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Combat Operations C^3I

Fundamentals and Interactions

by

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DISCLAIMER-ABSTAINER

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Foreword

Command, control, communications, and intelligence have been subjects of military importance since before the dawn of recorded history. The advent of modern three dimensional warfare in the 20th century has only exacerbated the need for superior capabilities in these areas. Coordinated high-speed maneuvers on land, at sea, and in the air cannot be achieved or countered without effective command structures, control mechanisms, communications systems, and intelligence capabilities. Such is the complex nature of modern war.

Unfortunately, the existence of command, control, communications, and intelligence (C^3I) structures, mechanisms, systems, and capabilities does not guarantee success. Command structures must be integrated across several operating mediums, control mechanisms must be appropriate for the diverse forces involved, communications must be fast and secure, and intelligence must be definitive and useful. More importantly, the C^3I capabilities and operations must be appropriate for the combat operations and the types of forces they support. It is this last area—appropriate C^3I capabilities and operations—that Major Orr investigates.

Before one can determine what is appropriate, one must understand the context of the problem. And thus it is that Major Orr attacks the basic problem of producing a conceptual model of the combat operations process. Only after he establishes the context, a paradigm of warfare based on classical literature, does he discuss the appropriate C^3I architecture that will yield the desired results.

In a larger sense, Major Orr's study is an attempt to redefine the nature of modern technology-intensive warfare. This is a broad and contentious problem. While the reader may not agree with all of Major Orr's assumptions and conclusions, this larger effort is vital to the American military's capability to cope successfully with a rapidly changing and increasingly dangerous world. In this larger sense, the importance of Major Orr's study goes far beyond the particular problems of C^3I.

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Preface

This study summarizes a wide-ranging investigation of combat operations, military theory, and command, control, communications, and intelligence (C^3I) that occurred during my 1981–82 tour at the Airpower Research Institute (ARI) as a research associate sponsored by Air Force Systems Command (AFSC). In previous assignments, I had used my training in mathematics and computer science in formulating, implementing, and using computer models of pieces of the combat operations process. I had also been introduced to C^3I systems and concepts during an extensive review of AFSC analysis efforts related to C^3I. These experiences left me dissatisfied with the treatment of strategy and C^3I in engagement modeling. Therefore, when AFSC asked for nominations for the ARI, I applied and suggested an investigation of the interrelation between C^3I and strategy as a research topic.

At ARI I was exposed to a vast amount of literature on military theory and combat operations. I spent much time reviewing books and periodicals to learn what was known about military theory and about possible changes in the combat operations process. I learned of impressive collections of observations and principles derived from these observations but found little basic unifying theory. Distinctions between such concepts as grand strategy, strategy, grand tactics, and tactics were very confusing and made me very uncomfortable. I concluded that I had little hope of understanding the role of C^3I in combat operations unless I could find some unifying fundamental structures or processes which could describe strategy and combat operations.

During this period, two unplanned events—made possible by ARI's access to guest speakers at the Air Force schools at Maxwell AFB—significantly influenced the direction of my research. The first was a briefing by John Boyd to the Air War College. Boyd's briefing introduced me to the concept of defeating an enemy by attacking his combat operations process rather than by destroying his forces. The idea of attacking an enemy's combat operations process, and especially the decision functions within that process, