages on the CRITICOMM (Critical Communications) network. Though the CRITICOMM system delivered the two messages in rapid fashion, the actual introduction of the messages into the network was too late for advantage to be taken of the quicker transmission times. As a result, the Pueblo was seized by North Korean forces without any opposition from the United States. [Ref. 1:p. 6010-A-16]

A Naval Court of Inquiry was convened to investigate the seizure of the Pueblo. Findings of that investigation stated that message transmission delays were "grossly excessive" and that these delays were "at least partially responsible for the failure of U.S. forces to come to the aid of that ship". More explicitly, the message delays and subsequent lack of response led to the "death of one sailor, the long imprisonment of the remainder of the crew and the loss of the vessel" and that the "capture of USS Pueblo resulted in a serious compromise of our Nation's intelligence capability." [Ref. 1:p. 6010-A-18]

The loss and long delays of the messages transmitted from both USS Liberty and USS Pueblo could not be attributed to disabled communication facilities, enemy jamming, or any restriction upon the use of any mode of available communications. [Ref. 1:p. 6010-A-19] Instead, in these instances, broken down command and control held sole responsibility.

3. Operation URGENT FURY

The arena with which the modern military must contend is defined by computer systems and communication systems of growing complexity, of the unstable and ever-changing influence of world politics, and the capabilities or limitations of man himself. Clearly, the problem of providing effective and reliable command and control is greater today than ever. The confusion that comes hand in hand with joint operations may be overwhelming. A contemporary example of this may be seen in Operation URGENT FURY or, by its better known name, the Grenada Campaign. This operation involved Air Force, Army, Navy, and Marine Corps elements and was generally proclaimed to be successful in its stated mission objectives. [Ref. 2:p. 17, Ref. 3:p. 351] However, well publicized instances of coordination difficulties at the onset of the operation reveal that even successful operations are not without command and control concerns. Blame for coordination problems has been placed on the Navy's inability to maintain satellite communications. [Ref. 2:p. 17] Another scathing analysis of URGENT FURY states:

> It is ridiculous for each of the four services to have different radio frequencies for controlling air-to-ground strikes. During the initial days of the Grenada operation, Army ground units had to send calls for air strikes back to their headquarters in Fort Bragg, North Carolina. The messages would then be relayed via satellite to the Navy commander, who passed the requests on to the air controller aboard the aircraft carriers. [Ref. 4:p. 178]

Much of the information on the Grenada Campaign remains classified thus an accurate depiction of the actual command and control issues of that campaign cannot be examined in this thesis. However, one may rest assured that in any operation, whether single-service or joint, command and control issues will be in the forefront.

B. THE EFFECT OF COMMUNICATIONS

There are similarities among the preceding examples of command and control failures. The most obvious similarity is that the failures were attributed to deficiencies in the respective communication networks. The close relationship that exists between command, control, and communications is the aspect of C^2 that is most widely discussed and, for that reason, has earned its own name of C^3. In fact, in the multitudinous writings on the topic of C^3, it is easy to forget that command and control itself is the real issue while communications is the means to the end of the C^2 process. The study of the effect of communications on C^2 is important in that, as four historical examples have shown, command and control is only as effective as its weakest link is strong.

C. CONTINUING C^2 ISSUES

While few would deny that effective command and control is essential to any successful military operation, the fact remains that it is difficult to find proponents willing to fund extensive research or modernization in the area of C^2. In the world of shrinking military budgets, C^2 is losing out to more apparent weapon systems and platforms. The inherent intangibility of the C^2 process is simply no match for the tangibility of ships, tanks, aircraft, and missiles. More eloquently stated:

> Warriors and those who would like to be associated with them will argue simplistically that the enemy is killed by effective employment of firepower; not by throwing at him radios, computers, black boxes or analytic tools for battle staffs, despite all of their usefulness. [Ref. 5:p. 22]

The difficulty in finding advocacy for command and control systems may be due, in part, to their very "transparent" nature. [Ref. 1:p. 55] However, regardless of the reason, it is the wise student of command and control who remembers that despite the undeniable benefit of effective C^2, patronage is difficult to find.

D. PURPOSE

The primary purpose of this thesis is to provide its readers with a basic understanding of command and control as it pertains to the American military establishment. The scope of the thesis is intentionally broad to offer a good introduction to the myriad issues and fields of study that, taken together, allow the understanding of command and control and permit the ultimate development of C^2 architectures.

II. FUNDAMENTALS OF COMMAND AND CONTROL

A. FUNDAMENTAL DEFINITIONS

1. Command and Control

The key to understanding the complex phenomena of command and control is establishing a clear and concise definition for command and control, and its associated terminology. The Joint Chiefs of Staff Publication 1 (JCS Pub 1) provides the basic definition of command and control.

> Command and control is the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. [Ref. 7:p. 77]

This simple and straightforward definition is the Armed Forces standard for defining C^2. No additional interpretation should be read into what is stated. Acceptable alternatives for the term command and control are C^2 (C-squared) or C2. Command represents the vested "authority that a commander in the military service lawfully exercises over subordinates by virtue of rank or assignment." [Ref. 7:p. 76] Control is typically associated with the commander's direction of forces. When used in the context of C^2, control is defined as operational control which according to JCS Pub 1, is considered synonymous with the term operational command. The term control therefore represents:

> those functions of command involving the composition of subordinate forces, the assignment of tasks, the designation of objectives, and the authoritative direction necessary to accomplish the mission.... [Ref. 7:p. 262]

A properly designated commander is the individual placed in command in accordance with the laws and the Constitution of the United States. The definition of C^2 also stipulates the following:

> 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 the accomplishment of the mission. [Ref. 7:p. 77]

2. Command and Control System

The second most important and fundamental definition is for the term command and control system. A command and control system consists of:

> The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned. [Ref. 7:p. 77]

At this point, it is critical to realize that the term C^2 system describes the C^2 system as a whole. It is an all encompassing term used to describe all the elements and aspects involved in a commander's execution of command and control. C^2 system includes all the processes, inter-relationships, and inter-dependencies of all the components and subsystems relating to command and control. It is crucial to understand and accept the fact that anything that relates to C^2, either currently existing or developed through technology advances in the future, is still only a part of the C^2 system. Students of C^2 should bear this in mind when they encounter these other popular terms which are often used throughout literature and among the C^2 "experts" of the Department of Defense: command, control, and communications (C^3); command, control, and communication system (C^3 system); command, control, communications, and computers (C^4); command, control, communications, and intelligence (C^3I); and command, control, communications, intelligence, and interoperability (C^3I^2) [Ref. 8:p. 23]. Why not C^nI^m? The problem is that all the terms above, and those not yet devised, are used interchangeably to represent C^2 or the C^2 system. In actuality, each term is merely a focused and limited description of component parts of the C^2 system, which is clearly defined in JCS Pub 1. Figure 1 attempts to present a hierarchical description of the relationships among C^2 terminology.

The fundamental problem facing the C^2 community is the lack of an agreement or understanding of exactly what is meant by the variety of terms used, or more readily misused, to describe C^2 and the C^2 system. Overall, the plethora of terms used throughout the community usually involves terms referring only to some subsystem of the overall C^2 system, and the terms rarely describe the command and control process, a process which is as "old as war itself." [Ref. 9:p. 1] The term "command and control means many things to

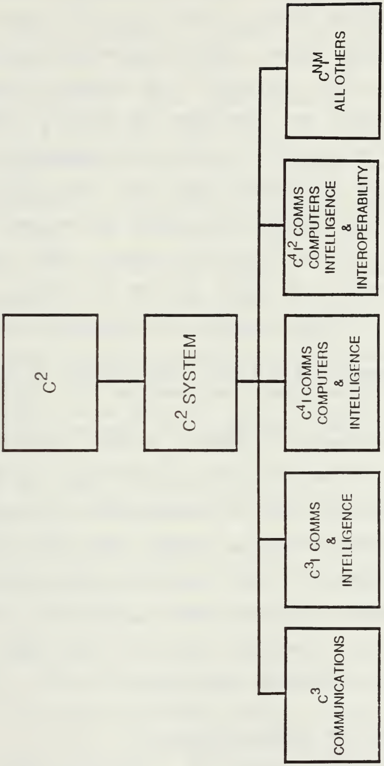


Figure 1.
C^2 Terminology Relationships

many people, and definitions range widely even among veteran policy developers, analysts, designers, vendors, purchasers and users." [Ref. 10:p. 2] Most experts of the C^2 community loosely use the term and its derivatives to serve parochial interests. No accepted glossary of terms exists within the Department of Defense other than those provided by JCS Pub 1, which is inadequate for trying to clarify the many terms being used. The lack of a consensus on just what command and control is has led to a diversity of efforts by the technical community [Ref. 11:p. 880]. As this diversity of effort evolved C^2 systems, it also gave birth to the many parochial descriptions of C^2.

> One of the least controversial things that can be said about command and control is that it is controversial, poorly understood, and subject to wildly different interpretations. The term can mean almost everything from military computers to the art of generalship: whatever the user wishes it to mean. [Ref. 8:p. 23]

A suitable starting point must be established in order to study and to understand the complex world of command and control, its process, and its system. The key is a simple approach to the terminology associated with command and control. As presented earlier, JCS Publication 1 provides that starting point in its clear and concise definition of command and control.

B. COMMAND AND CONTROL PROCESS

Command and control is a process which has existed since the beginning of warfare; its concept and true meaning have not changed. What has changed drastically through technology is the command and control system that supports the commander and his process of command and control. The command and control of Armed Forces is not new; however, "...its dimensions have grown exponentially in modern times, especially since 1939." [Ref. 9:p. 1] The evolution of high technology command and control systems has brought about new perspectives of the nature of command and control. A variety of science and engineering disciplines have attempted to remove some of the complexity of these systems by trying to automate and improve the means by which commanders exercise command and control. As the C^2 systems evolved, so have a variety of definitions for the term command and control.

The command and control process "in essence, is the process of making, disseminating, and implementing informed command decisions in order to obtain optimum effectiveness of the nation's military forces in peace time, crisis, conflict, or war." [Ref. 12:p. 9] The C^2 process consists of three major functional areas: information management, decision management, and execution management. [Ref. 13:p. 3] These areas incorporate the four fundamental functions of the command and control process: observe, orient, decide, act (O-O-D-A). In 1981, these functions were presented in a briefing to the Air War College by Colonel John Boyd in his work, <u>Patterns of Conflict</u> [Ref. 8:p. 97]. The functions are driven by the state of the environment which the C^2 process is attempting to manipulate. Figure 2 represents Boyd's O-O-D-A loop structure, which provides the basic relationships of the functions of the C^2 process. [Ref. 8:p. 26]

The most important functional area of the process is the decision management area, whose product is the commander's decision. Therefore, the essential element of the C^2 process is the commander/decision maker. Decision making is the essence of the C^2 process. Decisions are usually made under conditions of great uncertainty, stress, and critical time constraints. [Ref. 14:p. 14] The commander's objective is to reduce the uncertainty about the environment to aid him in making the best decisions. [Ref. 15:p. 117]

> From Plato to NATO, the history of command (and control) in war consists of an endless quest for certainty-certainty about the state and intentions of the enemy's forces; certainty about the manifold factors that together constitute the environment in which the war is fought, from the weather and the terrain to radioactivity and the presence of chemical warfare agents; and, last but definitely not least, certainty about the state, intentions, and activities of one's own forces. [Ref. 9:p. 264]

Another problem with trying to make the best decision is that the correct decision for one situation may not be the best for another due to the stochastic nature of combat. Combat is not a deterministic process dependent only on a commander's decisions. The action or reaction of enemy

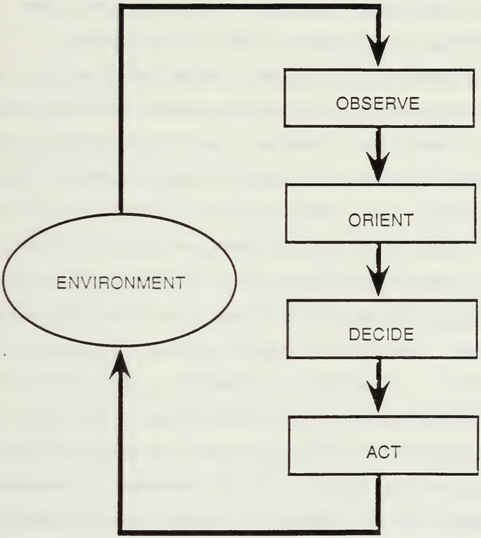


Figure 2.
Boyd's O-O-D-A Loop

forces greatly affects the outcomes of the battles. The commander's decisions do not always determine the actual results of combat, and because of the probabilistic or stochastic nature of combat, the commander "is only influencing the probability of outcomes rather than directly controlling outcomes." [Ref. 8:p. 47] "Warfare is two-sided, and outcomes depend on decisions made by many commanders on both sides." [Ref. 15:p. 117]

Compounding the problem, technological C^2 systems and modern warfare have placed the commander "at a distance both from the phenomena on which he bases his decisions, and from the people whom he will task to execute them." [Ref. 15:p. 11] Because the commander must rely on the C^2 system to provide the information to make decisions as well as the means to execute decisions, the commander needs some control over the structure and the procedures of the C^2 system. The structure, however, is usually established by a previous commander or a superior commander. Most C^2 systems are designed to support several commanders. [Ref. 15:p. 13] An important concern for the commander is to assure that the C^2 system does not control his C^2 process. A commander must understand the C^2 system he acquires and manipulate the system to meet his needs, his C^2 process. To do this, the commander must determine the needs for the variety of different situations he may face. "The key to success in combat is identifying foreseeable combat situations and thinking them through in order to create plans to deal with them." [Ref. 15:p. 25] The commander must establish the "arrangement of personnel, equipment, communications, facilities, and procedures" to serve the needs of his command and control process.

The information management functional area of the C^2 process consists primarily of inputs from the observe function. Observations of the environment are made through a myriad of sensors ranging from human intelligence (HUMINT) and active surveillance systems to the perceptions of subordinate commanders. The commander "requires a network of information flow from sensors and reporting commanders through a process of correlation, filtering, and analysis that converts data into information, and information into knowledge." [Ref. 15:p. 117] Inputs are also received from higher levels of authority providing guidance and direction sometimes reflecting national policy objectives, depending on the level of command and nature of conflict.

The ability of the C^2 system to provide complete and accurate information in a timely manner will significantly impact how well a commander can perform the orient function. This function actually leads to a situation assessment of what is occurring in the environment. Because of the complex nature of the C^2 processes occurring at each level of the C^2 system, the information received by the commander can already be distorted by the perceptions of subordinate commanders. Based on the information received, the commander must determine an estimate of the situation. Objectives and courses of action (COAs) must be formed. Decisions are made, and the final function of the cycle, act, can occur. [Ref. 9:p. 7]

The act function is a function of the execution management process and is a result of the decisions made based on the planning of alternative COAs. The orders must be transmitted to the proper forces for execution, and the orders must be clearly understood. The C^2 system must also provide a feedback system to monitor the proper execution of commands. The allocation of resources is also an output of the decision making process. Once the execution has occurred, the cyclic process then repeats itself. Although simplified in this discussion, the command and control process is continuous and must perform these fundamental functions throughout the entire spectrum of conflict. [Ref. 9:p. 7] The conceptual architecture of the C^2 process discussed in Chapter VII presents a more detailed description of the C^2 process.

C. COMMAND AND CONTROL SYSTEM

The primary mission of the C^2 system is to meet the needs of the commander. "The C^2 system is a combination of elements that form a complex whole." [Ref. 11:p. 880] The system must permit the commander to have full use of all his resources in order to effectively and efficiently employ military forces throughout the spectrum of conflict. [Ref. 14:p. 10] Figure 3 depicts the C^2 system supporting the commander and his C^2 process.

The three categories of information associated with the C^2 system are: friendly status, enemy status, and environmental status. The C^2 system must be able to perform five basic functions regarding information: collect, process display, disseminate, and retain. [Ref. 16] The Defense Science Board Task Force on Command and Control Systems Management describes the C^2 system this way:

> ...effective command and control systems-- support systems that aid the commander in the exercise of his command...a command and control system supporting a commander is not just a computer with its associated software and displays; it is not just communication links; and it is not even just all the information processing and fusion that must go in any well-designed and well-operating command and control system. It is all the above and much more. The ideal command and control system supporting a commander is such that the commander knows what goes on, that he receives what is intended for him, and that what he transmits is delivered to the intended addressee, so that the command decisions are made with confidence and are based on information that is complete, true, and up-to-date. The purpose of a command and control system is, in the end, to provide assurance that orders are received as originally intended with follow-up in a timely fashion, which can make the difference between winning and losing wars. [Ref. 12:p. 12]

The official definition for C^2 system divides the system into five basic subsets: communications, personnel, procedures, facilities, and equipment. [Ref. 7:p. 77]

Communications is the most dominant subsystem of the entire C^2 system, but not necessarily the most important. Modern warfare technology has changed the battlefield

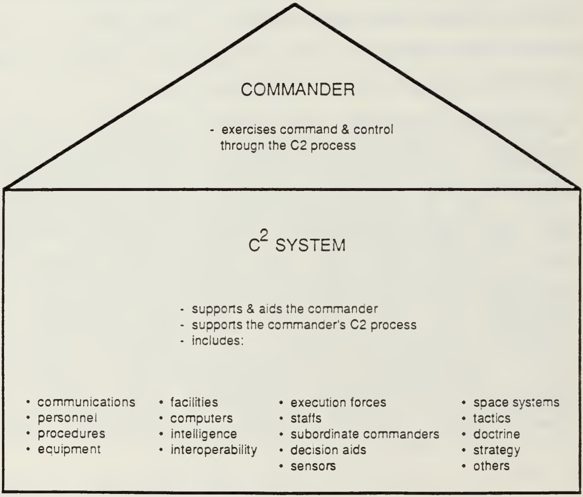


Figure 3.
C^2 System Supports the Commander

boundaries dramatically. The battles of today cover large expanses of goegraphy, and the weapons can assault the enemy without ever seeing him. Communications have permitted C^2 to keep pace with technology. The difficulties of command and control of modern armies over large areas require capable communication systems to allow for effective and efficient control of forces. In early warfare, the limitations of communications "kept armies fairly small in size, the battlefields fairly small in area, and the battles fairly short in duration." [Ref. 17:p. 17] Even as empires amassed larger armies, the lack of effective communications to control them "reduced them to little more than armed mobs." [Ref. 17:p. 17] The technological advances of communications since World War II have allowed commanders to maintain the ability to exercise command and control over large modern armies and modern weaponry on battlefields far removed from the physical location of the commander. The significant contribution of communications into the C^2 system has spawned the popular term C^3 or C3. Communications are the link between the commander and all the other components of the C^2 system. The term C^3 system describes only the communications subsystems which are a part of the overall C^2 system. Although frequently used to refer to the C^2 system, it is not a representation of the entire system.

The next subset of the C^2 system is the personnel. The personnel are perhaps the most important component of the system because the human element is both the weakest and most complex part. Without the "man-in-the-loop," the process of command and control, as we know it, would not exist. The commander and his assigned forces are part of the C^2 system [Ref. 15:p. 118] as well as users of it. In addition to the primary commander in the C^2 system and the execution forces, man provides many inputs to the C^2 system at all levels. The man-machine interface is critical to the overall success of the C^2 system. "No matter how good the final...(C^2) system is, it is reliant on the human interface for initial input and for final decision making." [Ref. 18:p. 30] These inputs are directly affected by the decision making process of the individual and the individual's perception, right or wrong, of the information or data he has. If these individuals are not properly trained or they are adversely affected by the confusion of combat, often referred to as the "fog of war", the C^2 system will not adequately serve the commander. This was sadly demonstrated in July 1988 when USS Vincennes shot down an Iranian airliner, which was incorrectly perceived to be an attacking jet aircraft during combat hostilities in the Persian Gulf. Expert system and artificial intelligence technology is attempting to remove man from the loop wherever feasible, but it is not an easy problem to solve.

In contrast, keen perception and ingenuity of reporting subordinates that can often make the difference in warfare cannot be easily replaced by a systematic machine process.

The equipment and facilities of the C^2 system are comprised of all the components which are not part of communications or personnel. They include sensing, processing, computing, and displaying equipment as well as all the facilities to operate and maintain the equipment. The often overlooked component is the logistics support not only for guns and bullets, but "everything an army needs to exist-- its food supply, its sanitary services, its system of military justice, and so on." [Ref. 9:p. 6]

Computers have become a key piece of equipment in support of the command and control process. The evolution of computer technology within the C^2 system has been so significant that it has prompted the call for another of the many terms of C^2 to be adopted: C^4. In May 1987, Lieutenant General Emmett Paige, Jr., then Commanding General U. S. Army Information Systems Command, stated:

> I believe that it is time to add computers as the fourth "C" to C^3I and get on with the job that must be done to bring the communications and automation business areas together. [Ref. 19:p. 56]

General Paige is absolutely correct in insisting that automation by computers needs to be emphasized, but there is no need to introduce another term to include computers, which are already a part of the C2 system description. The computer's role in C^2 is constantly evolving. Computers presently perform the following functions: 1) sensor and communication network automation; 2) correlation, filtering, and analysis of information regarding the enemy; 3) maintaining the status and location of friendly forces; 4) determining optimal deployment plans and their feasibility; and 5) evaluating battle plans and outcomes of engagements. Computer automation has greatly increased the commander's ability to collect and process immense amounts of data. This capability significantly enhances the commander's decision making process. However, if the proper procedures and processes are not performed, the commander will quickly become saturated with information. It is important to realize that computers are only as good as their application programs and their input data. If the programs are inadequate, or the data inaccurate, then the outputs are unreliable and usually invalid. Again, the influence of the man-in-the-loop significantly impacts the C^2 system's utilization of computers. Computers, computer security, and operating system interoperability pose tremendous and exciting challenges to the C^2 community and to the future of highly capable C^2 systems. [Ref. 15:pp. 83-85]

The procedures in the C^2 system include all the procedures used in the planning, directing, coordinating, and controlling of the assigned forces in the accomplishment of assigned missions. These procedures can be promulgated by the commander who has the responsibility of performing the tasks stated, or by pre-determined standard operating procedures. This perhaps is where the military leadership style of the commander is most prevalent. The commanders have various degrees of flexibility in their "choices concerning the ways to employ available technical means within the military command (and control) structure." [Ref. 8:p. 87] The commander also has the flexibility to determine what information he receives, and often the format and speed at which he receives it.

The modern C^2 system is a complex and constantly evolving system of technological and procedural advances rooted by the fundamental functions of command and control. To grasp a sound understanding of the C^2 system requires the study of a wide variety scientific fields including: human factors, social sciences, psychology, organizational theory, leadership, communication engineering, computer sciences, operations analysis, behavioral sciences and others. [Ref. 8:p. 32]

D. CHARACTERISTICS OF A C^2 SYSTEM

Six basic system characteristics are required to enable the C^2 system to perform its mission of aiding the commander in the exercise of command and control. These C^2 system characteristics include: 1) reliability, 2) survivability, 3) flexibility, 4) responsiveness, 5) interoperability, and 6) user-orientation. [Ref. 14:p. 22]

1. Reliability-- Reliability is defined by JCS Pub 1 as the "ability of an item to perform a required function under stated conditions for a specified period of time." [Ref. 7:p. 305] High mean time between failures (MTBFs) for equipment and the reduction of the causes of fatigue for personnel are critical in assuring C^2 system reliability. The system must be designed to perform in wartime as well as peacetime. [Ref. 14:p. 22]

2. Survivability-- A C^2 system must possess the robustness to withstand enemy attacks across the entire spectrum of conflict. It must have the "potential for graceful degradation." [Ref. 12:p. 12] The loss of part of the system cannot result in the catastrophic loss of the entire system. The ability to continue to provide the commander with the essential elements to conduct effective C^2 can be achieved through a variety of measures which include: hardening, mobility, redundancy, dispersal, and distributed networking [Ref. 14:p. 22].

3. Flexibility-- A C^2 system must possess the ability to adapt to quickly changing environments and a wide range of operations. The commander must be allowed to manipulate the system quickly and with relative ease in order to meet the requirements of the missions assigned within the constraints of higher authority. [Ref. 14:p. 22] The system must be flexible to evolutionary changes enabling it to keep pace with advances in state of the art technology.

Modifications of portions of the system should not adversely affect the operation of the whole system.

4. Responsiveness-- A C^2 system must respond quickly and accurately to provide the commander with essential information in a timely manner. In crisis situations, time becomes the critical factor. Time-late information is useless information.

5. Interoperability-- Interoperability of C^2 systems and subsystems is critical to the success of military operations, especially in joint and combined operations. The C^2 system must go beyond compatibility and achieve interoperability [Ref. 15:p. 70]. As defined in JCS Pub 1, compatibility is merely the ability to "function in the same system or environment without mutual interference," while interoperability is "the ability of systems, units, or forces to provide services to and accept services from other systems, units or forces and to use them to operate effectively together." [Ref. 7:pp. 82,192]

6. User-orientation-- A C^2 system must be designed for the user. The commander must have useable information presented or displayed in a clear, unambiguous format; and it should not require elaborate interpretation. This characteristic is critical at all levels of the system. Information must be entered just as efficiently and effectively as it is extracted. [Ref. 14:p. 22]

E. SUMMARY

Establishing a fundamental understanding of the definition of command and control, and the command and control system, is the key to understanding the organizations and operations of complex command and control structures. Chapter III describes the command and control structure of the United States military organization including: the Department of Defense, the Office of the Secretary of Defense, the Joint Chiefs of Staff, the Armed Services, and the Unified and Specified Commands.

III. THE DEPARTMENT OF DEFENSE

A. HISTORY

The first move to reorganize the military forces of the United States under one department began in the closing months of World War II. The war itself revealed the need for some form of consolidated military department to be placed under the direction of a cabinet-level secretary. The National Security Act of 1947 was the first piece of legislation to bring about this organizational change. The act created the National Military Establishment (NME) and placed this entity under the control of a civilian secretary. The act also created "co-equal" cabinet-level secretaries for the newly established Departments of the Army, Navy, and Air Force. [Ref. 20:p. 27]

Several amendments to the National Security Act of 1947 have been legislated. Among these is the Reorganization Act of 1958 which asserted the "direction, authority, and control of the Secretary of Defense" over the newly named Department of Defense (DOD) and defined the operational chain of command to run "from the President and the Secretary of Defense to the combatant forces." [Ref. 20:p. 27]

The current expressed functions of the DOD are as follows:

- To support and defend the Constitution of the United States against all enemies, foreign and domestic;
- To ensure, by timely and effective military action, the security of the United States, its possessions, and areas vital to its interest; and
- To uphold and advance the national policies and interests of the United States. [Ref. 21:p. 3]

B. GOLDWATER-NICHOLS DOD REORGANIZATION ACT

Numerous suggestions for organizational reform for the DOD have been made in the years since the Reorganization Act of 1958. These suggestions have been made both by senior military members and official investigative bodies. The culmination of all these forums was appointed in July 1985 by then President Reagan. Chaired by David Packard, former Deputy Secretary of Defense, the commission became known as the Packard Commission. It was tasked to "conduct a study of the entire defense management organization, including budget, procurement, legislative oversight, organization, and operational arrangements." [Ref. 21:pp. 141-142] The commission's most publicized finding stated:

> Today, there is no rational system whereby the Executive Branch and the Congress reach coherent and enduring agreement on national military strategy, the forces to carry it out, and the funding that should be provided-- in light of the overall economy and competing claims on national resources. [Ref. 21:p. 142]

The commission proposed that sweeping changes be made within the DOD. With regard to command and control, these changes may be summarized simply as increased authority for the Chairman, Joint Chiefs of Staff (CJCS), increased authority for combatant commanders, and increased influence and prestige for the Joint Staff. [Ref. 21:p. 143]

The need for change was recognized by Congress and legislated through the Goldwater-Nichols Department of Defense Reorganization Act of 1986. The act was signed as Public Law 99-433 on 1 October 1986. [Ref. 22:p. 1032] The expressed intent of Congress in the enactment of this Act was manifold:

- To reorganize the Department of Defense and strengthen civilian authority in the Department;
- To improve the military advice provided to the President, the National Security Council, and the Secretary of Defense;
- To place clear responsibility on the commanders of unified and specified combatant commands for the accomplishment of missions assigned to those commands;
- To ensure that the authority of the commanders of the unified and specified combatant commands is fully commensurate with the responsibility of those commanders for the accomplishment of missions assigned to their commands;
- To increase attention to the formulation of strategy and to contingency planning;
- To provide for more efficient use of defense resources;
- To improve joint officer management policies; and
- To enhance the effectiveness of military operations and improve the management and administration of the Department of Defense. [Ref. 22:pp. 1034-1035]

The major provisions of the Goldwater-Nichols Act pertaining to command and control involve specific changes in the role and authority of the Chairman of the Joint Chiefs of Staff, of the added authority given to the combatant commanders

(CINCs), the establishment of the position of Vice-Chairman, and modifications made to the role of the Joint Staff. [Ref. 21:p. 144]

The current organization of the Department of Defense is depicted in Figure 4. [Ref. 20:p. 29] The operational chain of command runs from the President through the Secretary of Defense (SECDEF) to the unified and specified combatant commanders. DOD Directive 5100.1 dated 25 September 1987 [Ref 21] places the CJCS in the communication chain of command between the Secretary of Defense and the combatant commanders. [Ref. 20:p. 42] The administrative chain of command includes the military departments. These departments (Department of the Army, Department of the Navy, and Department of the Air Force) are under the control of civilian secretaries who supervise the service chiefs in matters which are of a "service nature" but not operationally related. The civilian secretaries were removed from the operational chain of command by the Reorganization Act of 1958. The basic function of the department secretaries is to oversee the areas of recruitment, supply, training, mobilization/demobilization, and the construction/outfitting and repair of equipment and buildings. [Ref. 20:p. 30]

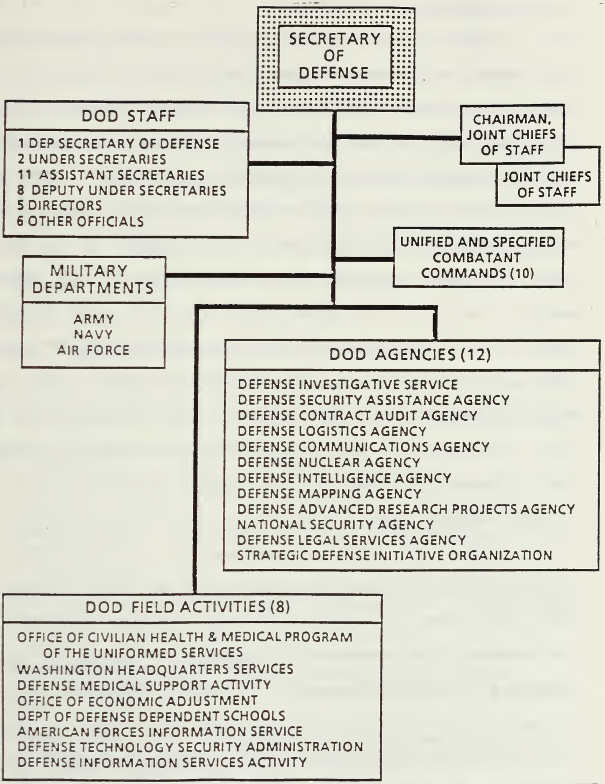


Figure 4.
DOD Organization

C. JOINT CHIEFS OF STAFF (JCS)

1. History

The JCS came into being as the result of the need for "coordinated staff work" during World War II. The original JCS was based upon the British Chiefs of Staff Committee and the original members of the JCS were parallel to the members of the British organization. This first organization was developed "without legislative sanction" or "formal Presidential definition." At the end of the war the need for formal definition was determined. The National Security Act of 1947 established the JCS as a permanent agency and designated the JCS as the principal military advisors to the President and the Secretary of Defense. Modifications to the structure of the JCS have been made since its inception, the latest being the changes imposed by the 1986 Goldwater-Nichols Act. [Ref. 20:pp. 31-33]

2. The JCS Today

Today the JCS is comprised of the Chairman, the Chief of Staff of the Army, the Chief of Staff of the Air Force, the Chief of Naval Operations, and the Commandant of the Marine Corps. The Vice-Chairman is the second ranking member of the Armed Forces. He is not a member of the JCS but may participate in all meetings. He votes on matters before the JCS only when acting in the capacity of the Chairman. The JCS exerts no executive authority to the command combatant forces. Specifically, the Goldwater-Nichols Act states the "Secretaries of the military departments shall assign all forces under their jurisdiction to unified and specified combatant commands to perform missions assigned to those commands...." Also, while the Chairman is the chief military advisor to the President, Secretary of Defense, and the National Security Council (NSC), current law allows all members of the JCS to respond to a request or to voluntarily submit advice or opinions to the President, the SECDEF, or the NSC. [Ref. 20:pp. 33-34]

3. Role and Function of the Chairman

The Goldwater-Nichols Act did much to expand the role of the Chairman. Specifically, the functions of the Chairman include the following:

- Furnish strategic direction of the Armed Forces;
- Prepare strategic plans, joint logistics and mobility plans and net assessments of the capabilities of the Armed Forces;
- Provide for the preparation and review of contingency plans and advise on critical deficiencies and strengths in force capabilities;
- Advise on the priorities of requirements, program recommendations and budget proposals and assess military requirements for defense acquisition programs; and
- Develop doctrine for joint employment and formulate policies for coordinating military education and training. [Ref. 20:p. 35]

D. UNIFIED AND SPECIFIED COMMANDS

1. History

Again, World War II proved to be the catalyst for redefinition of basic components within the existing military system. "The complexity of modern warfare" had brought about the need for a "unified command arrangement." The National Security Act of 1947 directed the Joint Chiefs of Staff to "establish unified commands in strategic areas" and for the President to "establish unified and specified combatant commands to perform military missions." [Ref. 20:p. 42] The official JCS definitions of these two entities are:

> Unified Command-- A command with a broad continuing mission under a single commander and composed of significant assigned components of two or more services, and which is established and so designated by the President, through the Secretary of Defense with the advice and assistance of the Joint Chiefs of Staff, or, when so authorized by the Joint Chiefs of Staff, by a commander of an existing unified command established by the President. [Ref. 7:p. 384]

> Specified Command-- A command that has a broad continuing mission and that is established and so designated by the President through the Secretary of Defense with the advice and assistance of the Joint Chiefs of Staff. It normally is composed of forces from but one service. [Ref. 7:p. 340]

The operational chain of command as decreed by the 1986 Goldwater-Nichols Reorganization Act runs from the President through the Secretary of Defense to the CINCs. The CJCS is within a communication chain of command between the SECDEF and the CINCs. [Ref. 20:p. 42] Today there are eight unified commands and two specified commands. All of the unified commands contain a service component command from each service.

2. Command Authority of Combatant Commanders

Unified and specified commanders are invested by law with Operational Command (OPCOM) authority defined as:

> The authority to perform those functions of command involving the composition of subordinate forces, assignment of tasks, designation of objectives, and authoritative direction necessary to accomplish the mission. [Ref. 24:p. 3-9]

OPCOM is not shared with other echelons of command. CINCs exercise OPCOM only through service component commanders, functional component commanders, subordinate unified commanders, commanders of single-service forces, and commanders of joint task forces. [Ref. 20:p. 42] OPCOM grants the CINCs the authority to accomplish the following tasks:

- Give authoritative direction to subordinate commands and forces necessary to carry out missions assigned to command, including authoritative direction over all aspects of military operations, joint training, and logistics;

- Prescribe the chain of command to the commands and forces within the command;

- Organize commands and forces within that command as is considered necessary to carry out missions assigned to the command;

- Employ forces within that command as is considered necessary to carry out missions assigned to that command;

- Assign command functions to subordinate commanders;

- Coordinate and approve those aspects of administration, support (including control of resources and equipment, internal organization, and training), and discipline necessary to carry out missions assigned to the command; and

- Exercise the authority with respect to selecting subordinate commanders, selecting combatant command staff, suspending subordinates, and convening courts-martial. [Ref. 21:pp. 8-9]

Another level of authority used by CINCs is Operational Control (OPCON). This authority is delegated to echelons below that of the combatant commander. [Ref. 20:p. 45] OPCON is defined as:

> The authority delegated to a commander to perform those functions of command over subordinate forces involving the composition of subordinate forces, the assignment of tasks, the designation of objectives, and the authoritative direction necessary to accomplish the mission. [Ref. 24:p. 3-9]

3. The Role of CJCS

Within the communication chain of command, the Chairman of the Joint Chiefs of Staff fulfills three roles. First, the CJCS has the responsibility for communications between the President and the Secretary of Defense and the CINCs. This communication responsibility includes the numerous duties associated with the direction and control of combatant commanders, specifically: strategic direction, strategic planning, and contingency planning and preparedness. Second, CJCS retains oversight authority over the activities of the unified and specified commands in matters dealing with the "statutory responsibility of the Secretary of Defense." This function includes the recommendation of changes in the assignment of functions, roles, and missions in order to achieve the maximum effectiveness of the Armed Forces. Third, the CJCS acts as the spokesman for the CINCs providing summary and analysis of requirements, programs, and budgets. [Ref. 20:pp. 45-46]

4. The Unified Commands

The eight unified commands are categorized in two groups-- commands based on function (U.S. Space Command, U.S. Special Operations Command, U.S. Transportation Command) and commands based on geographic area (U.S. Pacific Command, U.S. Atlantic Command, U.S. European Command, U.S. Southern Command, U.S. Central Command). The general definition of a unified command was stated in section D.1. of this chapter. The wide range of roles and missions fulfilled by each of these commands requires that some time be spent examining each in order to obtain a good working knowledge of the Nation's military structure. The relationships between the President, SECDEF, CJCS, and the unified and specified commands may be seen in Figure 5. [Ref. 20:p. 41]

a. U.S. Space Command (USSPACECOM)

The first step towards development of a unified space command was taken in the formation of the Air Force Space Command in 1982 and the Naval Space Command in 1983. The United States Space Command was established in September 1985. It was designated as a unified command whose mission is "to support joint employment of military space related forces and to ensure improved operational support to other

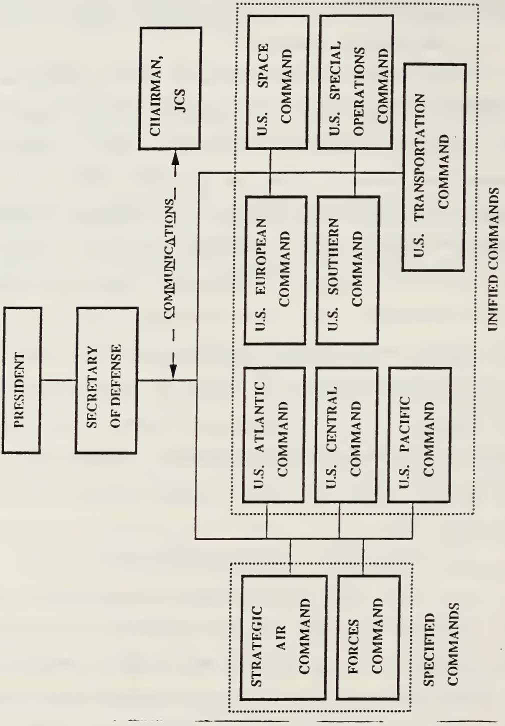


Figure 5.
Organizational Relationships

unified commands." USSPACECOM headquarters are located at Peterson AFB, Colorado. The service components of this command are the Air Force Space Command at Colorado Springs, Colorado; the Naval Space Command at Dahlgren, Virginia; and the Army Space Command, also at Colorado Springs. [Ref. 25:pp. 44-45]

The three primary mission areas may be broadly stated: space operations, surveillance and warning, and ballistic missile defense planning. The space operations aspect of this command's mission involves space control and the direction of space support operations for its assigned systems and operation of JCS designated space systems in support of the President, SECDEF, JCS and other unified and specified commands. [Ref. 25:p. 45]

b. U.S. Special Operations Command (USSOCOM)

The need for the ability to resolve low-intensity conflict situations while still at relatively low levels of violence has long been recognized. However, serious recognition of the need for a dedicated special operations organization did not occur until the Iranian hostage rescue attempt that ended in tragedy in April 1980. [Ref. 26:pp. 48-50] The U.S. Special Operations Command came into being in April 1987, a direct result of the Goldwater-Nichols DOD Reorganization Act. Some of the functions of this unified command are:

- To provide combat-ready special operations forces for rapid reinforcement of the other unified commands;

- To develop joint doctrine, tactics, techniques, and procedures for special operations forces;
- To train assigned forces and ensure interoperability of equipment and forces;
- To monitor the preparedness of special operations forces assigned to the other unified commands;
- To develop and acquire unique special operations forces equipment, material, supplies, and services; and
- To be prepared to plan and conduct selected special operations as directed by the President and/or SECDEF. [Ref. 26:p. 51]

USSOCOM is headquartered at MacDill AFB, Florida. The service components of the Special Operations Command are the Army's 1st Special Operations Command at Fort Bragg, North Carolina; the Air Force Special Operations Command at Hurlburt Field, Florida; and the Naval Special Warfare Command at Coronado, California. [Ref. 26:pp. 51-52]

c. U.S. Transportation Command (USTRANSCOM)

The need for unifying the nation's mobility forces was recognized in the years following World War II. Serious attention to this matter was given following a 1978 command post exercise called Nifty Nugget. The exercise simulated a blitzkrieg by the Warsaw Pact on NATO forces in Europe. The exercise made clear the fact that the transportation elements of U.S. forces were not coordinated. The Joint Deployment Agency (JDA) was formed in 1979 to address this problem. The effectiveness of this agency was limited, however, in that it served as a coordinating authority only with no actual direction ability. The need for a single unified command to "integrate global air, land, and sea transportation" was expressed in the Goldwater-Nichols Act of 1986. In October 1987, the U.S. Transportation Command was formally activated. The Joint Deployment Agency was disestablished and its functions and responsibilities assumed by the Transportation Command. [Ref. 27:pp. 53-56] The mission of the Transportation Command is "to provide common-user airlift, sealift, terminal services, and U.S. commercial air and land transportation to deploy, employ, and sustain U.S. forces on a global basis." The service components are the U.S. Air Force's Military Airlift Command (MAC) headquartered at Scott AFB, Illinois; the U.S. Navy's Military Sealift Command (MSC) headquartered at Washington, D.C.; and the U.S. Army's Military Traffic Management Command (MTMC) headquartered at Falls Church, Virginia. [Ref. 27:p. 55]

d. U.S. Pacific Command (USPACOM)

The U.S. Pacific Command was established in January 1947. Its original structure was based on the unified command structure used during World War II. The Pacific Command is the largest unified command spanning both the Pacific and Indian Ocean areas and includes the Asian landmass. In this area lie the interests of the United States, the Soviet Union, China, Korea, India, Japan, and others. The Pacific Command is headquartered in Oahu, Hawaii. The service component commands on Oahu are the U.S.

Army Western Command, U.S. Pacific Fleet, and the Pacific Air Forces. The mission of this command is:

- To maintain the security of the command and defend the United States against attack through the Pacific Ocean;

- To support and advance the national policies and interests of the United States and discharge U.S. military responsibilities in the Pacific, Far East, South Asia, Southeast Asia, and Indian Ocean; and

- To prepare plans, conduct operations, and coordinate activities of the forces of the U.S. Pacific Command in accordance with the directives of higher authority. [Ref. 28:pp. 5-7]

e. U.S. Atlantic Command (USLANTCOM)

The U.S. Atlantic Command was established December 1947 and is headquartered in Norfolk, Virginia. The command is responsible for the geographic area encompassing the Atlantic Ocean to the North and South Poles and the Pacific Ocean west of Central America. Service component commands of the Atlantic Command are Army Forces Atlantic, Air Forces Atlantic, and the Atlantic Fleet. There are also two special commands, Joint Task Force 120 and Joint Task Force 140. These commands are directed to "plan and conduct joint operations in specific areas." [Ref. 29:pp. 28-31]

The Atlantic Command is primarily a maritime command as reflected in its missions:

- To maintain an unbroken link between Europe and North America to ensure the safe and timely flow of reinforcement and resupply shipping over the sea lines of communication; and

- To provide direct application of combat power in support of the land campaign.

An additional requirement of USLANTCOM involves the U.S. commitment to the NATO treaty which states that an attack on any NATO ally is an attack against all of NATO. The commitment of the United States to this treaty is evident in the dual-hat of USCINCLANT and the Supreme Allied Commander, Atlantic (SACLANT). [Ref. 29:p. 28]

f. U.S. European Command (USEUCOM)

In the aftermath of World War II, the serious threat to western nations by the Soviet Union prompted the formulation of the North Atlantic Treaty Organization (NATO) in 1949. Part of the American commitment to this new organization was the establishment of the United States European Command in 1952. The primary purpose of this command was to "coordinate the U.S. military support for NATO." [Ref. 30:p. 12]

Today, USEUCOM covers an area ranging from the north cape of Norway, through the Mediterranean and parts of the Middle East to the southern tip of Africa. The command is headquartered at Stuttgart-Vaihingen, Federal Republic of Germany. The primary missions of the European Command include:

- Providing combat-ready forces to support U.S. commitments to the NATO alliance;
- Unilateral and multilateral contingency planning ranging from humanitarian relief in support of friendly governments to military operations in support of U.S. national interests;
- Intelligence activities geared toward maintaining an accurate picture of the Warsaw Pact threat; and

- Security assistance to help friendly nations protect themselves from aggression and to contribute to collective security. [Ref. 30:p. 17]

The Commander in Chief of the European Command (USCINCEUR) is dual-hatted as Supreme Allied Commander, Europe (SACEUR), reflecting the commitment of the U.S. Armed Forces to NATO. The service components of USEUCOM are U.S. Naval Command, Europe; U.S. Army Command, Europe; and U.S. Air Force Command, Europe. [Ref. 20:p. 50]

g. U.S. Southern Command (USSOUTHCOM)

The U.S. Southern Command is headquartered at Quarry Heights, Panama and encompasses all of Central and South America. The command is comprised of three service components: U.S. Army South, U.S. Southern Air Force, and U.S. Naval Forces Southern Command. [Ref. 30:p. 26] The Commander in Chief, U.S. Southern Command (USCINCSOUTH) is the principal DOD representative in the region. USCINCSOUTH, in conjunction with his service component commands, has the mission to:

- Provide for the defense of the Panama Canal and other DOD obligations of the Panama Canal Treaty of 1977;
- Exercise operational command over U.S. forces in Central and South America;
- Prepare strategic assessments and contingency plans and conduct training or operations as directed by the JCS;
- Conduct disaster relief, search and rescue or evacuation of U.S. citizens from endangered areas; and
- Promote mutual security and development among nations of the region. [Ref. 30:p. 25]

h. U.S. Central Command (USCENTCOM)

The U.S. Central Command has become highly visible during the past few years against the backdrop of the turbulent and violent Persian Gulf arena. The command is headquartered at MacDill AFB, Florida and controls U.S. forces in an area ranging from Southwest Asia, the Middle East, and East Africa. The component commands of USCENTCOM are U.S. Army Central, U.S. Central Air Force, and U.S. Navy Central Command. Additionally, due to the rapid and recent increased presence and activities of U.S. military forces within the region, Central Command has now been supplemented with Joint Task Force Middle East. The commander of this joint task force has "on-scene responsibility for all U.S. operations in the Persian Gulf, North Arabian Sea, and Gulf of Oman." The commander of this force reports directly to the Commander in Chief of Central Command (USCINCCENT) and his presence and that of his task force is intended to strengthen the command and control of the Central Command. [Ref. 31:pp. 36-41] The primary missions of USCENTCOM are:

- Ensuring the unimpeded flow of oil through the Strait of Hormuz;
- Supporting the right of free passage through other international straits;
- Promoting the security, stability and cooperation of the moderate states of the region; and
- Limiting the influence and presence of the Soviet Union. [Ref. 31:p. 36]

5. **The Specified Commands**

There are two specified commands-- the Strategic Air Command and the Forces Command.

a. Strategic Air Command (SAC)

Strategic Air Command was established in 1946 and is headquartered at Offutt Air Force Base, Nebraska. The simply stated mission of the Strategic Air Command is to provide the United States and her allies with a "nuclear shield of deterrence against aggression." The United States possesses a Triad of Strategic Forces which consists of sea launched ballistic missiles (SLBMs), intercontinental ballistic missiles (ICBMs), and long-range, manned bombers. The U.S. Navy maintains control over the SLBMs and the fleet ballistic missile submarines (SSBNs) which carry them. The Strategic Air Command controls the remaining two legs of the Triad. [Ref. 33:pp. 59-61]

The primary mission of SAC is to add to deterrence by providing "ready, flexible, and credible strategic offense forces." The command maintains more than 2,000 aircraft and 1,000 ICBMs for the accomplishment of its mission. The command supports a conventional mission by providing the capability for delivering conventional munitions via long-range bombers. Also of great importance are the command's missions of aerial refueling and strategic reconnaissance. [Ref. 33:pp. 61-63]

b. Forces Command (FORSCOM)

Another product of the Goldwater-Nichols DOD Reorganization Act was the designation of Forces Command as a specified command. FORSCOM was officially established in July 1987. Though extremely new, much of the organization and experience was readily attainable from the Army components of the U.S. Atlantic Command and the now defunct U.S. Readiness Command. [Ref. 34:p. 68]

Forces Command is the strategic land force reserve for the Free World. Among its many missions are the following:

- Provide a general reserve of combat-ready ground forces to reinforce other commands as directed;
- Plan for, and execute the land defense of the continental United States including military support of civil defense and protection of key assets;
- Plan for the land defense of Alaska (excluding the Aleutians); and
- Coordinate with Canadian Forces Mobile Command to plan for the combined land defense of Canada and the United States. [Ref. 34:p. 67]

E. JOINT COMMANDS AND COMBINED COMMANDS

Occasionally, some confusion arises with regard to the definition and use of the terms "joint command" and "combined command". Joint commands have been discussed in this thesis as the unified and specified commands-- that is, commands incorporating the forces of two or more services. A combined command is defined as a "force under a single commander that is composed of sizable assigned or attached elements of two or more allied nations." The command authority of combined commanders as well as the missions and responsibilities of the combined command are assigned to conform with the binational or multinational treaties, alliances, or agreements between or among the nations concerned. Examples of combined commands in existence today include the North American Aerospace Defense Command (NORAD), Combined Forces Command Korea (CFC), and the North Atlantic Treaty Organization (NATO). [Ref. 20:p.66]

F. SUMMARY

The Department of Defense is, in itself, an extremely complex organization. However, it is also part of an even larger structure which will be explored in greater depth in the next chapter-- the National Command Structure.

IV. U.S. NATIONAL COMMAND STRUCTURE

A. INTRODUCTION

The National Command Structure of the United States is undoubtedly the largest and most complex to be found in the Free World. It incorporates the people, data, and processes of dozens of widely diverse organizations and an accurate depiction of its entire structure is well beyond the scope of this text. However, there are various major components and systems of this structure whose study offers a good foundation on which to build a basic understanding of the complex processes and interrelationships that produce and support our National Command Structure. The intent of this chapter is to introduce the reader to those major components and systems.

B. NATIONAL COMMAND AUTHORITIES (NCA)

Perhaps the most important entity to understand within the national defense command structure is that of the National Command Authorities. The formal definition of the actual composition of the NCA is "the President and the Secretary of Defense or their duly deputized alternates or successors." [Ref. 7:p. 243] The term National Command Authorities signifies much more than that special relationship between the President and SECDEF. Its use represents the constitutionally guaranteed civilian authority of the President and the Secretary of Defense to direct the Armed Forces in the execution of military action. As directed by law, no one else or no other entity exists which has the authority to direct the movement of troops or the execution of any military action. [Ref. 20:p. 41] In other words, the ultimate authority with regard to command and control is the NCA. The relationships between the NCA, JCS, and the unified and specified combatant commanders is represented in Figure 5.

C. NATIONAL SECURITY COUNCIL (NSC) SYSTEM

1. Background

The National Security Council System was established by the National Security Act of 1947. The purpose of the NSC is to act as the principal forum for the consideration of national security issues which require Presidential decision. The NSC develops its national security policy based on the integration of domestic, foreign, and military policies as they relate to national security. The NSC possesses a statutory description as defined by Congress. However, built-in flexibility to the Council allows its composition, influence, and schedule of meetings to vary with each President or to conform to the needs of his administration. [Ref. 20:p. 102]

2. Organization

There are four statutory members of the NSC: the President, the Vice President, the Secretary of State, and the Secretary of Defense. The charter of the NSC also provides for statutory advisors. These positions are filled by the Chairman of the Joint Chiefs of Staff and the Director of Central Intelligence (DCI). [Ref. 20:p. 102] The Assistant to the President for National Security Affairs (the National Security Advisor), in consultation with the statutory members of the NSC, is responsible for the development, coordination, and implementation of national security policy as approved by the President as well as responsibility for the day-to-day operation of the Council. [Ref. 35:p. 21] All meetings of the NSC are attended by the statutory members and advisors as well as the National Security Advisor. [Ref. 20:p. 102] Further, the President may extend an invitation to attend NSC meetings to any other individual he believes should be present.

Another mechanism developed to work within the NSC to assist the individual members in the fulfillment of their responsibilities is that of the interagency group. These groups perform the following functions:

- Establish policy objectives;
- Develop policy options;
- Make appropriate recommendations;
- Consider the implications of agency programs for foreign policy or overall national security policy; and
- Undertake other activities as assigned by the NSC. [Ref. 35:p. 22]

Under the Reagan Administration, the following senior interagency groups (SIGs) recommended, coordinated, and monitored the implementation of national security policy: the National Security Planning Group (a senior committee of the NSC); the Senior Review Group (a cabinet-level interagency group); and the Policy Review Group (a senior sub-cabinet-level interagency group). Additionally, regional and functional interagency groups are sometimes used to supplement the primary SIGs. These are the Senior Interagency Group for Intelligence (SIG-I), the Senior Interagency Group for Foreign Policy Formulation (SIG-FP), and the Senior Interagency Group for Defense Policy Formulation (SIG-DP). [Ref. 20:pp. 102-103] The structure and use of the SIGs as well as the entire National Security Council System is dependent upon the needs of the President and his administration. President Bush may well redefine the NSC to suit the needs of his national security policy.

A simplified diagram of the U.S. Command Structure may be seen in Figure 6. [Ref. 36:p. 105] All of the major components in this diagram have been discussed thus far in the thesis. Another highly important aspect of the national command structure that remains to be discussed is the means by which these major components interact and make the command structure a working system.

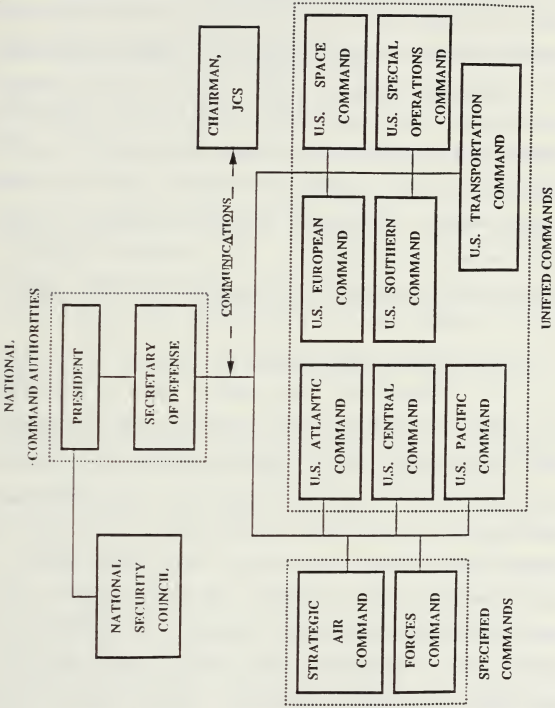


Figure 6.
Simplified U.S. Command Structure

D. WORLDWIDE MILITARY COMMAND AND CONTROL SYSTEM (WWMCCS)

1. Definition

WWMCCS is defined as "the system that provides the means for operational direction and technical administrative support involved in the function of command and control of U.S. military forces." [Ref. 24:p. 3-39] WWMCCS was created with the intent of serving as a "system of systems focusing on C^3 capabilities within the context of day-to-day operations, crisis management, theater war, and strategic nuclear war." The WWMCCS system was meant to unify the independent development of command, control, and communication systems by the military services. [Ref. 37:p. 55]

2. System Description

WWMCCS has the immense task of providing the NCA, DOD, and Joint Chiefs of Staff with the ability to plan, direct, and control the United States military forces the world over. To accomplish this task WWMCCS employs approximately sixty communication systems and thirty command centers spread around the world. This system works to link key government and military decision makers with the nation's command structure. Today, the stated mission of WWMCCS is the "command and control of globally-deployed U.S. military forces during peacetime, crisis, and all phases of a general war." [Ref. 38:p. 122] WWMCCS consists of:

- The National Military Command System (NMCS);
- The command and control systems of the unified and specified commands;
- The WWMCCS-related management/information systems of the headquarters of the military departments;
- The command and control systems of the headquarters of the service component commands; and
- The command and control support systems of DOD agencies. [Ref. 20:pp. 116-117]

In order to support the function of national-level command and control, WWMCCS incorporates these five basic elements:

- Warning systems: the tactical warning systems that notify operation command centers of the occurrence of a threatening event;
- WWMCCS communications: including the general-- and special-- purpose communication capabilities to convey information, hold conferences, and issue orders;
- Data collection and processing: the collection and handling of data to support information requirements of WWMCCS;
- Executive aids: WWMCCS-related documents, procedures, reporting structure, and system interaction that permit the user to connect with the system, enter data, and receive output records, forms, and displays; and
- WWMCCS command facilities: the primary or alternate command centers. [Ref. 20:p. 117]

Because WWMCCS is not a single system but a system of systems ranging from the national to the theater level, there is a mechanism for users of one system to communicate with users of other systems. This mechanism is the WWMCCS Intercomputer Network (WIN). Through this network users may communicate with other users, review and update data at other WWMCCS sites, and achieve accurate and rapid data transfer. WIN fulfills its functions through the use of a Telecommunications Network (TELNET), a File Transfer Service (FTS), and the WIN Teleconference (TLCF) System. [Ref. 20:pp. 118-120]

3. WWMCCS Information System (WIS)

The most visible aspect of the Worldwide Military Command and Control System and that which forms its backbone is its automatic data processing (ADP) equipment and supporting software. The critical nature of WWMCCS's missions and its requirement to process data and display information from around the globe in virtual real time necessitates continual upgrade and evolution of the entire system to enable it to handle both advances in technology and increasing demands placed upon it. The WWMCCS Information System is directed at correcting deficiencies in the WWMCCS system by replacing and improving obsolescent ADP equipment and software. [Ref. 38:p. 122] The WIS program is intended to support the command and control requirements of the NCA, combatant commanders, the JCS, and the Department of Defense by providing the following capabilities:

- Transmission of timely and accurate information on the status and location of forces and major resources;
- Speedy development and implementation of operation plans and options; and
- Formulation and transmission of direction to, and receipt and assessment of reports from appropriate commands and organizations. [Ref. 20:pp. 260-261]

E. NATIONAL MILITARY COMMAND SYSTEM (NMCS)

1. Definition

The highest level of command and control systems is the National Military Command System. [Ref. 39:p. 82] NMCS is the component of WWMCCS that supports the NCA in the exercise of their military command responsibilities. The system is defined as being "a responsive, reliable, and survivable system that relays the warning and intelligence that permits accurate and timely decisions." [Ref. 20:p. 120]

2. Description

Major subscribers of the NMCS include the National Military Command Center (NMCC), the Alternate National Military Command Center (ANMCC), the National Emergency Airborne Command Post (NEACP), and other command centers designated by the SECDEF. The NMCC, ANMCC, and NEACP will be discussed in Chapter V. NMCS also serves as a communication link between command centers and the combatant commanders, service headquarters, and other commands and agencies. [Ref. 20:pp. 120-121]

F. DEFENSE RESOURCES MANAGEMENT AND THE JOINT PLANNING PROCESS

1. Introduction

Today's world of tight fiscal constraints renders the management of defense resources a very important aspect of command and control. While seemingly very administrative in nature, resources management is closely tied to the operational capabilities of each of the services. Further, as the capability for "joint interoperability" becomes more and more important to military planners, the more tightly knit defence resources management and the joint planning process will become.

2. Planning, Programming, and Budgeting System (PPBS)

PPBS is a cyclic process containing the three interrelated phases of planning, programming, and budgeting. The process is intended to provide for decision making on future programs and to permit that prior decisions be examined and analyzed from the viewpoint of the current environment (theater, political, economic, technological, and resources). [Ref. 40:p. 3] In short, the PPBS produces a plan, a program, and a budget for the DOD. [Ref. 20:p. 103] There are three documents that are specific to the PPBS cycle and which directly effect other planning processes:

- POM (Program Objective Memorandum): The recommendations of the service secretaries and heads of DOD agencies to the SECDEF on proposed application of their portion of DOD appropriations;

- PDM (Program Decisions Memorandum): Contains Defense Resources Board decisions on the POMs that are distributed to the DOD components and the Office of Management and Budget as the basis for the Budget Estimate Submission; and

- DG (Defense Guidance): The SECDEF's guidance to the services and defense agencies on the development of their Program Objective Memorandum. [Ref. 20:pp. 332-333]

3. Joint Strategic Planning System (JSPS)

The JSPS is the official means by which the Chairman of the Joint Chiefs of Staff accomplishes the following tasks:

- Prepares strategic plans to conform to projected resource levels;
- Assists the President in giving strategic direction to the Armed Forces;
- Reviews service programs and conducts risk assessments;
- States the regional concerns of the combatant commands in terms of a global perspective;
- Sets guidance and apportions resources for contingency planning;
- Furnishes planning continuity for the strategic planning process; and
- Submits input to the PPBS. [Ref. 20:p. 103]

The JSPS utilizes the following six documents to accomplish its tasks:

- JSAM (Joint Security Assistance Memorandum): Contains views of the CJCS on funding levels projected for the U.S.-- financed Security Assistance Program, security assistance manning levels, development of Special Defense Acquisition Fund procurement and priorities, and key arms transfer policy matters.
- JPAM (Joint Program Assessment Memorandum): Gives views of the CJCS on the adequacy and capabilities of the total forces contained in the service Program Objective Memorandums (POMs) to execute the national military strategy and the risks inherent in those force capabilities.
- JSPD (Joint Strategic Planning Document): Contains the advice of the CJCS to the NCA and NSC on the military strategy and force structure required to attain U.S. national security objectives. It is the principal JCS input to the Defense Guidance (DG).

- JIEP (Joint Intelligence Estimate for Planning): Contains estimative intelligence on possible worldwide situations that would affect U.S. security interests in the short- and mid-range periods.

- IPSP (Intelligence Priorities for Strategic Planning): Contains a comprehensive statement of substantial military intelligence priorities to support the assignment of tasks to DOD intelligence production, collection, and support activities in the short- and mid-range periods.

- JSCP (Joint Strategic Capabilities Plan): Contains the military strategy to support the national security objectives and the derived military objectives. Gives guidance, based on projected military capabilities and conditions during the short-range period, and task assignments to the CINCs and Chiefs of the Services for accomplishment of military tasks. Apportions forces and lift assets available for planning. [Ref. 20:pp. 321-322]

The JSPS and the PPBS are interconnected systems which, together, provide the CINCs with the optimum mix of missions, forces, equipment, and support attainable within given fiscal constraints. The cycle created by these two systems lasts six years with a new cycle beginning every other year. [Ref. 20:p. 103]

4. Joint Operation Planning System (JOPS)

JOPS is the system used by the DOD to conduct joint planning during peacetime and in crisis. JOPS enables the Chairman of the Joint Chiefs of Staff to give strategic direction to the Armed Forces and also established procedures for the development, review, and execution of global and regional plans. The intent of JOPS is to enable its users to solve the "complex strategic mobility problem associated with force and support deployment and sustainment." [Ref. 20:p. 121]

The development of JOPS began in the 1960's in an attempt to unite the disparate computers, software programs, planning procedures, and documentation that had been developed by each service and command. Today, JOPS directive documentation is organized in the following volumes:

- JOPS Volume I (JCS Pub 5-02.1) "Deliberate Planning Procedures": Contains guidance and administrative procedures for developing, coordinating, disseminating, reviewing,and approving joint operation plans during peacetime.
- JOPS Volume II (JCS Pub 5-02.2) "Supplementary Planning Guidance": Gives directions, procedures, and planning guidance keyed to certain plan annexes, as well as formats for classified subjects.
- JOPS Volume III (JCS Pub 5-02.3) "ADP Support": Describes the WWMCCS system that supports the plan development phase of deliberate planning.
- JOPS Volume IV (JCS Pub 5-02.4) "Crisis Action Procedures": Outlines guidance and procedures for joint planning during emergency or time-sensitive situations. The procedures give guidance to the JCS, Services, CINCs, and defense agencies for developing timely recommendations to the NCA. [Ref. 20:pp. 121-122]

JOPS is closely entwined with the Planning, Programming, and Budgeting System as well as the Joint Strategic Planning System. The points of intersection between the three systems are depicted in Figure 7. [Ref. 20:p. 124]

5. Joint Deployment System (JDS)

Crisis action planning places many demands upon its participants. In rapid and accurate fashion the joint

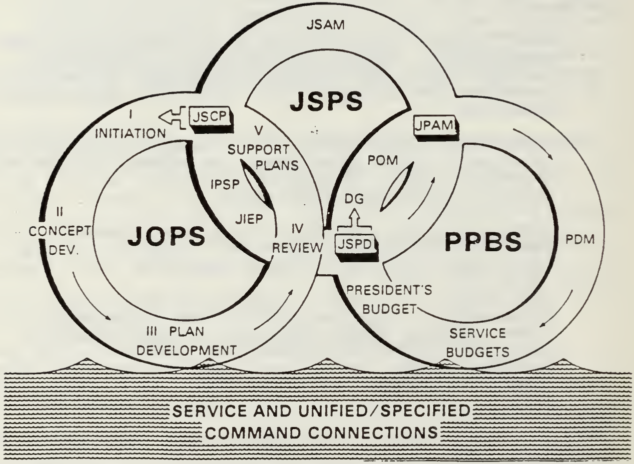


Figure 7.
Systems Relationships

planner must analyze the situation, develop courses of action (COAs), assess the adequacy of those courses of action, create the detailed plan, test the feasibility of the plan, and translate the plan into an operational order. JDS was developed to assist the crisis action planner in his duties. JDS is a "real-time, transaction-oriented, distributed database system" that manages the flow of deployment data. It is an integral part of the WWMCCS and interfaces with other C^2 systems. JDS fulfills not only deliberate planning functions, it serves to bridge the gap between deliberate planning and the formulation of crisis action procedures (CAPs). Through JDS, crisis action planners are able to:

- Simultaneously build, maintain, and manage exercise and real-- world deployment plans;
- Establish operational plans or courses of action from JOPS-- created deployment plans or force modules;
- Create a JOPS-formatted deployment plan from the JDS database;
- Add, change, or delete information by using computer terminals or automated system interfaces;
- Schedule or monitor deployments;
- Offer close-hold capabilities to develop operational plans;
- Automatically alert units and installations of scheduled deployments;
- Monitor ongoing system performance;
- Integrate force module capabilities; and
- Improve the timeliness and accuracy of deployment information.

JDS is refined, administered, and operated by the U.S. Transportation Command. A schematic representation of the relationship between JDS and JOPS may be seen in Figure 8. [Ref. 20:pp. 238-241]

6. Joint Operation Planning and Execution System (JOPES)

Despite the positive aspects of the Joint Operation Planning System and the Joint Deployment System, the fact remains that two separate systems exist to accomplish war planning and execution. Two new systems were introduced to correct interface problems between JOPS and JDS. One of these programs is the WWMCCS Information System (WIS) which has already been described. The second program is the Joint Operation Planning and Execution System or JOPES. [Ref. 20:p. 251]

JOPES will replace JOPS and JDS. It will be an integrated C^2 system designed to satisfy the information needs of senior-level decision makers in conducting joint planning and operations. JOPES will monitor, plan, and execute mobilization, deployment, employment, and sustainment activities for national, theater, and supporting echelons in time of peace and war. JOPES will not have the ability to execute actions on its own but, rather, will serve as a means of providing decision makers with the ability to monitor, analyze, and control events during execution. The JOPES concept is based on seven interrelated functions. These are:

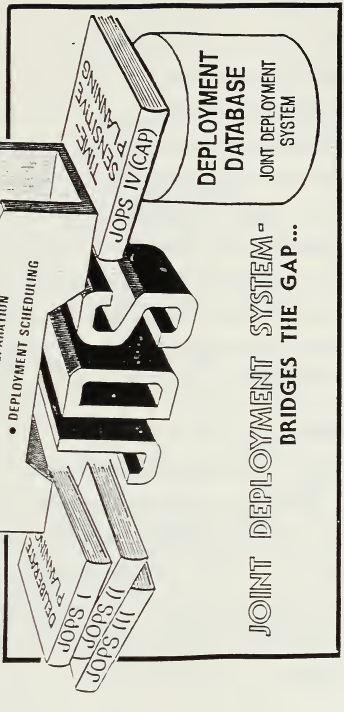


Figure 8.
JDS/JOPS Relationships

- Monitoring;
- Threat identification and assessment;
- Strategy determination;
- Course of action development;
- Execution planning;
- Implementation; and
- Simulation and analysis.

A diagram of these functions is shown in Figure 9. [Ref. 20:p. 254] The development of JOPES will be evolutionary, each increase in capability to be accompanied by a supporting block of ADP development by WIS. JOPES will provide the identification and analysis of force requirements and capabilities to both JSPS and PPBS. [Ref. 20:pp. 251-256]

G. SUMMARY

Now that the major components of the Department of Defense and the National Command Structure have been presented and explored, specific command and control structures will now be presented and analyzed. The largest and most complex of these structures is that which is found in the strategic nuclear command and control system of the United States.

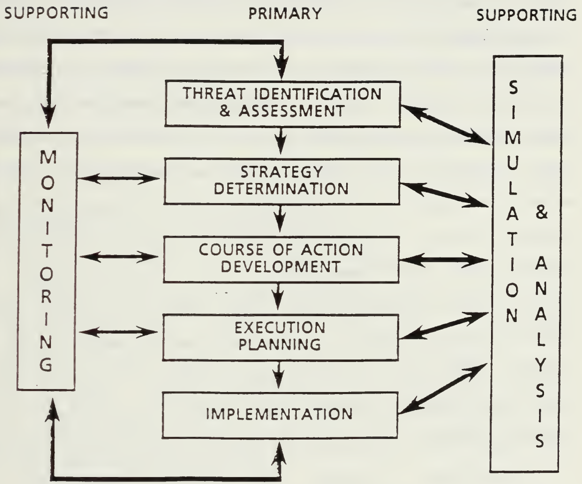


Figure 9.
JOPES Functions

V. STRATEGIC NUCLEAR COMMAND AND CONTROL

A. INTRODUCTION

Nowhere are C^2 requirements more demanding than they are in the realm of strategic nuclear command and control. The purpose of the strategic nuclear C^2 system sounds simple enough -- the detection of incoming attacks, the ability to provide direction to the Armed Forces, and the ability to carry out battle management during prolonged confrontations. Each of these tasks, however, involves requirements that are seemingly impossible to satisfy. Sea launched ballistic missile (SLBM) firings from off the coast of the United States can reach Washington, D.C. within minutes. The detection of incoming attacks must therefore be made swiftly and accurately. Also, provisions must be made so that some sort of command structure remains intact to provide the NCA with the means to direct their forces. This task implies survivability-- an extremely costly and difficult attribute to guarantee. Lastly, for battle management to be sustained, the strategic nuclear command structure must be such that it is easily and quickly reconstituted. In the ravaged environment left by nuclear exchange, this task may be the most difficult to accomplish.

Today it is generally acknowledged that a homeland to homeland exchange of nuclear weapons with the Soviet Union is an improbable scenario and therefore, the strategic nuclear C^2 system may seem superfluous. This C^2 structure is better understood if viewed as having both peacetime and wartime functions. Its function during war is obvious. Its function during peacetime is more subtle. The existence of a quick, accurate, survivable, and reconstitutable strategic nuclear command and control system adds great credibility to the nation's current strategic nuclear policy of "deterrence through guaranteed reprisal." [Ref. 38:p. 113] A simplified depiction of the U.S. strategic command and control structure may be seen in Figure 10. [Ref. 41:p. 2]

B. EVOLUTION OF U.S. STRATEGIC POLICY

Since the advent of nuclear weapons our nation's strategic policy has been shaped by presidential administrations, the warmth or coolness of U.S./USSR relations, and the status of relations with other nuclear capable nations. Study of the changing strategic policies tells an interesting story of the role that nuclear weapons play with our nation's military.

1. Mutual Deterrence or Massive Retaliation

This strategic policy was born during the Eisenhower Administration. The world retained quite a bit of naivete about this new weapon. This form of strategic policy was based on the following logic:

> Because it is usually assumed that neither side can disarm the opponent, choosing to attack risks nuclear retaliation; attack would thus be irrational and both

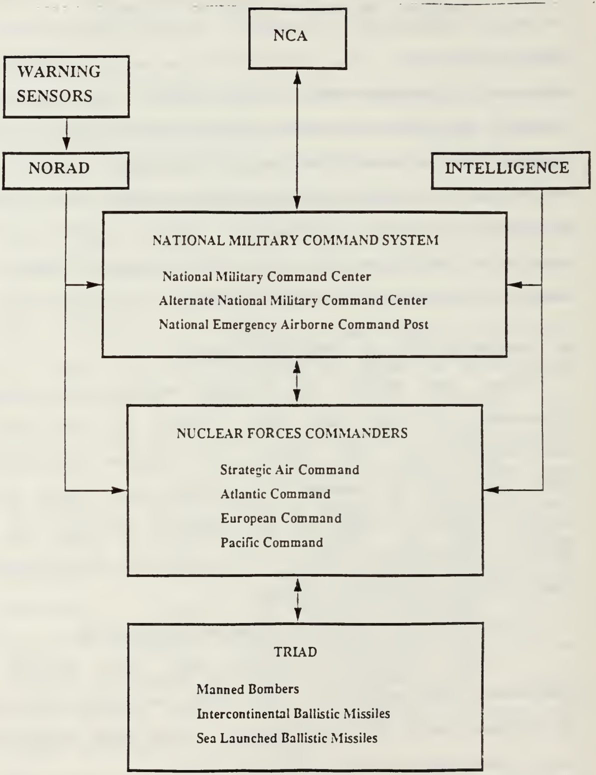


Figure 10.
U.S. Strategic Command and Control Structure

> sides are deterred. Nuclear stalemate exists despite the possibility that an aggressor might expect to destroy a large part of the opponent's forces and substantially weaken his resolve. Unless the probability of retaliation is vanishingly small, the expected costs of a first strike will always outweigh the benefits. [Ref. 42:p. 16]

Later the issue of survivability was taken into account. Victory, as defined by the policy of mutual deterrence, could be achieved only with obliteration of all the enemy's nuclear capabilities. By the early 1960's, the Kennedy and then the Johnson Administrations determined that "assurance of obliteration could no longer be provided" and that "under the technological conditions of the times, there were reasons to believe it would remain out of reach forever." [Ref. 42:p. 18]

2. Mutually Assured Destruction

Under this policy one finds a quantification of the desirable amount of destruction to be achieved with nuclear retaliation after a Soviet first strike. This policy called for U.S. strategic nuclear forces to be able to destroy 20 to 25 percent of the Soviet population and 50 percent of the Soviet industrial complex. [Ref. 42:p. 21]

The late 1960's saw the beginning of the shift away from thoughts of homeland-to-homeland nuclear exchange with the Soviet Union. The formulation began of a new policy that would allow the nation to assume a "flexible posture based on the forces, the plans, and the control arrangements to execute, as necessary, a sequence of two distinct types of nuclear operations." The emphasis of this new policy would be on central Europe should the "direct defense of NATO territory with conventional forces fail to repel enemy invaders." The two types of nuclear war now being planned for were escalation to local use of nuclear weapons and, if necessary, resorting to general nuclear war. [Ref. 42:p. 22]

3. Flexible Response

There is speculation that the unpopularity of the Vietnam War forced the Nixon as well as the Ford Administrations to shy away from stances that might be perceived to be excessively pro-military. Whatever the reason, the fact remains that the years of the Nixon and Ford Administrations saw "the most substantial reduction in American military capabilities relative to those of the Soviet Union in the entire postwar period." During this period command and control systems became severely neglected. [Ref. 43:p. 320]

Also during this period came the discovery of a paradox concerning the two previous strategic policies. This paradox was that "if strategic deterrence based on the threat of unrestrained retaliation fails, then it would not be rational actually to carry out the threat." Flexible Response made its appearance in the mid 1970's at the end of the Nixon Administration and was upheld throughout that of President Ford. Under this new policy a failure of deterrence did not automatically lead to general nuclear war. It was an important policy in that it extended deterrence into the war itself and provided "distinguishable firebreaks" between levels of intercontinental nuclear warfare. [Ref. 42:p. 23, Ref. 43:pp. 352-353]

4. Countervailing Strategy and Survivability

This policy was developed during the Carter Administration and was further refined by the Reagan Administration. In the late 1970's the need for survivability was recognized in earnest. Countervailing Strategy reflects this stating that the United States must be able to "absorb the enemy's maximum attack and still be able to destroy a specified percentage of Soviet economic, political, and military resources." Under the Reagan Administration, the policy was modified to reflect budgetary constraints as well as operational needs. Emphasis was placed on "controlled attacks" on specified targets to include enemy missiles in hardened silos. [Ref. 42:p. 26]

The emphasis on survivability shed new light on the issue of command and control. Countervailing Strategy called for the nation's C^2 assets to be able to provide the following:

- Connectivity between the National Command Authorities and strategic and other appropriate forces to support flexible execution of retaliatory strikes during and after an enemy nuclear attack; and
- Responsive support for operational control of the Armed Forces, even during protracted nuclear conflict. [Ref. 44:p. 1]

Survivability in terms of command and control had come to demand the early detection of incoming attacks and the ability to ride out the first attack and restore command and control of surviving strategic nuclear forces in the aftermath. In short, C^2 must provide the means to detect, assess, and react.

Before beginning a detailed discussion of the detection, assessment, and reaction mechanisms one must first have some knowledge of the Single Integrated Operational Plan (SIOP) and the North American Aerospace Defense (NORAD) Command.

C. SINGLE INTEGRATED OPERATIONAL PLAN (SIOP)

U.S. strategic nuclear capabilities are described in terms of the Strategic Triad, each leg of the Triad being composed of a different weapon system. These systems are sea launched ballistic missiles, intercontinental ballistic missiles, and long-range manned bombers. [Ref. 33:p. 59] The concept of the Triad was briefly discussed in Chapter III. In order to unify the control of these forces under one plan, the Single Integrated Operational Plan was developed.

The most recent version of the SIOP is SIOP-6 which came into effect on 1 October 1983. Input to the SIOP is given by the NCA, NSC, Office of the Secretary of Defense (OSD), and Office of the Joint Chiefs of Staff (OJCS) but the actual construction of the SIOP comes under the cognizance of the Joint Strategic Target Planning Staff (JSTPS) located at SAC headquarters, Offutt AFB, Nebraska. [Ref. 45]

The SIOP is, understandably, a highly classified plan. However, unclassified guidance on its basic structure is available. The SIOP has undergone frequent yet subtle changes since its beginning. SIOP-6 reportedly states "extremely comprehensive" U.S. target plans for strategic nuclear war. The SIOP specifies four principal target groups:

- Soviet nuclear forces;
- Soviet general purpose forces;
- Soviet military and political leadership centers; and
- Soviet economic and industrial bases.

The SIOP is further divided into four "general categories of options available for the employment of nuclear weapons." These are:

- Major Attack Options (MAOs);
- Selective Attack Options (SAOs);
- Limited Nuclear Options (LNOs); and
- Regional Nuclear Options (RNOs).

LNOs are designed so as to permit "the selective destruction of fixed enemy military or industrial targets." RNOs are intended to "destroy the leading elements of an attacking force." [Ref. 45]

D. THE NORTH AMERICAN AEROSPACE DEFENSE (NORAD) COMMAND

NORAD is located behind 25-ton blast doors deep within Colorado's Cheyenne Mountain. The command is housed in 15 steel buildings mounted on spring shock absorbers and stocked with a 30 day supply of food and water for its personnel. The missions of NORAD are defined by agreements between the United States and Canada. Specifically, NORAD is responsible for "surveillance and control of North American airspace, for providing warning and assessment of attack, and for defending the continent against attack." NORAD is responsible for the initial coordination of the detection, assessment, and reaction mechanisms that make up the Strategic Command and Control System. Of these functions, NORAD's mission of warning and assessment is considered to be the most critical. The mission of attack warning entails the determination that an air attack on the North American continent is taking place. The mission of attack assessment involves the identification of the types of threats involved, the threat origin, and probable targets. The Commander in Chief of NORAD (CINCNORAD) is responsible for making such assessments. To do so he draws on several resources:

- A general base of information about Soviet weapon capabilities and locations;
- Inputs from U.S. intelligence agencies about the current strategic situation; and
- Data from infrared, optical, and radar sensors located around the world and in orbit.

Once made, CINCNORAD's assessment is relayed to the NCA. [Ref. 38:pp. 53-59]

E. DETECTION

The first mission of strategic command and control is the detection of threats to the U.S. homeland. One type of threat is that which is perceived by U.S. military planners due to a deteriorating international picture. U.S. response in such a case would no doubt involve stepped-up readiness postures for the Armed Forces at the very least. Another type of threat involves a surprise nuclear attack, presumably by Soviet forces. It is for this surprise attack that our warning sensors must be geared though the possibility of such an attack is currently thought to be small. The impressive Soviet nuclear arsenal and the close range at which Soviet ballistic missile submarines patrol the coast of the U.S. mandates that accurate and reliable sensors be active at all times to minimize the level of surprise.

1. Missile Warning Systems

The consequences of faulty detection and assessment of a Soviet attack may be catastrophic. To ensure that no such mistakes are made, U.S. strategic nuclear policy requires conformance with a policy called "dual phenomenology." This is a formal Department of Defense policy which requires "two independent means and systems to detect and verify nuclear attacks. The second source would serve to verify warning information about the first." [Ref. 41:p. 43] The concepts of dual phenomenology apply to all nuclear launch policies of the United States.

a. Defense Support Program (DSP) Early Warning Satellites

The DSP is the element of U.S. strategic surveillance which is designed to provide the earliest possible detection of ballistic missile launch. DSP began development in the late 1960's and became operational in 1973. The system today consists of three satellites in geosynchronous orbits over South America, the central Pacific and the Indian Ocean. DSP satellites are configured so that they can detect SLBM launches from the Atlantic or the Pacific and ICBM launches from the Soviet Union. DSP satellites at their 22,000 mile orbital altitude are considered to be fairly safe from Soviet antisatellite (ASAT) weapons. Connectivity from DSP to the NCA is dependent upon highly vulnerable ground communication lines and overseas downlink facilities. Intelligence collected by DSP is relayed to the NCA via NORAD. It should be noted that while no specific replacement for the DSP is currently under consideration, the next-generation detection system could be born of Strategic Defense Initiative (SDI) Research. [Ref. 37:p. 65]

b. The Ballistic Missile Early Warning System

Ballistic Missile Early Warning System (BMEWS) has been in operation since 1962 and, since its beginnings, has served as one of North America's primary alert mechanisms against airborne attack. The original system has undergone frequent upgrades and currently consists of three radar sites at Clear, Alaska; Thule, Greenland; and Fylingdales Moor, England. These three sites provide detection and tracking from the northern approaches. Data is transmitted to NORAD headquarters at the Cheyenne Mountain Complex (CMC) and SAC headquarters. [Ref. 41:pp. 107-108] The areas of BMEWS coverage may be seen in Figure 11. [Ref. 46:p. 312]

Future planned modifications for the BMEWS include the installation of a two-faced 240-degree azimuth radar at Thule, and a 260-degree three-sided radar at Fylingdales Moor. These modifications will greatly augment the ability of BMEWS to track an attack by multiple independently targetable reentry vehicles (MIRVs). [Ref. 41:p. 108]

c. Cobra Dane

The Cobra Dane system consists of an immense phased-array radar located on the island of Shemya in the Aleutian chain. The radar has been in operation since 1977 and was specifically designed for the tracking of ICBMs, SLBMs, and satellites. Cobra Dane serves as a back-up for

1. PARCS
2. BMEWS (Clear)
3. BMEWS (Thule)
4. BMEWS (Fylingdales)
5. PAVE PAWS (Beale)
6. PAVE PAWS (Goodfellow)
7. PAVE PAWS (Cape Cod)
8. PAVE PAWS (Robins)

Figure 11.
Detection Sweeps

the BMEWS system and is capable of providing NORAD with information on 200 target tracks. [Ref. 38:p. 59]

d. Pave Paws

The Pave Paws system consists of phased-array radars located on the borders of the continental United States which "detect, track, and provide early-warning and attack characterization" of SLBMs. Warning and attack data from the Pave Paws system is relayed to NORAD, SAC headquarters, and the NCA via WWMCCS. There are four operational Pave Paws sites. These are located at Beale AFB, California; Otis Air National Guard Base, Cape Cod, Massachusetts; Robins AFB, Georgia; and Goodfellow AFB, Texas. [Ref. 46] The area of coverage of Pave Paws is depicted in Figure 11. [Ref. 45:p. 312] As a secondary mission, Pave Paws provides track orbit data of space objects for NORAD.

e. Perimeter Acquisition Radar Characterization System (PARCS)

PARCS operates as a back-up to BMEWS for ICBM attacks as well as offers limited coverage of SLBM attacks from near-arctic areas. PARCS is located in Cavalier, North Dakota and is composed of one single-sided phased-array radar. [Ref. 38:p. 104] Its capability for distant early earning is far outdistanced by the long-range BMEWS and Pave Paws systems. However, PARCS fulfills a vital function in its role as an attack characterization sensor. It is able to track hundreds of MIRVs and predict impact points to within several thousand feet. Data from PARCS is relayed to NORAD and includes raid count, impact profile, and target class summary which is defined as the number of weapons expected to land on cities, missile fields, bomber or tanker airfields, C^2 centers, and Washington, D.C. [Ref. 42:p. 224] The area of detection coverage of PARCS is depicted in Figure 11. [Ref. 45:p. 312]

2. Air-Breathing Attack Warning Systems

The air-breathing threat consists of manned bomber aircraft, air-to-surface missiles, and cruise missiles. Recently this threat has received greater attention due to the offensive potential of the Soviet Union's supersonic Backfire and Blackjack penetrating bombers, both of which can be loaded with nuclear-capable air-to-surface missiles. After years of neglect due to preoccupation with ICBMs and SLBMs, the air-breathing threat warning systems are being thoroughly upgraded to provide a viable detection system. [Ref. 38:pp. 99-100]

a. Over-the-Horizon Backscatter (OTH-B) Radar

The mission of OTH-B is to provide long-range detection and early warning of air-breathing threats to the continental United States. OTH-B is capable of detecting objects flying at very low altitudes. OTH-B works in the high frequency (HF) band. Its signal is refracted off the ionosphere and is capable of traveling well beyond the horizon to distances of approximately 1,800 nautical miles. [Ref. 37:p. 81]

The OTH-B system currently consists of one operational site located in Maine. Further sites (the East, West, North-Central, and Alaskan OTH-B radars) are scheduled to be operational in the early 1990's. The total system will provide long-range surveillance of all but the polar air approaches. This gap in coverage is due to the adverse affect of the aurora borealis on OTH-B technology. However, OTH-B is used in conjunction with other systems to provide complete coverage. [Ref. 37:p. 82]

b. North Warning System (NWS)

NWS is the means by which full air coverage is obtained of the northern air approaches. NWS is the stop-gap system to OTH-B's "hole" at the north pole. The primary component of NWS is the North Warning Radar. The North Warning Radar is the extensive update to the antiquated Distant Early Warning (DEW) System, a line of radars strung across the northern reaches of North America. The 31 DEW radars are to be replaced with 52 newer and better radars. Thirteen of the radars will be long-range, manned radar systems. The remaining 39 will be "short-range, unattended gap-filler type radars." The system is expected to be fully operational by the early 1990's. [Ref. 38:pp. 106-107]

c. Airborne Warning and Control System (AWACS)

The detection systems discussed thus far represent our nation's primary means of detection of airborne and spaceborne threats. However, they are not without their limitations. All systems are non-mobile and must be considered to be vulnerable and non-survivable. And, as stated earlier, DSP is dependent upon vulnerable ground communications and overseas stations. The mission of AWACS is to provide a survivable airborne surveillance post for air defense early warning. AWACS has a secondary C^2 mission of serving as a flying command, control, and communication center for the direction of tactical aircraft. [Ref. 38:p. 82]

AWACS has been operational since 1977. The electronics and data processing suite is housed in a Boeing 707 commercial jet airframe. AWACS is capable of detecting airborne targets from distances as great as 350 miles, over both land and water, and at all altitudes. As a highly survivable system, AWACS can be used in a strategic defense role by "providing detection, identification, tracking and warning functions, and by using its command and control features to help intercept the attack." [Ref. 38:p. 83]

F. ATTACK ASSESSMENT AND REACTION

SLBMs launched from Soviet Yankee-class submarines patrolling in the Atlantic Ocean and Caribbean Sea are capable of reaching Washington, D.C. within five to seven minutes. Inland targets (SAC headquarters, missile fields, etc.) would be within reach of these SLBMs in less than 15 minutes. Intercontinental ballistic missiles launched from Soviet missile fields would reach their intended targets between 25 to 30 minutes after launch. Clearly, rapid detection of an incoming air attack is necessary to allow any time at all for attack assessment and reaction. An attack by SLBMs probably will not allow for safe relocation of the NCA. The National Military Command Center (NMCC) is the operational nerve center for the command and control of U.S. military forces on a day-to-day basis. Located within the Pentagon, the NMCC will not survive a direct attack. The Alternate National Military Command Center (ANMCC) is a hardened, underground facility located near Fort Ritchie, Maryland and it, too, will not survive a direct attack. Even NORAD is incapable of surviving direct hits by the Soviet Union's highly accurate SS-18 ICBMs. While the Soviets build deep underground command facilities in which to ride out nuclear attacks, the United States operates on the principle that "anything that can be found can be destroyed." [Ref. 47:p. 125] The survival of command and control, therefore, has been placed in the hands of highly mobile command posts.

1. National Emergency Airborne Command Post (NEACP)

There are three command centers of the National Military Command System (NMCS) which directly support the

NCA and the Joint Chiefs of Staff. The primary and alternate command centers have already been mentioned. The third command center is the National Emergency Airborne Command Post or NEACP. NEACP was designed to be a survivable command and control platform to enable the NCA to direct retaliatory forces during and following an attack against the United States. The survivability of NEACP increases the probability that the NCA will exist to be able to direct the execution of the SIOP and wage nuclear war against the attacker. [Ref. 38:p. 113]

The NEACP platform is the E-4B aircraft, a derivative of the commercial Boeing 747 jet. The NEACP system is comprised of four fully operational aircraft. NEACP is managed by the Strategic Air Command and the aircraft are based at Grissom AFB, Indiana. Each aircraft carries a communication suite which is capable of linking with military assets ranging from submarines to satellites. Further, NEACP is considered to be the key component of the Minimum Essential Emergency Communications Network or MEECN. This network makes up the core of the WWMCCS system and consists of an assortment of strategic command and control systems which are intended to provide survivable connectivity between the NCA and U.S. Armed Forces around the globe. [Ref. 38:pp. 113-116]

2. Post Attack Command and Control System (PACCS)

PACCS, like NEACP, belongs to the Strategic Air Command. The mission of this system is to serve as an airborne strategic command and control network to be used to control SAC bombers and ICBM forces in the "event that its underground command centers, alternate command posts, or ground-based communications are destroyed." Whereas NEACP is the survivable backup to be used by the NCA to direct the full range of U.S. strategic forces, PACCS possesses the more specific mission of providing C^2 for SAC's nuclear assets. [Ref. 38:p. 117] The air platform for PACCS is the EC-135 aircraft and the entire system is composed of several components:

- SAC Airborne Command Post (code name "Looking Glass");
- East Auxiliary Command Post;
- West Auxiliary Command Post;
- Three Airborne Launch Control Centers; and
- Two Radio Relay Aircraft. [Ref. 38:p. 117]

a. Looking Glass

The mission of Looking Glass is to provide survivable connectivity between the NCA and the SIOP forces. In order to preclude command and control decapitation from a surprise Soviet first strike, a Looking Glass aircraft has been on continual 24-hour airborne alert status since 1961. The Looking Glass aircraft are based at Offutt AFB, Nebraska. [Ref. 38:p. 118]

b. East and West Auxiliary Command Post

These aircraft are back-ups to the Looking Glass aircraft and are utilized in the event of incapacitation of Looking Glass or when otherwise directed by the NCA. The East Auxiliary Command Post is colocated with Looking Glass at Offutt AFB. The West Auxiliary Command Post is located at Ellsworth AFB, South Dakota. [Ref. 46:p. 178]

c. Airborne Launch Control Centers

The mission of these aircraft are to provide a capability for ICBM launch in the event that the underground launch control centers become incapacitated. These three aircraft are based at Ellsworth AFB, South Dakota. [Ref. 46:p. 178]

d. Radio Relay Aircraft

These two aircraft are stationed at Grissom AFB, Indiana. Their mission is to provide an alternative means of maintaining strategic connectivity between NEACP and all PACCS aircraft. [Ref. 46:p. 179]

e. ICBM Launch Mechanisms

The battlestaffs aboard Looking Glass, the East and West Auxiliary Command Posts, and the three Airborne Launch Control Centers all possess the capability to launch Minuteman missiles. The order to launch the ICBMs can be given only after receipt of authorization from the NCA via authenticated Emergency Action Messages (EAMs).

EAMs are the means by which nuclear launch orders are dispersed to any nuclear capable platform. The EAMs are pre-formatted and encoded and originate only with the National Command Authorities. EAMs and their supporting documentation (decoding documents, procedures, etc.) are highly sensitive. Two-man control is required for the decoding of the EAMs as well as for the launch of any missile.

The key component of the airborne launch control system is the Looking Glass aircraft. The Looking Glass aircraft possesses four primary means of ensuring missile launch following the receipt of an authenticated EAM. First, Looking Glass may transmit the EAMs to the underground launch facilities itself. Secondly, Looking Glass may direct the Airborne Launch Control Centers to launch their assigned missiles. Third, in case of a communication failure, Looking Glass can fire the Minuteman missiles on its own by transmitting coded Ultra High Frequency (UHF) signals to a receiving antenna installed next to each silo. Finally, Looking Glass may cause the launch of the Emergency Rocket Communications System (ERCS). [Ref. 47:pp. 149-150] ERCS consists of a group of Minuteman missiles located at Whiteman AFB, Missouri. These missiles carry a UHF communication package in place of warheads. ERCS missiles are launched into suborbital trajectories of approximately 30 minutes duration during which time these missiles continually transmit recorded launch orders. [Ref. 38:pp. 117-118] All PACCS aircraft are components of MEECN. [Ref. 38:p. 118]

3. Worldwide Airborne Command Post (WWABNCP)

A variation of the EC-135 aircraft is the Worldwide Airborne Command Post or WWABNCP. WWABNCP is used by the nuclear force commanders: the Commanders in Chief of the Atlantic, Pacific, and European Commands. The aircraft has a mission of providing strategic command and control platforms for these commands as well as serving as a platform for tactical command and control missions. The WWABNCP aircraft is a component of MEECN. [Ref. 38:p. 118]

4. TACAMO Strategic Submarine Communication System

The mission of TACAMO (Take Charge and Move Out) is to serve as the strategic airborne radio relay between the NCA and deployed ballistic missile submarines (SSBNs). TACAMO aircraft are kept on continuous 24-hour patrol over the Atlantic and Pacific Oceans to increase the probability that EAMs will be received by the submarines during and following a strategic attack against the United States. [Ref. 38:p. 89]

EC-130s currently make-up the TACAMO fleet. The U.S. Navy is replacing this fleet with the E-6A aircraft, a derivative of the Boeing E-3A (707) airframe. The complete transition to the E-6A is expected to occur in the 1990's. TACAMO uses Very Low Frequency (VLF) signals to communicate with the SSBNs. TACAMO is also one of the surviving elements of MEECN. [Ref. 37:pp. 73-75]

The TACAMO system is considered to be extremely survivable and reliable. No systems are expected to replace TACAMO for many years. However, a few new systems have been identified which may improve the connectivity to and from the TACAMO system. Systems of this nature which are likely to generate future interest are the Extremely Low Frequency (ELF) Submarine Communication System [Ref. 38:p. 86], an Extremely High Frequency (EHF) satellite system (Milstar) [Ref. 37:p. 75], and a possible blue-green laser satellite communication system. [Ref. 37:p. 144]

G. STRATEGIC COMMUNICATIONS

Strategic communications and the survivability of strategic communications is perhaps the most important aspect of strategic nuclear command and control. Failure of strategic communications might mean that warning data is not received by NORAD, or that attack assessments are not received by the NCA, or that EAMs are not received by the strategic nuclear forces.

The complete make-up of the strategic communication system is complex and immense and well beyond the scope of this thesis. However, students of command and control should have some knowledge of a few of the larger components of the system.

1. The Defense Satellite Communications System (DSCS)

The backbone of DOD communications is the Defense Satellite Communications System or DSCS. The latest generation of this system is DSCS III. The complete program calls for four operational satellites in synchronous orbit and two on-orbit spares. The satellites provide "high-capacity, long-haul superhigh frequency (SHF)(7 to 8 GHz) satellite communications for all U.S. services and some allies." [Ref. 37:pp. 63-64]

2. Military Strategic/Tactical and Relay System (Milstar)

A follow-on system to DSCS is already designed-- the Military Strategic/Tactical and Relay System or Milstar. This satellite system will be used "to control both strategic and tactical forces and to relay intelligence information from satellites and other sources." [Ref. 37:p. 61]

Due to the inherent vulnerability of satellites to ASAT weapons and electronic countermeasures, Milstar has been designed from the beginning to be able to continue fulfillment of its functions even in the environment of all-out war. Milstar will be able to provide communication support for AWACS, NEACP, Pave Paws, TACAMO, SSBNs, SAC bombers, and many more subscribers. Milstar is expected to reach initial operational capability in the early 1990's. [Ref. 37: pp. 61-62]

3. Ground Wave Emergency Network (GWEN)

A primary concern of command and control is the survivability of our strategic communications. The current primary means for strategic communications is the DSCS III and, eventually, Milstar. However, the nation's only satellite launch facilities-- Cape Kennedy, Florida and Vandenburg AFB, California-- are located on the coasts and are vulnerable to airborne attack. Further, Soviet antisatellite (ASAT) technology places at risk our overhead platforms. The need for an alternate means of strategic communications was recognized and gave rise to the Ground Wave Emergency Network or GWEN.

GWEN is a "ground-based strategic communication system consisting of a large number of EMP-hardened low frequency unmanned radio relay stations deployed across the continental United States." GWEN's mission is to provide a survivable long-range strategic C^2 system which links the NCA with strategic command centers and SIOP forces. GWEN is a highly redundant system that utilizes packet switching techniques which permit rapid reconstitution of connectivity despite heavy damage. The entire GWEN system may involve nearly 400 relay nodes and is expected to be ready for operations by 1990. Once operational, GWEN will be a vital component of MEECN. [Ref. 38:p. 85]

Students interested in a more in-depth analysis and description of U.S. strategic nuclear command and control should refer to Reference 48.

H. SUMMARY

Strategic nuclear command and control is critical for the reason that its failure might mean undetected and, possibly, unanswered nuclear strikes against the United States. Today, with the general perception that the chances of homeland to homeland nuclear exchange are remote, the study of command and control with regard to tactical warfare doctrine takes on added importance and will be discussed in Chapter VI.

VI. SERVICE DOCTRINE AND TACTICAL C^2

A. INTRODUCTION

A fundamental understanding of the warfighting doctrines of each of the Armed Forces will significantly enhance future endeavors to unite the services in joint operations. Because the area of command and control crosses all service boundaries and ensures the opportunity for successful joint operations, it is the biggest problem facing the DOD in its attempt to obtain complete interoperability. This chapter provides an introduction to the warfighting doctrines of services, and presents an example of the tactical warfare command and control structure of each service including: Army, Air Force, Navy, Marine Corps, and Coast Guard. To reach our ultimate goal of true "jointness" among the services, military leaders must have a basic understanding of each service's warfighting doctrine.

B. DOCTRINE

As always, terminology is our foremost problem in discussing service doctrine. "A common word may have different meanings to each service." [Ref. 49:p. 29] This is even more prevalent among our allies. It is important not to "interject your service perspective into the reading of other service's doctrine." [Ref. 49:p. 29] Let us again refer to JCS Pub 1 for standardized definitions of DOD terminology.

> Doctrine-- Fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgement in application. [Ref. 7:p. 118]

In essence, doctrine represents our beliefs in how we should employ our military forces. There are three types of doctrines: service, joint, and combined. The only distinction between each type is the actual participants who support the specified doctrine.

> Service doctrine is binding only upon that service, while joint and combined doctrines are binding upon all the services that agreed to it. Joint doctrine is doctrine between two or more services, while combined doctrine is between two or more nations. [Ref. 49:p. 30]

Although it is recommended, service doctrines do not have to be aligned with joint or combined doctrines. However, it is expected that "when a service employs forces in a joint or combined operation, it must be in line with the accepted joint and combined doctrines." [Ref. 49:p. 30] General Curtis E. Lemay, former Chief of Staff of the Air Force, described doctrine in this way:

> At the very heart of warfare lies doctrine. It represents the central beliefs for waging war in order to achieve victory. Doctrine is of the mind, a network of faith and knowledge reinforced by experience which lays the pattern for the utilization of men, equipment, and tactics. It is the building material for strategy. It is fundamental to sound judgement. [Ref. 50:p. i]

C. PRINCIPLES OF WAR

The principles of war play a significant role in the doctrines of the military forces of many countries. The principles vary from country to country dependent on the each country's history and experiences. "The principles of war represent generally accepted major truths which have proved successful in the art and science of conducting war." [Ref. 3:p. 2-4] The Army and Air Force warfighting doctrines are born out of the principles of war. The doctrines provide "naturally accepted and officially sanctioned guidelines to the application of these principles in warfare." [Ref. 3:p. 2-5]

The order of importance among the principles will vary based on the conflict or situation in which they are applied [Ref. 3:p. 2-5]. The nine principles of war described here are taken from Army Field Manual 100-1, which "expresses the fundamental roles, principles, and precepts" of the U. S. Army. Although the descriptions vary slightly from those in the Air Force doctrinal manual, AFM 1-1, the principles are essentially the same.

- OBJECTIVE-- Every military operation should be directed towards a clearly defined, decisive, and attainable objective. The ultimate military objective of war is the defeat of the enemy's Armed Forces. Correspondingly, each operation must contribute to the ultimate objective. Intermediate objectives must directly, quickly, and economically contribute to the purpose of the ultimate objective. The selection of objectives is based on consideration of the mission, the means and time available, the enemy, and the operational area. Every commander must understand and clearly define his objective and consider each contemplated action in light thereof.

- OFFENSIVE-- Offensive action is necessary to achieve decisive results and to maintain freedom of action. It permits the commander to exercise initiative and impose his will on the enemy, to set the terms and select the place of battle, to exploit enemy weaknesses and rapidly changing situations, and to react to unexpected developments. The defensive may be forced on the commander as a temporary expedient while awaiting an opportunity for offensive action or may be adopted deliberately for the purpose of economizing forces on a front where a decision is not sought. Even on the defensive, the commander seeks opportunities to seize the initiative and achieve decisive results by offensive action.

- MASS-- Superior combat power must be concentrated at the critical time and place for decisive results. Superiority results from the proper combination of the elements of combat power. Proper application of this principle, in conjunction with other principles of war, may permit numerically inferior forces to achieve decisive combat superiority at the point of decision.

- ECONOMY OF FORCE-- This principle is the reciprocal of the principle of mass. Minimum essential means must be employed at points other than that of the main effort. Economy of force requires the acceptance of prudent risks in selected areas to achieve superiority at the point of decision. Economy of force missions may require limited attack, defense, cover and deception, or retrograde action.

- MANUEVER-- Maneuver is an essential ingredient of combat power. It contributes materially in exploiting success and in preserving freedom of action and reducing vulnerability. The object of maneuver is to concentrate (or disperse) forces in a manner to place the enemy in a position of disadvantage and thus achieve results that would otherwise be costly in men and materiel.

- UNITY OF COMMAND-- The decisive application of full combat power requires unity of command. Unity of command results in unity of effort by coordinating the action of all forces towards a common goal. While coordination may be achieved by cooperation, it is best achieved by vesting a single commander with requisite authority.

- SECURITY-- Security is essential to the preservation of combat power. Security results from the measures taken by a command to protect itself from espionage, observation, sabotage, annoyance, or surprise. It is a condition that results from the establishment and maintenance of protective measures against hostile acts or influences. Since risk is inherent in war, application of the principle of security does not imply undue caution and avoidance of calculated risk.

- SURPRISE-- Surprise can decisively shift the balance of combat power. With surprise, success out of proportion to effort expended may be obtained. Surprise results from striking an enemy at a time and/or place and in a manner for which he is unprepared. It is not essential that the enemy be taken unaware, but only that he become aware too late to react effectively. Factors contributing to surprise include speed, cover and deception, application of unexpected combat power, effective intelligence, variations of tactics and methods of operation, and operations security (OPSEC). OPSEC consists of signals and electronic security, physical security, and counterintelligence to deny enemy forces knowledge or forewarning of intent.

- SIMPLICITY-- Simplicity contributes to successful operations. Direct, simple plans and clear, concise orders reduce misunderstanding and confusion. Other factors being equal, the simplest plan is preferred. [Ref. 51:pp. 14-16]

In addition to these nine principles, the Air Force includes three other principles.

- TIMING AND TEMPO-- Timing and tempo is the principle of executing military operations at a point in time and at a rate which optimizes the use of friendly forces and which inhibits or denies the effectiveness of enemy forces.

- LOGISTICS-- Logistics is the principle of sustaining both man and machine in combat by obtaining, moving, and maintaining warfighting potential. Success in warfare depends on getting sufficient men and machines in the right position at the right time.

- COHESION-- Cohesion is the principle of establishing and maintaining the warfighting spirit and capability of a force to win. Cohesion is the cement that holds a unit together through the trials of combat and is critical to the fighting effectiveness of a force. [Ref. 50:pp. 2-8,2-9]

The Navy and Marine Corps do not officially recognize the principles of war as the basis for their warfighting doctrine, nor do they publish broad doctrinal documents similar to the Air Force and Army. A variety of Naval Warfare Publications (NWPs) address the warfighting doctrines for the various combat sea operations. One of the problems "with the principles of war is that they fail to distinguish between land and sea combat." [Ref. 52:p. 143] Retired Navy Captain Wayne P. Hughes' work, Fleet Tactics, provides five "propositions" upon which naval tactics are built [Ref. 52:p. 145]. They are the principles of war for combat at sea.

- Naval warfare centers on the process of attrition. Attrition comes from the successful delivery of firepower.

- Scouting-- locating the enemy sufficiently to deliver effective firepower-- is a crucial and integral process of tactics.

- C^2 is the process that transforms scouting and firepower potential into the reality of delivered force.

- Naval combat is a force-on-force process tending, in the threat or realization, toward the simultaneous attrition of both sides. To achieve victory one must attack effectively first. Therefore actions taken to interfere with the enemy's firepower, scouting, and C^2 processes are also of fundamental importance.

- Maneuver is also a tactical process. In fact, maneuver in battle was once the classic definition of tactics. Maneuver is the activity by which C^2 positions forces to scout and shoot. [Ref. 52:pp. 145-146]

Although one of the Marine Corps' primary missions is to conduct operations that "may be essential to the prosecution of a naval campaign" [Ref. 24:p. 2-7], they are capable of a variety of operations not necessarily related to naval campaigns [Ref. 49:p. 36]. This is evidenced by the recent replacement of the term "amphibious" with "expeditionary" when referring to their fighting forces. The Marine Corps' warfighting doctrine is more closely aligned to the principles of war used by the Army.

D. U. S. AIR FORCE

1. Tactical Doctrine

The U. S. Air Force's tactical air forces (TAFs) have six tactical combat missions. As described in AFM 1-1, these missions include: counter air; air interdiction; close air support; tactical airlift; tactical air reconnaissance; and special operations. The primary objective of the counter air mission is to gain "air supremacy." Air superiority must be established in order to "protect friendly forces," to guarantee the free use of the airspace environment for our purposes, and to "deny the use of that environment to an enemy." [Ref. 50:p. 3-3] The Air Force uses three types of counter air operations to accomplish this: offensive counter air (OCA); defensive counter air (DCA); and suppression of enemy air defense (SEAD). [Ref. 50:p. 3-3]

"Air interdiction objectives are to delay, disrupt, divert, or destroy an enemy's military potential before it can be brought to bear effectively against friendly forces." [Ref. 50:p. 3-3] Air interdiction strikes are conducted against enemy ground forces, command and control communication networks, and supply routes. They can be deep behind enemy lines or relatively close to friendly positions. [Ref. 50:pp. 3-3,3-4] Close air support mission "objectives are to support surface operations by attacking hostile targets in close proximity to friendly surface forces." [Ref. 50:p. 3-4]

The objectives of airlifts "are to deploy, employ, and sustain military forces" through air transport of "personnel, equipment, and supplies." Tactical airlifts pertain to operations performed within a theater of operations in support of theater objectives. [Ref. 50:p. 3-5]

Tactical air reconnaissance missions "provide timely notification of hostile intent...." They also provide information to combat commanders regarding "the composition and capability of enemy and potentially hostile forces." [Ref. 50:p. 3-5]

Special operations mission objectives "are to influence the accomplishment of...tactical objectives normally through the conduct of low visibility, covert, or clandestine military actions. [Ref. 50:p. 3-4] Command and control of the assets which conduct these missions is critical to their success.

2. Tactical Command and Control

The Tactical Air Control System (TACS) is the primary C^2 system currently used to employ TAFs. TACS is defined by JCS Pub 1 as "the organization and equipment necessary to plan, direct, and control tactical air operations and to coordinate air operations with other services. It is composed of control agencies and communication-electronic facilities which provide a means for centralized control and decentralized execution of missions." [Ref. 7:p. 356] Figure 12 represents what is referred to as the "classical TACS" structure. Actually, "there is no set 'classical TACS' structure because a commander can modify" the structure "to meet tactical needs." [Ref. 54:p. 30]

The Tactical Air Control Center (TACC) assists the "tactical air force commander" in exercising "centralized control of resources available to him." [Ref. 54:p. 32] Air tasking orders, which specify tasking for assigned units, are published by the TACC and distributed to the subordinate commands. [Ref. 54:p. 32]

The Wing Operations Center (WOC) directs its resources to perform decentralized execution of assigned missions. "The wing commander uses the WOC for managing and controlling all assigned and attached resources,

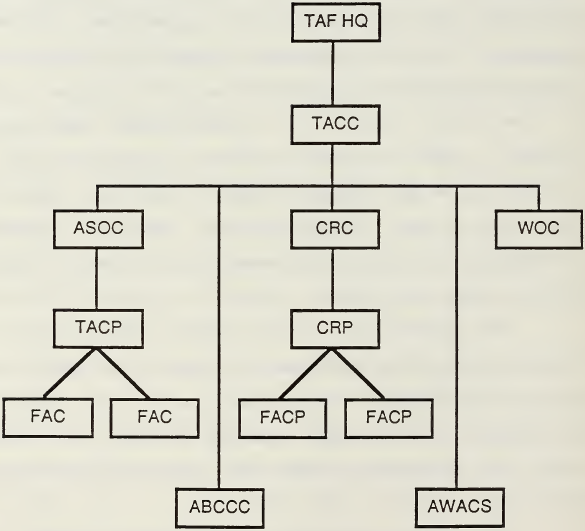


Figure 12.
Classical TACS

specifically, the generation of sorties by his wing." [Ref. 54:p. 35]

The surveillance and control elements of TACS consist of the Control and Reporting Center (CRC), the Control and Reporting Post (CRP), and the Forward Air Control Post (FACP). [Ref. 53] The CRC:

- Directs the air defense activities within its sector;
- Provides threat warning to friendly aircraft;
- Provides control or flight following data to both offensive and defensive missions;
- Relays mission changes to aircraft as directed from the TACC;
- Coordinates the control of missions with subordinate TACS units; and
- Identifies aircraft. [Ref. 54:p. 33]

The CRP is a subordinate command to the CRC and performs the same functions as the CRC [Ref. 7:p. 88]. The FACP is "a highly mobile tactical air control system radar facility subordinate to the CRC/CRP used to extend the radar coverage and control (aircraft) in the forward combat area." [Ref. 7:p. 151]

The Air Support Operations Center (ASOC) is responsible for "decentralized execution of close air support for ground units in the ASOC, which reports directly to the TACC." [Ref. 54:p. 35] Tactical Air Control Parties (TACPs) are subordinate to the ASOC and are "designed to provide air liaison to land forces and for the control of aircraft." [Ref. 7:p. 356] The TACP forward air controllers (FACs) control tactical close air support mission aircraft in support of ground forces [Ref. 54:p.35]. The TACPs are assigned to each Army corps, division, brigade, and battalion [Ref. 54:p. 35].

The Airborne Warning and Control System (AWACS), discussed in Chapter V, provides similar services as the CRC, as well as, FACP functions. AWACS has various mission capabilities, including air defense warning, aircraft control, navigational assistance, and coordination of air rescue missions." [Ref. 54:p. 34]

The Airborne Battlefield Command and Control Center (ABCCC) can be used as an alternate ASOC or a "limited TACC" for some operations. The ABCCC's communication suite gives it the "capability to control and coordinate tactical air operations in the forward battle areas that are beyond normal communication coverage of ground TACS elements." [Ref. 54:p. 34]

E. U. S. ARMY

1. Airland Battle Doctrine

The basic warfighting doctrine for the U.S. Army is known as the Airland Battle.

> It reflects the structure of modern warfare, the dynamics of combat power, and the application of the classical principles of war to contemporary battlefield requirements. It is called Airland Battle in recognition of the inherently three-dimensional nature of modern warfare. [Ref. 55:p. 9]

Airland Battle doctrine is a joint doctrine in that the success of ground forces in modern combat is heavily dependent on tactical air forces. The tactical air forces critical to the success of the Airland Battle are U.S. Air Force assets, which must be interoperable with U.S. Army ground forces. The object of the Airland Battle is to "impose our will upon the enemy-- to achieve our purposes." [Ref. 55:p. 14] To achieve this, the Army must seize the initiative by delivering decisive and powerful blows upon the enemy in an aggressive and unrelentless manner. "These operations must be rapid, unpredictable, violent, and disorienting. The pace must be fast enough to prevent him from taking effective counteractions." [Ref. 55:p. 14] Army Field Manual 100-5 (FM 100-5) states that "success on the battlefield will depend on the Army's ability to fight in accordance with four basic tenets: initiative, agility, depth, and synchronization." [Ref. 55:p. 15]

- Initiative-- Initiative means setting or changing the terms of battle by action. In attack, initiative implies never allowing the enemy to recover from the initial shock of attack. [Ref. 55:p. 15]

- Agility-- Agility (the ability of friendly forces to act faster than the enemy) is the first prerequisite for seizing and holding the initiative. [Ref. 55:p. 16]

- Depth-- Depth is the extension of operations in space, time, and resources. In tactical actions, commanders fight the enemy throughout the depth of his dispositions with fires and with attacks on his flanks, rear, and support echelons. [Ref. 55:p. 16]

- Synchronization-- Synchronization is the arrangement of battlefield activities in time, space, and purpose to produce maximum relative combat power at the decisive point. [Ref. 55:p. 17]

2. Tactical Command and Control

The Army identifies five battlefield functional areas that must be integrated by a superior command and control system in order to accomplish its mission. These functional areas are: maneuver control, fire support, air defense control, combat service support control, and intelligence/ electronic warfare control. [Ref. 14:p. 110] Figure 13 depicts these five functional areas with regard to the Army Command and Control System (ACCS). [Ref. 56:p. 86] The Army coordinates the tactical air support of the other services through the Army air-ground system [Ref. 7:p. 36].

The largest tactical unit in the Army is the corps. Army corps' are tailored to meet the tactical requirements of their mission. "Corps may be assigned divisions of any type required by the theater and the mission." [Ref. 55:p. 185] Within each division there are three basic tactical command and control facilities: Tactical command post (TAC), Main command post or Tactical Operations Center (TOC), and the Rear Area Operations Center (RAOC). The TAC is the forward most command post, usually eight to 25 km from the forward line of troops, or FLOT. The TAC is responsible for maneuvering forces in the near or forward battles areas. The TOC fights the deep battle and plans future operations and contingency operations. It is usually positioned 20 to

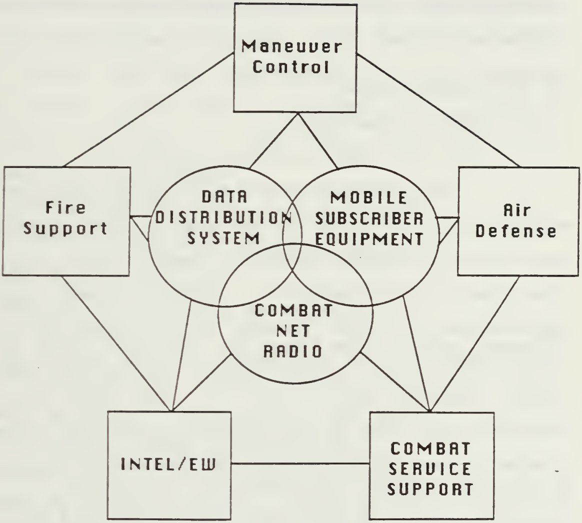


Figure 13.
Army Command and Control System

50 km behind the FLOT. The RAOC provides for the sustainment of the current battle and for future battles. It is the logistics center for the division. It is responsible for the security of the division rear. The RAOC is usually located at least 50 km from the FLOT. The TOC is the focal of the three command posts (CPs). The division commander will move between the CPs as necessary to control his forces. [Ref. 53]

F. U. S. MARINE CORPS

1. Tactical Doctrine

a. Marine Air-Ground Task Force

The doctrine of the U. S. Marine Corps strongly emphasizes that "Fleet Marine Forces will normally be employed as integrated air-ground teams." [Ref. 57:p. 1-2] Fleet Marine Force Manual 0-1 (FMFM 0-1) "sets forth the organization, doctrine, tactics, and techniques to be used in the formation and deployment of Marine Air-Ground Task Forces" (MAGTFs) [Ref. 57:p. i]. The MAGTF is a task organized team which is established to accomplish a specific mission. Each MAGTF consists of four basic elements: a command element, a ground combat element, an aviation combat element, and a combat service support element. [Ref. 57:p.1-2] MAGTFs are organized in three basic types ranging from the small Marine Expeditionary Unit (MEU) to the large Marine Expeditionary Force (MEF).

b. Marine Expeditionary Unit

The Marine Expeditionary Unit (MEU) is the smallest of the three MAGTF types. The MEU is generally organized around a battalion landing team, a composite aviation squadron, and a MEU service support group. [Ref. 57:p. 5-3] A MEU is continuously deployed to the Mediterranean Sea and Western Pacific Ocean aboard three to five Navy amphibious ships [Ref. 53]. The MEU is used to meet "routine peacetime requirements for forward deployed afloat forces...it provides an immediate reaction capability in crisis situations...." [Ref. 57:p. 5-2] Some of the missions of the MEU include:

- Advance force for follow on larger MAGTF;
- Limited duration amphibious operations;
- Amphibious raids; and
- Evacuation of civilian installations.

Because these operations are small and of short duration, the MEU headquarters usually remains aboard ship and is commanded by an O-6, colonel [Ref. 57:p. 5-2].

c. Marine Expeditionary Brigade

The Marine Expeditionary Brigade (MEB) is a MAGTF with a "combined arms force from two to five times the size and combat power of a MEU." [Ref. 57:p. 6-1] The ground combat element (GCE) of a MEB may be composed of two to five battalion landing teams formed into a regimental landing team. The aviation combat element (ACE) is a Marine

Aircraft Group, which contains both fixed wing aircraft and helicopters. The ACE also includes antiair warfare and air control capabilities. [Ref. 57:p. 6-3] The combat service support element (CSSE) is a BSSG, brigade service support group, organized to provide the necessary combat service support (CSS) for the GCE and ACE. [Ref. 57:p. 6-4] The MEB is "capable of conducting all types of amphibious operations, and is normally committed to combat operations of limited scope." [Ref. 57:p. 6-2] As the situation permits, the MEB headquarters transition from ship-to-shore where the MAGTF commander will establish his command post ashore. The MEB is usually commanded by a brigadier general. [Ref. 57:p. 6-1]

d. Marine Expeditionary Force

The Marine Expeditionary Force (MEF) is "the largest of the MAGTFs, ranging in size from just over half of the assets of a division/wing team to a force of one or more divisions and aircraft wings." [Ref. 57:p. 7-1] The GCE is usually a Marine division comprised of infantry regiments and battalion landing teams [Ref. 57:p. 7-4]. The ACE is a Marine aircraft wing, which is comprised of aviation assets capable of all types of tactical air missions. The CSSE for a MEF "is a force service support group tailored to provide CSS beyond the organic capability of the air and ground elements." [Ref. 57:p. 7-5] "The MEF is capable of the full range of amphibious operations and sustained operations ashore in any combat environment." [Ref. 57:p. 7-3] The MEF is commanded by a major general, or lieutenant general, and the headquarters will transition from ship to shore as the tactical situation dictates [Ref. 57:p. 7-4].

2. Tactical Command and Control

Command and control of the MAGTF becomes complex as the assault forces land and advance the forward edge of the battle area (FEBA). The commander landing force, CLF, is collocated with the commander amphibious task force, CATF, aboard an amphibious command ship. The command relationships for the amphibious operations are depicted in Figure 14 [Ref. 53]. The CATF is responsible for the ship-to-shore movement of all landing forces, and he will maintain control until the CLF has established adequate command and control facilities ashore. The shift of command and control from CATF afloat to CLF ashore is actually a gradual transfer of the major control agencies in the MAGTF. These major control agencies are discussed below.

- The combat operations center (COC) is the key element for control of ground combat forces. It acts as the hub or focal point for tactical command and control in every major tactical command post down to the battalion level, including combat support units.

- The fire support coordination center (FSCC) is the senior ground commander's most valuable tool for getting the best weapon assigned to the preplanned targets and emergency requests for fire during the land battle.

- The fire direction center (FDC) is the primary control agency for ground artillery forces....

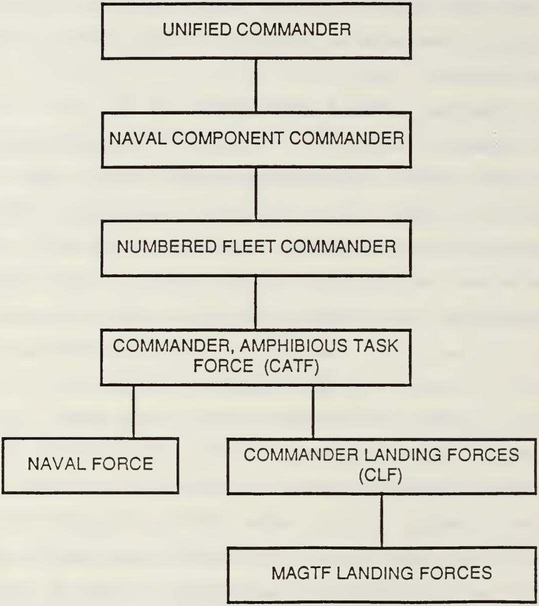


Figure 14.
Command Relationships During Amphibious Operations

- The tactical air command center (TACC) and tactical air direction center (TADC) are the major air command and control agencies...responsible planning and employment of air assets that belong to the landing force.
- The tactical air operations center (TAOC) is the agency responsible for airspace control and air defense.
- The antiair operations center (AAOC) assists TAOC in the air defense role through control of the Hawk missile sites.
- The direct air support center (DASC) directs close air support aircraft onto assigned targets.... [Ref. 53:p. 20]

During the initial stage of the landing, the CLF maintains his command post afloat and "the assault commanders...run their command posts from jeeps, helicopters, or amphibious landing craft." [Ref. 53:p. 21] All the control agencies listed earlier gradually become established ashore as the battle moves inland. "The final stage of an amphibious operation involves the establishment of the landing force command post ashore (MAGTF HQ) along with all the other air, ground, and logistic control agencies." [Ref. 53:p. 23]

It should be emphasized that the MAGTF is designed to perform specific operations. The objective of the amphibious assault is to establish secure areas in order to provide staging areas for Army units to initiate occupation missions and offensive campaigns. Once the objectives are met, the MAGTF will be dissolved and the Marine forces will return to the amphibious task force vessels. [Ref. 53]

G. U. S. NAVY

1. Tactical Doctrine

The primary mission of the U. S. Navy is accomplished through the performance of two fundamental missions: sea control and power projection [Ref. 49:p. 34]. Sea control is the control of the sea lines of communication (SLOC), while power projection is the infliction of damage to ashore targets through naval air strikes, cruise missiles, and amphibious operations [Ref. 52:p. 220]. To match these missions to the forces available, the Navy uses task forces. The task force concept provides "the assembly of the right forces in the right numbers to carry out an assigned task." [Ref. 52:p. 218] The single fighting force of today's Navy is the integrated naval battle force. The Navy achieves sea control "by the engagement and destruction of, or by deterrence through, the threat of destruction of hostile aircraft, ships, and submarines at sea." [Ref. 49:p. 34] Power projection employs the same process as sea control except for targets ashore. "Power projection would be clearer if its definition included the safe movement of shipping and the timely military reinforcement and resupply of ground operations...." [Ref. 52:p. 220] The integrated naval battle force accomplishes these missions through the correlation of "mission-specific" forces [Ref. 52:p. 238]. These forces are separated by mission areas which include: antiair warfare (AAW), antisurface warfare (ASUW), and antisubmarine warfare (ASW). The integrated naval battle force normally consists of one or more battlegroups, which include various combinations of aircraft carriers, battleships, guided missile cruisers, frigates, destroyers, and other escort vessels.

2. Tactical Command and Control

The composite warfare commander (CWC) doctrine provides the tactical command and control structure for the integrated naval battle force in the accomplishment of its mission.

> The CWC doctrine enables the officer in tactical command (OTC) of the naval force at sea to aggressively wage combat operations against air, surface, and subsurface threats while carrying out the primary mission of the force. [Ref. 14:p. 111-112]

The command relationships are depicted in Figure 15 [Ref. 14:p. 112]. The OTC is often the CWC, depending on the size of the battle force. Each of the subordinate warfare commanders is designated by, and accountable to the CWC. "The warfare commanders are responsible for collecting, evaluating, and disseminating tactical information, and, at the discretion of the CWC, are delegated authority to respond to threats with assigned forces." [Ref. 14:p. 113] The AAWC (AAW commander), ASUWC (ASUW commander), and ASWC (ASW commander) are directly responsible for their respective mission areas. The CWC is flexible in the amount of authority he may choose to delegate to each of the warfare commanders. This flexibility can "range from full

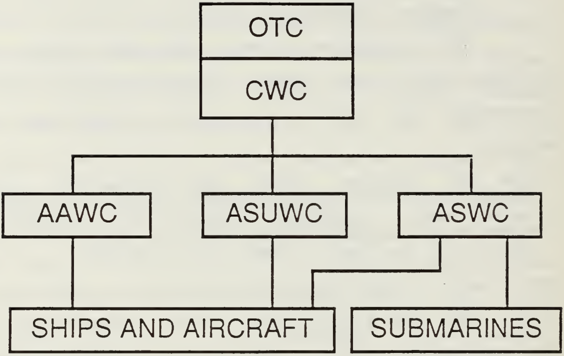


Figure 15.
CWC Command Structure

delegation of authority to no delegation at all, depending upon the threat and the tactical situation." [Ref. 14:p. 112]

H. U. S. COAST GUARD

1. Maritime Defense Zone

Since World War II, the U. S. maritime strategy has emphasized the forward offensive strategy of the Navy with little or no regard to the coastal defense of the U. S. littoral regions [Ref. 14]. Alfred Thayer Mahan, called the "philosopher of sea power" [Ref. 59:p. m-62], recognized that there was a "fundamental need for (coastal) defense." [Ref. 58] "Mahan strongly endorsed offensive actions over defensive actions in the majority of maritime situations...but he was quick to warn that 'offense... dominates, but does not exclude' the need for defense." [Ref. 58] Mahan also indicated that the Navy's primary concern should be offensive, and that defense of the homeland should be done by others. In 1980, the Navy Coast Guard (NAVGUARD) board was formed to address the issues of coastal defense. The board was co-chaired by the Vice Chief of Naval Operations and the Vice Commandant of the Coast Guard. The NAVGUARD board commissioned a study to determine the wartime tasking of the Coast Guard, which is part of the Department of Transportation, not the Defense Department. As a result of the commission's recommendations, the Maritime Defense Zones (MARDEZs) were established in March 1984. In the event of war, the Navy would assume command of the MARDEZ commands. "The Maritime Defense Zone is a Navy mission, similar to the old sea frontiers concept, which places a Coast Guard admiral directly under each Navy Fleet Commander in Chief." [Ref. 60:p. 53] The mission of the MARDEZ is to:

> ...plan for and when directed, conduct, coordinate, and control operations in the area designated as the MDZ, as required in order to ensure the integrated defense of the area, to protect coastal sea lines of communications, and to establish and maintain necessary control of the vital coastal sea areas, including ports, harbors, navigable waters, and offshore assets of the United States, exercising both statutory and naval command capability. [Ref. 58]

The mission also includes:

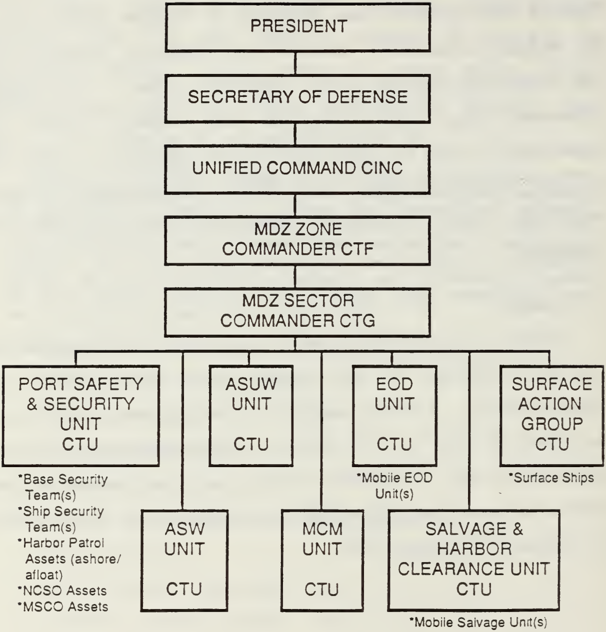
- Naval control of shipping;
- Harbor defense and security;
- Mine countermeasures;
- Antisubmarine warfare;
- Coastal surveillance and interdiction;
- Convoy escort;
- Wartime search and rescue; and
- Inshore undersea warfare. [Ref. 58]

2. Wartime Command and Control

There are two Maritime Defense Zone commands: Commander, U. S. Maritime Defense Zone Atlantic (COMUSMARDEZLANT); and Commander, U. S. Maritime Defense Zone Pacific (COMUSMARDEZPAC). Coast Guard vice admirals are in charge of both commands. These commands are equivalent to the numbered fleet commands of the Navy. The command relationships are depicted in Figure 16 [Ref 58]. The MARDEZ commanders' area of responsibility extends from the coastline seaward to 200 nautical miles. The MARDEZ commands are further divided into sectors which are commanded by Navy or Coast Guard rear admirals. [Ref. 58] In the event of war, the MARDEZ command and control structure will be readily integrated into the Navy C^2 structure.

I. SUMMARY

Various theories have sprung up concerning organizations and the dynamics of the groups that exist within the organizations. A vital aspect of command and control that is often ignored is the study of the construction of the organization or, in broader terms, the architecture of the system in question. This aspect of command and control will be explored in Chapter VII.



LEGEND:

- *ASW-Antisubmarine Warfare
- *ASUW-Antisurface Warfare
- *CTF-Commander Task Force
- *CTG-Commander Task Group
- *CTU-Commander Task Unit
- *EOD-Explosive Ordinance Disposal
- *MCM-Mine Countermeasures
- *MSCO-Military Sealift Cmd Office
- *NCSO-Naval Control of Shipping Office

Figure 16.
MDZ Command Relationships

VII. SYSTEMS ARCHITECTURE

A. INTRODUCTION

A basic understanding of architectures and their uses is fundamental to all aspects and all levels of command and control and the C^2 system. The development of an architecture is the first stage of the system engineering process [Ref. 39:p. 82]. Architectures come in a variety of forms and have a variety of applications. Many architectures are actually architectures of architectures. Simply, an architecture is "the structure of anything," or "the art or science of building." [Ref. 62:p. 53] Architectures, as they apply to combat systems are described as a "translation of function into form." [Ref. 15:p. 99] Some general definitions for system architectures are listed here:

- A specific arrangement of basic elements (of a system) satisfying the required functions and boundary conditions of the system; [Ref. 39:p. 82]
- An integrated set of systems whose physical entities, structure, and functionality are coherently related; and [Ref. 61:p. 9]
- A generic design which partitions combat systems into parts, describes their functions and defines the interrelationships between the parts. [Ref. 63:p. 62]

Architectures serve a variety of purposes. Generally, system architectures provide for:

- The clear identification of subsystems;
- The allocation of functions to subsystems; and
- The establishment of the standards for interfaces between subsystems.

The identification of subsystems provide the basic framework for the development and procurement of combat system components [Ref. 63:p. 62]. The allocation of functions allows for the generation of system requirements and specifications. The establishment of standards for interfacing all the component subsystems is very important. Not only does it require integration within the system, but considerations must be made for the integration into other systems. Some other uses of architectures include: providing guidance for defining and understanding the mission of the system, supporting planning [Ref. 64:p. 68], aiding in the design of systems and subsystems, and allowing for comparative system evaluation methods to be developed [Ref. 61:p. 6].

B. C^2 SYSTEM ARCHITECTURE

A C^2 system architecture maps the C^2 system to the command and control process [Ref. 15:p. 100]. Another look at the functions of the commander's C^2 process is necessary: information management, decision management, and execution management [Ref. 15:p.99]. The C^2 system architecture's role is to provide the framework for the C^2 system to support the C^2 process. C^2 system architecture is defined as "the arrangement of (or process of arranging) basic elements of a...(C^2) system into an orderly system framework." [Ref. 39:p. 82] It also provides the "technical framework for subsystem architectures, allowing for the development of communication architecture, information system architecture, headquarters architecture, air defense architecture, intelligence architecture, and so forth." [Ref. 64:p. 68]

The most difficult part of any command and control system is the integration and physical interdependency among the communication and computer systems. The combination of computer and telecommunication technology has brought about the opportunity for direct computer information exchange over great distances. These technological advances have resulted in requirements for distributed information systems to interact with other systems of "different design and manufacture." [Ref. 15:p. 102] These advances have significantly enhanced the potential for improved C^2 system effectiveness, while compounding the problems of interoperability. The 1987 Defense Science Board Task Force on C^2 System Management points out that one of the major deficiencies in "tactical and theater command and control systems worldwide" is the "continuing absence of an agreed-upon, well understood DOD architectural framework with its well defined interfaces and standards to guide the evolution of command and control systems..." [Ref. 12:p. 12]

The International Organization for Standardization has developed a new architecture called Open System Interconnection (OSI) to establish "standards for the design, development, and evolution of distributed information systems." [Ref. 15:p. 102] These standards have been extended into the C^2 systems arena by the development of a C^3 Reference Model (C^3RM). The goal of the C^3RM model is to:

> provide the framework of choice to guide the development of a consistent set of standards and specifications for interoperability and to offer substantial protection of extensive investments in acquisition by being conducive to the promotion of modular reuseable technologies. [Ref. 65:p. 1]

The key to understanding, designing, using, and evaluating C^2 systems is the development of a C^2 system architecture that is an integrated structure "that will support a specific military force under all anticipated battle situations and conditions." [Ref. 39:p. 82] An architecture with well defined goals and clearly supportive of the C^2 process is needed.

C. GENERIC ARCHITECTURES

There are three general types of architectures currently used to describe C^2 systems. They divide the overall architecture into three distinct architectures: organizational, functional, and physical. The integrated naval battle force structure is used to demonstrate these concepts.

1. Organizational Architecture

An organizational architecture is perhaps the most readily recognized and most commonly used both in the military and private sector. Basically, it represents the command structure of the organization. It establishes clear, unambiguous lines of authority and responsibility. Figure 17 depicts the organizational (chart) architecture of the integrated naval battle force [Ref. 66]. The architecture also shows the relationships between the various levels of command.

2. Functional Architecture

The functional architecture performs a functional decomposition of the various mission areas presented in the organizational architecture. The generic functional architecture presented in Figure 18 demonstrates the various basic functions that need to be performed by each of the mission areas of the command and control system. These functions are generic for all levels of command within the battle force structure. [Ref. 66]

3. Physical Architecture

The physical architecture represents the specific hardware systems and their physical relationships. It details distinct communication links between all the internal and external components that the C^2 system must integrate and interact with. As shown in Figure 19, the level of detail has increased significantly in this

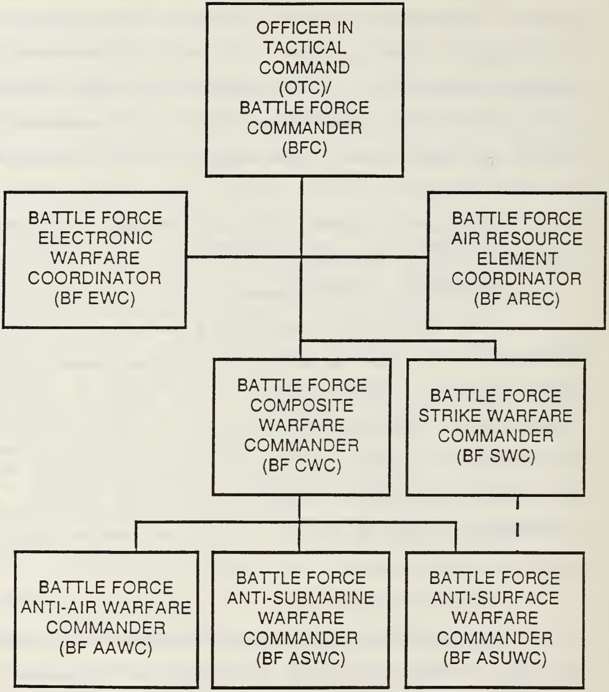


Figure 17.
Organizational Architecture

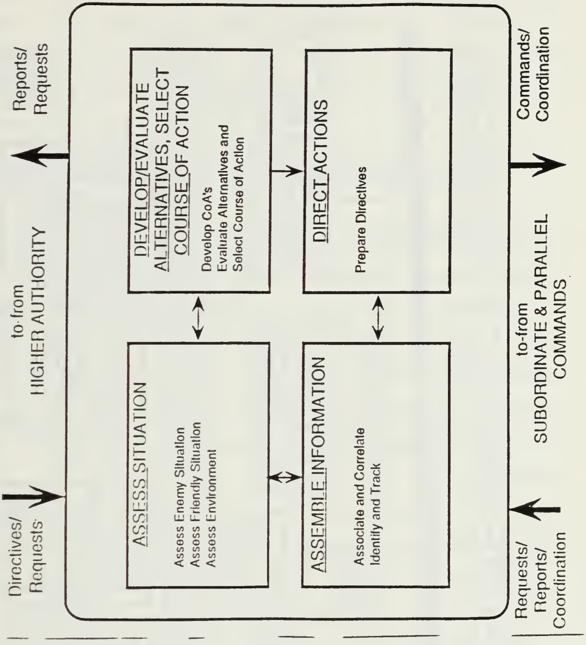


Figure 18.
Functional Architecture

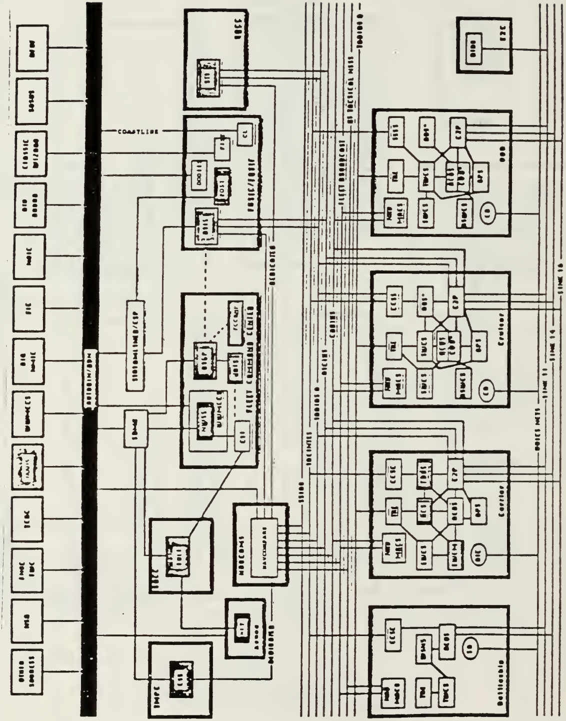


Figure 19.
Physical Architecture

architecture. The physical architecture will serve as the primary tool for the system engineers to design and integrate the physical systems required to perform the functions presented in the functional architecture. These two architectures then support the organizational C^2 architecture. [Ref. 66]

D. SYSTEMS APPROACH TO ARCHITECTURE DEVELOPMENT

1. Introduction

The systems approach concept is the methodology of the future for the design and development of all weapons systems. The systems approach is simply an extension of the system engineering discipline which was developed by Bell Telephone Laboratories in the late 1930's. The systems approach emphasizes "that you cannot concentrate on a single subsystem, or set of subsystems,...but that you must look at the entire system-- its interconnections, its interfaces, and its overall effectiveness." [Ref. 19:p. 48] Until recently, warfare systems were developed and designed in a piecemeal fashion usually to handle specific requirements of the warfighting forces. That is, sensors, C^2 systems, fire control systems, and weapons were designed independently of each other with little consideration for the equipment's integration into already existing warfare systems. Within the Navy, this resulted in platform level system engineering. This platform oriented, bottom-up approach forced system integration to be dealt with at sea by tactical users, not system engineers. The current U. S. fleet "consists of forces which were not system engineered or integrated." [Ref. 67]

Major difficulties and debates exist concerning what exactly is the best overall system, and where to establish the system boundaries and still maintain a manageable system. In 1985, the Navy took the initiative and developed the Warfare System Architecture and Engineering (WSA&E) concept. The concept embraces the systems approach using "force-level" system engineering. Although developed by the Navy, the concept can be tailored for all the services and at various force levels. The Navy established the system boundary to be the integrated naval battle force. The battle force is evaluated as a single integrated fighting unit and not a hodgepodge of various platforms operating autonomously in specific mission areas. [Ref. 67]

The steps to the WSA&E concept will be presented shortly, however, it should be realized that even though this is a significant step in the right direction, it is not a complete solution to design problems of future U.S. military fighting forces. The primary limitation is that the Navy historically and traditionally has been able to segregate their operations and missions from the other services. Unfortunately, most military operations in the future will require joint operations, as seen recently in operations in Grenada and Libya. These operations could have been conducted by a single service, however, in order to achieve both military and political objectives, multi-service forces were required. Although these operations were short in duration and used limited numbers of forces, the decision to use a multi-service force indicates the likelihood of future use of joint forces in larger scale operations. The requirement for interoperability and integration of forces from all services is paramount. It is important for the other services to adopt some form of this concept and for the Navy to consider the interoperability requirements with the other services. Although many U. S. Navy missions are autonomous, the capability to interoperate with the Air Force, Army, Marine Corps, and Coast Guard must exist within the Navy systems. The capability must be designed into all future systems regardless of cost savings or service attitudes.

2. Warfare System Architecture & Engineering

The Warfare System Architecture & Engineering concept follows five steps leading to force level system engineering. These five steps include:

- Threat determination and analysis;
- National strategy and objectives;
- Force level determination and mission definition;
- Functional decomposition of the missions; and
- System engineering.

Figure 20 depicts the last three steps [Ref. 67]. In the past, system commands generally acted on the final step and developed weapons systems to fill requirements of operational commanders. This method can no longer keep up with the technology of weapons systems because of the long development and acquisition process. Weapon systems are often outdated by the time they reach initial operational capability. To develop and design modern, fully integrated and evolutionary warfare systems, the initial three steps of the WSA&E process are critical.

a. Threat Determination and Analysis

The threat the United States faces, currently and in the future, must be evaluated and assessed. The various intelligence organizations of the U. S. perform this function. The threat assessment must not be limited to the threat presented by the Soviet Union, but it must also seriously determine the threat of the third world powers as well. These threats must be projected into the future, at least through the life cycle of the forces to be developed. [Ref. 67]

b. National Strategy and Objectives

JCS Pub 1 provides definitions for national strategy and objectives.

> national strategy-- The art and science of developing and using the political, economic, and psychological powers of a nation, together with its Armed Forces, during peace and war, to secure national objectives.

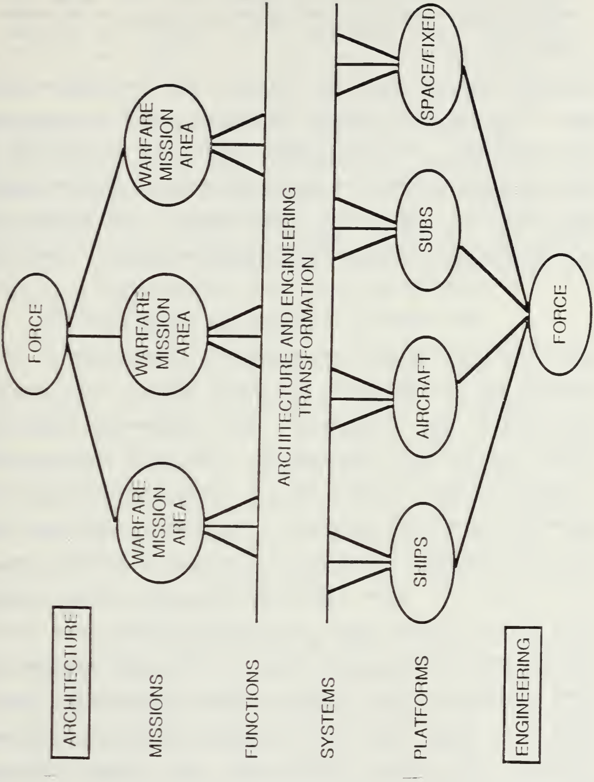


Figure 20.
Warfare System Architecture and Engineering

national objectives-- Those fundamental aims, goals, or purposes of a nation, as opposed to the means for seeking these ends, toward which a policy is directed and efforts and resources of the nation are applied. [Ref. 7:p. 240]

A careful understanding of what role the Armed Forces will play in the national strategy to achieve national objectives is fundamental. How the Armed Forces will be utilized in national policy determines the requirements for force design and capability. Additional requirements on the forces will be determined by the perceived threat assessment. [Ref. 67]

c. Mission and Force Level Determination

The specific missions of forces must be determined based on national strategy. These national level missions are divided among the Armed Forces. Each service then details the missions of force components that will fulfill the services requirements. The WSA&E requires that a system boundary be set for the force being designed to accomplish specified missions. The debate continues over where that boundary actually is. Should the boundary be at the division or corps level, battle group level, battle force level, theater level, or even the global force level? Current Navy doctrine lends itself to the integrated battle force structure as the logical boundary in that the battle force will operate as a single warfighting unit. Once this boundary has been established, top level warfare requirements (TLWRs) are developed. [Ref. 67]

d. Functional Decomposition of the Missions

During this phase, conceptual frameworks or architectures begin to be developed and compliance with TLWRs appears. The mission areas are defined and their associated functions are further specified. The relationships among the functions are determined. The desired performance requirements of each function are determined with regard to costs, schedules, and risks. Detailed required operational capabilities (ROCs) are generated. [Ref. 67]

e. System Engineering

The system engineers convert the ROCs into hardware. System engineering efforts concentrate on programs and define the following: force integration requirements, system performance and test specifications, and platform interfaces. Available technology is evaluated, and the adaptability of future technology is planned. The emphasis is on engineering systems for combat as well as performance and economy. [Ref. 67]

The WSA&E concept is just one example of using the systems approach for the development of architectures. These architectures are readily blended with established system engineering techniques. The net result is warfare systems designed from the top down and engineered from the bottom-up to form integrated and effective warfare systems.

The goal is to develop a synergistic system for enhanced weapons system effectiveness. [Ref. 67]

E. CONCEPTUAL ARCHITECTURE OF THE C^2 PROCESS

1. Introduction

The conceptual architecture of the C^2 process presented here is a result of a study performed in 1986 by the Armed Forces Staff College as described in "The Conceptual Architecture and Its Value" prepared by Major Patrick T. Thornton, USA. The objective of the study was to "develop a generic conceptual architecture of the command and control process." [Ref. 13:p. 2] This architecture provides the framework for the design of C^2 systems which will support the C^2 process. It allows for a more detailed analysis of the process, as well as an approach to the "modeling of command and control." [Ref. 13:p. 2]

The generic architecture includes the processes which are considered common to each service at all levels of command. The architecture consists of the general flow of information and processes which occur through the three functional areas of the C2 process. As presented earlier, these three major functional areas are: information management, decision management, and execution management. Figure 21 includes all these areas, the "subprocesses or tasks performed, and the products developed" [Ref. 13:p. 3], from within each functional area. The reader is encouraged to work through Figure 21 to help understand the complex

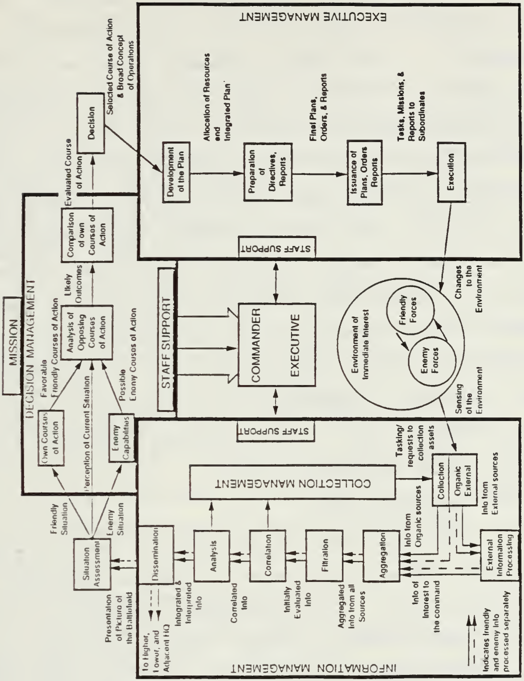


Figure 21.
Conceptual Architecture of the C^2 Process

process it describes. The processes displayed "encompass the fundamental elements of the military command and control process." It is these processes which every command, regardless of level or type of service, performs when exercising command and control. [Ref. 13:p. 4] Although the C^2 process is cyclical in nature, it must be realized that the cycle may have "several possible entry points." [Ref. 13:p. 4] The overall process is continuous and there may be several cycles occurring within each of the major functional areas before the entire cycle repeats itself. It should also be noted that the commander's staff interacts with all functional areas [Ref. 13:p. 6] and demonstrates the commander's flexibility in influencing the processes which support him. The environment presents the most logical point to enter the cycle.

2. The Environment

The environment is the area of responsibility the commander wishes to influence in some way dependent on his assigned mission. The environment consists of friendly forces, enemy forces, weather, terrain, and even rules of engagement (ROE). [Ref. 13:p. 7] It must also be understood that the environment on one level of command "is nested within a larger environment which is of immediate interest to the next higher commander." [Ref. 13:p. 8]

3. Information Management

The information management area includes all the activities associated with collecting, processing, analyzing, and disseminating information about the environment. Again, this includes friendly forces, enemy forces, and the physical nature of the environment. Specifically, these activities include collection, aggregation, filtration, correlation, analysis, and dissemination. [Ref. 13:p. 8]

a. Collection and Collection Management

Information collection and management "includes the total data and information gathering tasks performed" on the environment. Collection includes all sources, i.e., sensors and personnel. It includes organic, inorganic, and national level assets. Collection management deals with the allocation of available collection assets based on priorities determined by the needs of commander. [Ref. 13:p. 9]

b. Information Aggregation

Information aggregation is merely a process "of amassing the information" collected into some database. The information is usually raw data, but some of it may have "some minimal processing and may contain" some evaluation by the collection agency. [Ref. 13:p. 10]

c. Information Filtration

The process of filtration is critical due to the large amounts of information available to the commander on today's battlefield. The filtration process filters the information in accordance with the specified needs of the commander. The collected "information receives an initial evaluation based on such criteria as credibility, reliability, accuracy, and pertinency." [Ref. 13:p. 10] The process also includes a prioritization of information based on the commander's desire. "...it is essential that only information pertinent to the current and future operations of the command be allowed to continue through the processing stream." [Ref. 13:p. 11]

d. Information Correlation and Analysis

Information from multiple sources is correlated, and the process "begins to establish orderly connections concerning the amassed information...." [Ref. 13:p. 11] At this stage, a picture of the situation on the battlefield begins to take shape. A final evaluation of the correlated information develops into a "body of knowledge." [Ref. 13:p. 12] Both the enemy situation and friendly situation are determined.

e. Information Dissemination

The analyzed information develops a "picture" of the environment and disseminates it to the commander for a situation assessment. If necessary, the analyzed information is distributed to higher, lower, and adjacent commands. [Ref. 13:p. 12]

f. Situation Assessment

"The major purpose of the information management function is to provide the commander and staff the most timely and accurate picture of the current situation that is possible." [Ref. 13:p. 13] With that information, the commander performs one of the most critical functions of the C^2 process-situation assessment. The situation assessment is the commander's "perception of the current situation." [Ref. 13:p. 14] Even though this appears to be the first time the commander has directly entered the cycle, it must be understood that the commander, usually through his staff, is actively involved in the entire C^2 cycle.

4. Decision Management

Decision management involves the development and analysis of alternative courses of action (COAs) for both friendly and enemy forces. Friendly COAs are developed "using such criteria as suitability, feasibility, acceptability, variety, and completeness." [Ref. 13:p. 15] COAs are then analyzed against possible enemy courses of action. The commander evaluates these alternative COAs and makes his decision. The commander's decision "is often influenced by factors which are sometimes called 'non-real-time' information sources." [Ref. 13:p.17] These sources include the commander's background and experience. [Ref. 13:p. 17]

5. Execution Management

Based on the commander's decision, operational plans are developed and execution orders are transmitted to the execution forces. Operational plans consider all aspects of the operation. Some of those include mission objectives, concept of operations for forces, logistic requirements, support, and transportation. "The execution provides the culmination of the command and control process." [Ref. 13:p. 19] The execution of the commander's orders will influence the environment in some way. The effects of the execution are then sensed, and the C^2 process continues its cycle. [Ref. 13:p. 19]

It must be realized here that a cycle of the C^2 process can occur in a very short time. Many of the processes discussed are often skipped, and quick action is often more effective that the precisely correct action.

This conceptional architecture "presents the command and control process as a whole, highlighting the complexity of the process and identifying those major functions and processes which any potential command and control system must support...." [Ref. 13:p. 31]

F. SUMMARY

With an understanding of the architecture of generic command and control sytems, it is now time to examine the methods available to evaluate and quantify C^2 systems. Chapter VIII provides the reader with a fundamental approach to the complicated process of evaluating complex command and control systems.

VIII. SYSTEM EVALUATION

A. INTRODUCTION

The question of how to evaluate command and control systems has perplexed analysts from all academic disciplines. The effort to answer the question consumes a great deal of time and energy from a variety of individuals and organizations. The C^2 systems are extremely complex and evaluation requires a "multidisciplinary endeavor entailing technological, economic, organizational, and cognitive aspects." [Ref. 12:p. 28] A single unified discipline to study, specify, or evaluate C^2 systems does not exist. The command and control field is a "world of organized complexity-- complexity being defined by the number of elements in the system, their attributes, the interactions among the elements, and the degree of organization in the system." [Ref. 72:p. 5] There are two principal factors contributing to the complexity of C^2 systems. First is the human element. "The analysis of C^2 system utility requires an understanding of the human component in such systems." [Ref. 70:p. 167] The force effectiveness of a C^2 system is dependent on the quality of the decision making processes of the people interfacing with the system. The contributions of theories from the cognitive and behavioral sciences must be considered in evaluating the overall C^2 system. Secondly, the C^2 system cannot be analytically dissected and evaluated, as most weapons systems can. The interdependencies and interrelationships among all the various physical components, as well as the "interactions between the C^2 process" and those components add to the complexity of evaluation. [Ref. 11:p. 880] It is very difficult to quantify the effectiveness of a C^2 system, unlike a particular weapon system or platform. Even though C^2 received more of the attention it deserved in the 1980's, the determination of measures to quantify the value of C^2 systems has not emerged. An appreciation for the complexity of the C^2 problem has been gained. This inability to find a standard measure of effectiveness becomes critical in the battle for limited funding. "If money was plentiful, and if decision makers did not have to make painful choices across not only C^2 programs, but to combat arms, perhaps no problems would arise." [Ref. 68:p. 390] It is much less difficult to demonstrate and quantify the value of a new weapon system using familiar measures such as thrust-to-weight ratios, bombs on target, and kill ratios. The key element in developing improved systems is dollars. The systems that can prove that they "improve the military's capabilities to offset the threat" will be funded. [Ref. 70:p. 21] "What is the force effectiveness tradeoff between an improved communication satellite system and a new aircraft design?" [Ref. 68:p. 389] It is not the intent of this chapter to answer these questions or solve the problems. This chapter introduces the reader to the nature of the complexity of C^2 systems and their evaluation. A general methodology for evaluating a generic system will be presented, as well as an approach to viewing complex C^2 systems.

B. SYSTEMS APPROACH

It is generally accepted that the systems approach, mentioned in Chapter VII, is the fundamental approach for C^2 system analysis. The analytical method, or scientific method, cannot solve the problems associated with modern complex C^2 systems. The analytical method is based on the concept of breaking down the system into smaller components, independently analyzing them, and then rejoining them in order to achieve an understanding for the whole system. The systems approach "does not do away with the analytical thinking," however, system thinking understands that "because of the mutual interaction of the parts, the whole takes on distinctive properties that would be lacking were one to remove a part." [Ref. 72:p. 7] The evaluation of C^2 systems requires "a mixture of art and science" to achieve "a balance between the various (system) components, which rely on many fields." [Ref. 70:p. 21] There are a variety of system theories that attempt to deal with complex systems. "Among the more popular are general systems theory

(GST), and various specialized theories like cybernetics, system analysis, system engineering, etc." [Ref. 72:p. 8] An ordering of various system approaches is depicted in Figure 22. Techniques to deal with the behavioral and organizational characteristics of the command and control process may need to be developed further [Ref. 11:p. 880].

C. GENERAL SYSTEM EVALUATION METHODOLOGY

There are basically five steps to evaluating a system:

- Establish a set of objectives;
- Establish system boundaries;
- Determine measures of performance/effectiveness;
- Perform data collection; and
- Analyze data and make conclusions.

1. Establish a Set of Objectives

The first step in any analysis is problem definition. Knowing what the problem is, or what the desired result of the analysis should be, is the main obstacle. The definition of the problem should contain a clearly stated set of objectives. The objectives should be limited to one or two primary concerns, which will later determine the system boundaries. [Ref. 72:p. 27] Appropriate assumptions must be identified and acceptable to the stated objectives [Ref. 71:p. 6-1].

2. Establish System Boundaries

The system boundary is defined "as a function of the analysis at hand" [Ref. 71:p. 2-3], that is, it is

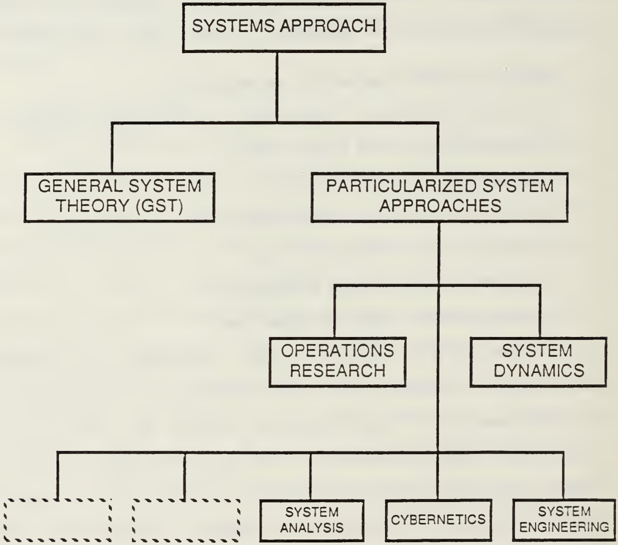


Figure 22.
Ordering of System Approaches

dependent on the objectives stated in the first step. The boundary is drawn arbitrarily around the parameters or variables being studied [Ref. 72:p. 26]. These variables are also determined by the objectives. The boundary clearly separates the system being evaluated from its external environment. Anything inside the system is controllable by the system. "The environment includes all that lies outside the system's control and that determines, at least in part, how the system performs." [Ref. 72:p. 29] All significant interactions and interfaces must occur inside the boundary. If this cannot be achieved, the analyst should thoroughly understand and determine the extent to which external interactions will impact the ongoing analysis. The determination of the system boundary is critical to the success of the evaluation. If the boundary is too narrow, it is unlikely that a meaningful solution will result, while making it too broad eliminates the chance of any real solution. Again, the objectives stated determine the system boundary. Also, analysts of different disciplines are most likely going to have different objectives, therefore the boundaries may be different, as well as the final solutions. This is acceptable, as long as the desired objectives provide solutions that are useful, accurate, and meaningful. [Ref. 72:p. 26]

3. Establish Measures of Performance/Effectiveness

Once a complete understanding of the objectives and the system boundary is achieved, the analyst can then determine some quantitative measurement of effectiveness for the system under evaluation. A measure of effectiveness (MOE) provides some meaningful reference for comparison and understanding for something that usually lacks a mathematical definition [Ref. 68:p. 389]. By using MOEs, "a highly subjective entity can be treated as though it were something rather concrete." [Ref. 68:p. 389] The Military Operations Research Society (MORS), a leader in the field of C^2 evaluation, provides the following list of desired criteria for characteristics of measures.

- Mission oriented-- Relate to force/system mission.
- Discriminatory-- Identify real differences between alternatives.
- Measurable-- Able to be computed or estimated.
- Quantitative-- Able to be assigned numbers or ranked.
- Realistic-- Relate realistically to the C^2 system and associated uncertainties.
- Objective-- Defined or derived, independent of subjective opinion. (It is recognized that some measures cannot be objectively defined.)
- Appropriate-- Relate to acceptable standards and analysis objectives.
- Sensitive-- Reflect changes in system variables.
- Inclusive-- Reflect those standards required by the analysis objectives.
- Independent-- Mutually exclusive with respect to other measures.

- Simple-- Easily understood by the user. [Ref. 71:p. 6-13]

Before proceeding, it should be noted that it has been inferred that the measurement used in the analysis may be defined as an "assignment of numerals to elements or objects according to certain rules." Although analysts make significant use of quantitative methods, "quantification is only one way of measuring. Another way of measuring, known as qualitative measurement, does exist and is as meaningful, and under certain conditions as useful, if not more so, than quantitative measurement." [Ref. 72:p. 279] Qualitative methods are more informal and descriptive, and they are often useful in describing the initial problem, which helps determine the objectives [Ref. 74:p. 6].

a. Measure of Performance (MOP)

A measure of performance (MOP) is defined as "a specific measure of a system's capability to perform internal activities, without regard to the consequences of those activities." [Ref. 70:p. 168] Performance relates to the technical capabilities inside the system boundary [Ref. 70:p. 168-169] Performance describes what a system does, for example the rate of fire, bit error rate, data storage capacity, single shot kill probability, etc. [Ref. 73:p. 25]

b. Measure of Effectiveness (MOE)

Measure of effectiveness (MOE) is described as "the quantitative expression of the extent to which specific mission requirements are attained by the system." [Ref. 73:p. 20] MOEs are "mission oriented." [Ref. 71:p. 6-12] MOEs describe what the system performance characteristics are worth with regard to the system mission objectives, for example the casualty exchange ratio, probability of mission success, etc. [Ref. 73:p. 25.] That is, how effective the system is in helping to accomplish the system's mission. Again, it must be emphasized that the "choice of an MOE depends on the system chosen for evaluation" [Ref. 73:p. 35] and its relation to the system boundary and the objectives.

c. Measure of Force Effectiveness (MOFE)

Measure of force effectiveness (MOFE) is sometimes referred to as the "utility measure." It is "a specific measure of a system's contribution to the total effectiveness of the associated combat force." [Ref. 70:p. 168] MOFEs examine what effect a complete system, like a C^2 system, has on the overall improvement of the combat forces' ability to accomplish its mission [Ref. 70:p. 168]. Utility or MOFE "relates how (technical) capabilities can be exploited to improve the effectiveness of a combat force." [Ref. 70:p. 168-169] It should be realized that a MOFE for one system can be a MOE for another, and vice versa, all dependent on system objectives and boundary. It is important to understand the distinction between utility and performance. Performance "relates to technical capabilities," and utility "exploits those capabilities to improve force or system effectiveness." [Ref. 70:p. 168-169]

> The distinction (between performance and utility) is important precisely because it is utility, and not performance, which justifies the acquisition of C^2 system hardware. A particular communication system or data-management system might perform very well in a technical sense. If, however, the technical capabilities cannot be exploited to support improved C^2 functions, the system hardware has not been justified. In the worst case, the system hardware might prove to be dysfunctional and actually degrade C^2 functions. [Ref. 70:p. 169]

4. Perform Data Collection

In order to effectively analyze a system, the analyst must have some means to collect data regarding the measurements of performance and effectiveness that have been chosen. There are a variety of data collection methods available.

a. Real World Data

Data collected from the actual use of a system in its intended environment is real world data. This is an ideal means to collect accurate data, however, it is actually the least likely when dealing with military systems designed for combat situations. Historical data is useful, but often it is too cumbersome and inaccurate to determine specific measures of effectiveness of a system's impact on the overall force effectiveness.

b. Exercise Data

Data collected from military field exercises can be very useful provided it is carefully collected and controlled. Two disadvantages are associated with this method. Field exercises cannot accurately imitate the true combat environment the system will operate in, and exercises can be very expensive and time consuming.

c. Simulations and War Games

Simulations and war games can be very productive tools for data collection. Simulation attempts to "imitate the phenomenon" in which the desired analysis is examining. "The simulation is an abstraction, but it is a very powerful abstraction when wisely employed." [Ref. 69:p. 3] War games can be either manual or computer assisted. With the aid of computers, both simulations and war games can be run many times in relatively short periods of time. The primary caution in these techniques is that the data collected is only as good as the inputs into the process. The goal is to avoid the result of "garbage in = garbage out."

d. Experimentation

Experimentation is the classic scientific method of collecting data. Experimentation is defined as the process of conducting tests or trials to verify or invalidate a hypothesis or some specific objective. It is usually limited in the amount and type of data which can be collected. Large field exercises, however, are often considered experiments.

e. Modeling

The process of modeling is the preferred means of data collection. "A model is a simplified representation of the entity it imitates or simulates." [Ref. 69:p. 1] There are three basic types of models: iconic, analogue, and symbolic. Iconic models are "physical representations of real objects, using a different scale." [Ref. 72:p. 6] Examples include miniature reproductions of airplanes, tanks, or even battlefields. Analogue models use one physical property to represent another physical property [Ref. 74:p. 6]. An example of an analogue model would be a map which uses contour lines and colors to represent heights and vegetation, respectively [Ref. 69:p. 1] The third type of model is a "symbolic or mathematical model in which we employ a set of mathematical symbols and relationships to represent some real physical situations." [Ref. 74:p. 6]

This discussion will concentrate on military modeling as described by the book <u>Military Modeling</u>, which was produced by the Military Operations Research Society (MORS), and edited by Captain Wayne Hughes, USN (Ret.), of the Naval Postgraduate School. A military model is defined as "an abstraction of reality, the elements of which are chosen for a) an investigative purpose or b) a resource management purpose, in other words, an abstraction to assist in decision making." [Ref. 69:p. 3] The goodness of a particular model is determined by "how well it achieves its purpose" or accomplishes the stated objectives of the evaluation. [Ref. 69:p. 1] Some common applications of military models are listed:

- Battle planning;
- Wartime operations;
- Weapons procurement;
- Force sizing;
- Human resources planning;
- Logistics planning;
- National policy analysis;
- Command, control, communication, and intelligence models; and
- Cost models. [Ref. 69:pp. 4-5]

All the data collection methods presented, except real world data collection, are sometimes considered to be some variant form of a model. With that perspective, Figure 23 provides a useful comparison of the various types of combat models with regard to four characteristics: operational realism, the degree of abstraction, convenience and accessibility, and the impact of human decision on the outcome. [Ref. 69:p. 10]

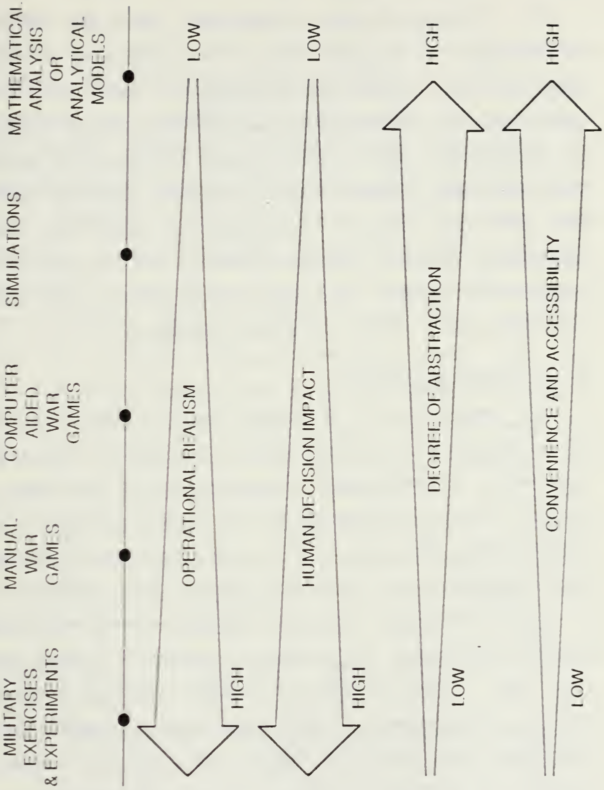


Figure 23.
The Spectrum of Combat Models vs Specific Characteristics

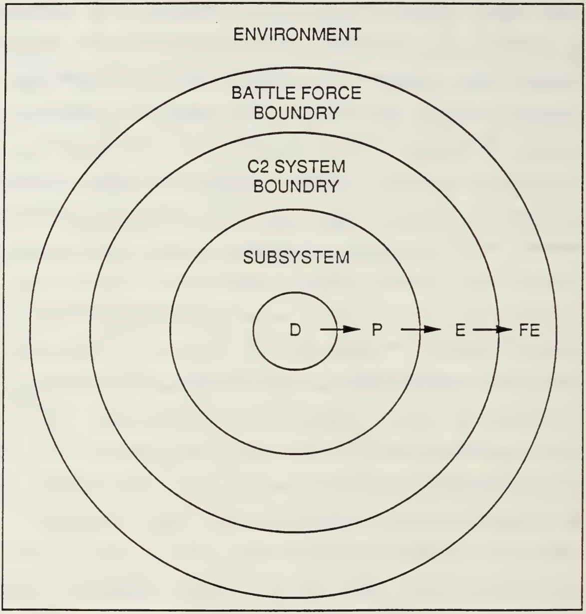
f. Analyze Data

A wide range of analytical tools are available to analyze the collected data. The decision of which analytical or statistical technique to help draw final conclusions will be largely determined by the type and means by which the data was collected. During the problem definition step, consideration should be given to exactly how the data will be analyzed in order to ensure significant results. Improper planning for the statistical analysis could result in a large amount of data that cannot be analyzed by a valid statistical procedure.

D. C^2 SYSTEM EVALUATION

The evaluation of C^2 systems can be approached from three fundamental perspectives: performance of system components, or subsystems; effectiveness of the total C^2 system; and the contribution of the system to overall force effectiveness [Ref. 15:p. 119]. Analytical techniques from many disciplines are required to gain a true understanding of the C^2 system and the relationships between each of the physical subsystems, as well as the system as a whole [Ref. 11:p. 880]. "This complex C^2 problem involving a diverse set of environments, policies, force applications, functions, and resources induces the need for means to measure C^2 assets in terms of their effectiveness in satisfying the C^2 operational requirements." [Ref. 70:p. xviii]

The diagram in Figure 24 depicts the relationships between the three perspectives and the measures used to evaluate each level. [Ref. 71:p. 2-5] Within the subsystem boundary, internal to the system boundary, the dimensional parameters and measures of performance are evaluated. Dimensional parameters include those "properties and characteristics inherent in the physical entities whose values determine system behavior and the structure under question...(size, weight, aperture size, capacity, luminosity)." [Ref. 71:p. 2-4] MOPs "measure attributes of system behavior (gain throughput, error rate, signal-to-noise ratio, display update frequency)." [Ref. 71:p. 2-6] As you go higher through the levels of command and control systems, that is, inside out in Figure 24, "the region and the number of assets that are of concern" is greater, but the level of detail required is reduced [Ref. 70:p. 119]. The unique complexity of the human interaction in C^2 systems impacts the evaluation process significantly when the system is viewed from the perspective of a total C^2 system. "Any analysis of C^2 system's utility should include an investigation of the various human decision processes supported by that system." [Ref. 70:p.169] The book entitled <u>Selected Analytical Concepts in Command and Control</u> presents an excellent discussion on the human element of complex command and control systems. Here are two excerpts from that work:



D = Dimensional Parameters
P = Measures of Performance (Variables)
E = Measures of Effectiveness (C2 System)
FE = Measures of Force Effectiveness

Figure 24.
C^2 System Measure Relationships

> ...most tactical C^2 systems exist to support human decision processes. The decision processes in turn make up the perception, assessment, planning, directing, and controlling activities which guide deployment and employment of combat forces; and
>
> ...the degree to which the technical capabilities of a C^2 system (performance) translates into combat-force effectiveness (utility) largely depends upon the human decision process which intervenes at each level within the command hierarchy. [Ref. 70:p. 169]

Once the total C^2 system effectiveness has been evaluated, the system can now be compared against equivalent measures of other weapons systems to determine the overall contributions of each system to the overall force effectiveness of the battle force in question. Dr. Mort Metersky of the Naval Air Development Center, located at Warminster, Pennsylvania, presents an evaluation approach in his December 1986 paper "A C^2 Process and an Approach to Design and Evaluation." Figure 25 provides a graphic description of that evaluation approach. [Ref. 11:p. 881] The difference between weapon systems and C^2 systems is that weapon systems are hardware intensive and C^2 systems are people intensive [Ref. 11:p. 881]. The C^2 system MOP/MOE is "a union of the C^2 process and C^2 physical component's MOPs. To combine these disparate parts into a C^2 system measure requires development of a model represented by a transfer function." [Ref. 11:p. 881] As stated earlier, the measures to evaluate the human component in the C^2 process are "different than those that measure hardware intensive C^2

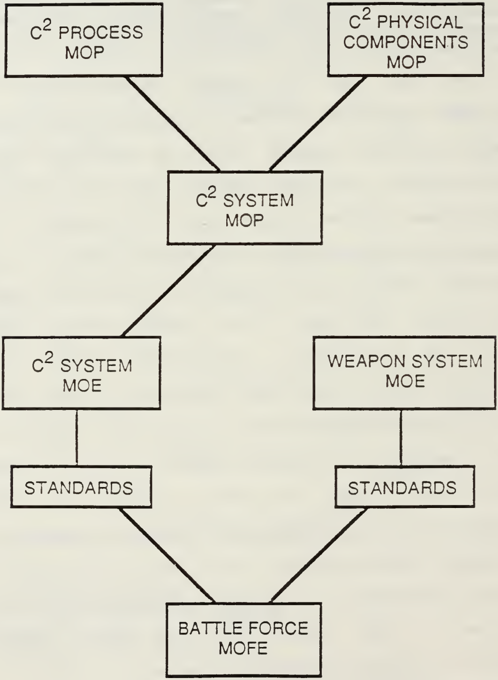


Figure 25.
C^2 System Evaluation Approach

physical components." [Ref. 11:p. 881] Dr. Metersky strongly emphasizes the need to concentrate more attention on the human element in command and control. In the past, the decision maker was usually assumed to perform in some set manner within the C^2 system, however, with the increasing advances in expert systems and artificial intelligence, "the contribution of the human element in system performance is finally becoming appreciated." [Ref. 11:p. 889]

The concept of C^2 being a "force multiplier" is derived by comparing the measure of force effectiveness of a C^2 system to "an equivalent increase in the number of naval units involved in the engagement." [Ref. 70:p. 119] In other words, does the equivalent investment in C^2 systems provide a better overall improvement of battle force effectiveness beyond that of a new weapons system or platform? If so, then C^2 is definitely a force multiplier.

IX. CONCLUSIONS

Clearly, command and control (C^2), and command and control systems, concepts, and issues are important at all levels within the military structure of the United States. This is true whether one is considering the needs of a small fighting unit or the requirements of a strategic system intended to serve all services and, perhaps, selected allies.

The very nature of command and control itself-- with its broad scope and diverse functions-- makes the task of determining a precise, all-encompassing definition for command and control very difficult. Also, the correct identification of command and control systems as such may be equally difficult. Command and control systems take many forms. There are systems for data collection, detection and warning, communications, data processing, and more. Many of these systems may appear to support functions or organizations that do not seem to be C^2 specific. However, it is the opinion of the authors of this thesis that any system which provides a flow of intelligence, data, or information to the commander, and/or allows for decisions and direction to be relayed from the commander to the forces to be controlled, fulfills vital command and control functions and is, therefore, a command and control system.

The challenges that await the C^2 specialist are many and varied. Command and control systems require continual upgrade and modernization to keep pace with new directions in technology. Also, a firm grasp of system architecture theory and command and control system evaluation is required to allow the innovative design of new systems or the remodeling of old systems. Finally, the C^2 specialist must strive to maximize command and control effectiveness while faced, as often is the case, with the problem of gaining adequate advocacy. Further, as the requirements for joint interoperability become more demanding, the more demanding will be the challenge of dealing with the problems caused by service parochialism.

This thesis has sought to present a basic introduction and overview of command and control and the wide spectrum of issues with which command and control specialists must be prepared to contend.

APPENDIX

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND TERMS

AAOC	Antiair Operations Center
AAW	Antiair Warfare
AAWC	Antiair Warfare Commander
ABCCC	Airborne Battlefield Command and Control Center
ABM	Antiballistic Missile
ACCS	Army Command and Control System
ACE	Aviation Combat Element
ADP	Automatic Data Processing
AFB	Air Force Base
AFM	Air Force Manual
ANMCC	Alternate National Military Command Center
ASOC	Air Support Operations Center
ASUW	Antisurface Warfare
ASUWC	Antisurface Warfare Commander
ASW	Antisubmarine Warfare
ASWC	Antisubmarine Warfare Commander
AWACS	Airborne Warning and Control System
BMEWS	Ballistic Missile Early Warning System
BSSG	Brigade Service Support Group
CAP	Crisis Action Procedures
CATF	Commander Amphibious Task Force
C^2	Command and Control
C^3	Command, Control, and Communications
C^3CM	Command, Control, Communications, and Countermeasures
C^3I	Command, Control, Communications, and Intelligence
C^3I^2	Command, Control, Communications, Intelligence, and Interoperability
C^3RM	Command, Control, and Communications Reference Model
C^4	Command, Control, Communications, and Computers
CFC	Combined Forces Command
CIA	Central Intelligence Agency
CINC	Commander in Chief
CINCNORAD	Commander in Chief NORAD
CINCSAC	Commander in Chief Strategic Air Command
CINCSOC	Commander in Chief Special Operations Command
CINCTRANSCOM	Commander in Chief Transportation Command
CJCS	Chairman of the Joint Chiefs of Staff
CLF	Commander Landing Forces
CMC	Cheyenne Mountain Complex
CMC	Commandant of the Marine Corps
CNO	Chief of Naval Operations

COA	Course of Action
COBRA DANE	ICBM Warning System
COC	Combat Operations Center
CP	Command Post
CPE	Conventional Planning and Execution
CRC	Control and Reporting Center
CRP	Control and Reporting Post
CSA	Chief of Staff of the Army
CSAF	Chief of Staff of the Air Force
CSS	Combat Service Support
CSSE	Combat Service Support Element
CWC	Composite Warfare Commander
DA	Department of the Army
DAF	Department of the Air Force
DASC	Direct Air Support Center
DCA	Defense Communications Agency
DCA	Defensive Counter Air
DCI	Director of Central Intelligence
DCS	Defense Communications Network
DEW	Distant Early Warning
DG	Defense Guidance
DIA	Defense Intelligence Agency
DLA	Defense Logistics Agency
DMA	Defense Mapping Agency
DNA	Defense Nuclear Agency
DOD	Department of Defense
DON	Department of the Navy
DSCS	Defense Satellite Communications System
DSP	Defense Support Program
EAM	Emergency Action Message
ELF	Extremely Low Frequency
EMP	Electromagnetic Pulse
ERCS	Emergency Rocket Communications System
FAC	Forward Air Controller
FACP	Forward Air Control Post
FDC	Fire Direction Center
FEBA	Forward Edge of the Battle Area
FLOT	Forward Line of Troops
FM	Field Manual
FMFM	Fleet Marine Force Manual
FSCC	Fire Support Coordination Center
GCE	Ground Combat Element
GST	General Systems Theory
GWEN	Ground Wave Emergency Network
HF	High Frequency
HQ	Headquarters
HUMINT	Human Intelligence

ICBM	Intercontinental Ballistic Missile
IPSP	Intelligence Priorities for Strategic Planning
JCS	Joint Chiefs of Staff
JDA	Joint Deployment Agency
JDS	Joint Deployment System
JIEP	Joint Intelligence Estimate for Planning
JOPES	Joint Operation Planning and Execution System
JOPS	Joint Operation Planning System
JPAM	Joint Program Assessment Memorandum
JRS	Joint Reporting Structure
JSAM	Joint Security Assistance Memorandum
JSCP	Joint Strategic Capabilities Plan
JSPD	Joint Strategic Planning System
JSTPS	Joint Strategic Target Planning Staff
JTF	Joint Task Force
LF	Low Frequency
LNO	Limited Nuclear Option
LOOKING GLASS	SAC Airborne Command Post
MAC	Military Airlift Command
MAF	Marine Amphibious Force
MAGTF	Marine Air-Ground Task Force
MAO	Major Attack Option
MARDEZ	Maritime Defense Zone
MEB	Marine Expeditionary Brigade
MEECN	Minimum Essential Emergency Communications Network
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MILSTAR	Military Strategic/Tactical and Relay System
MIRV	Multiple Independently Targetable Reentry Vehicle
MOE	Measure of Effectiveness
MOFE	Measure of Force Effectiveness
MOP	Measure of Performance
MORS	Military Operations Research Society
MSC	Military Sealift Command
MTBF	Mean Time Between Failure
MTMC	Military Traffic Management Command
NATO	North Atlantic Treaty Organization
NAVGUARD	Navy Coast Guard
NCA	National Command Authority
NEACP	National Emergency Airborne Command Post
NMCC	National Military Command Center
NMCS	National Military Command System
NME	National Military Establishment
NORAD	North American Aerospace Defense Command
NPE	Nuclear Planning and Execution

NSA	National Security Agency
NSC	National Security Council
NSDD	National Security Decision Directive
NUDET	Nuclear Detonation
NWP	Naval Warfare Publication
NWS	North Warning System
OCA	Offensive Counter Air
OJCS	Office of the Joint Chiefs of Staff
O-O-D-A	Observe, Orient, Decide, Act
OPCOM	Operational Command
OPCON	Operational Control
OPLAN	Operation Plan
OPORD	Operation Order
OPSEC	Operations Security
OSD	Office of the Secretary of Defense
OSI	Open System Interconnection
OTC	Officer in Tactical Command
OTH-B	Over-the-Horizon Backscatter Radar
PACCS	Post Attack Command and Control System
PARCS	Perimeter Acquisition Radar Attack Characterization System
PAVE PAWS	SLBM Warning System
PDM	Program Decisions Memorandum
POM	Program Objective Memorandum
PPBS	DOD Planning, Programming, and Budgeting System
RAOC	Rear Area Operations Center
RNO	Regional Nuclear Option
ROC	Required Operational Capability
ROE	Rules of Engagement
RUM	Resource and Unit Monitoring
SAC	Strategic Air Command
SACEUR	Supreme Allied Commander, Europe
SACLANT	Supreme Allied Commander, Atlantic
SAO	Selective Attack Option
SDI	Strategic Defense Initiative
SEAD	Suppression of Enemy Air Defenses
SECDEF	Secretary of Defense
SHF	Super High Frequency
SIG	Senior Interagency Group
SIOP	Single Integrated Operational Plan
SLBM	Sea Launched Ballistic Missile
SLOC	Sea Lines of Communication
SSBN	Fleet Ballistic Missile Submarine
TAC	Tactical Command Post
TACAMO	Take Charge and Move Out
TACC	Tactical Air Command Center (USMC)
TACC	Tactical Air Control Center (USAF)

TACP	Tactical Air Control Party
TACS	Tactical Air Control System
TADC	Tactical Air Direction Center
TAF	Tactical Air Forces
TAOC	Tactical Air Operations Center
TELNET	Telecommunication Network
TLWR	Top Level Warfare Requirements
TOC	Tactical Operations Center
TPFDD	Time-Phased Force Deployment Data
UHF	Ultra High Frequency
USA	U.S. Army
USAF	U.S. Air Force
USAFSO	U.S. Air Force South
USARSO	U.S. Army South
USCENTCOM	U.S. Central Command
USCG	U.S. Coast Guard
USCINCCENT	Commander in Chief Central Command
USCINCEUR	Commander in Chief European Command
USCINCLANT	Commander in Chief Atlantic Command
USCINCPAC	Commander in Chief Pacific Command
USCINCSOUTH	Commander in Chief Southern Command
USCINCSPACE	Commander in Chief Space Command
USEUCOM	U.S. European Command
USLANTCOM	U.S. Atlantic Command
USMC	U.S. Marine Corps
USN	U.S. Navy
USNAVSO	U.S. Navy South
USPACOM	U.S. Pacific Command
USSOCOM	U.S. Special Operations Command
USSOUTHCOM	U.S. Southern Command
USSPACECOM	U.S. Space Command
USTRANSCOM	U.S. Transportation Command
VHF	Very High Frequency
VLF	Very Low Frequency
WIN	WWMCCS Intercomputer Network
WIS	WWMCCS Information System
WOC	Wing Operations Center
WSA & E	Warfare System Architecture and Engineering
WWABNCP	Worldwide Airborne Command Post
WWMCCS	Worldwide Military Command and Control System

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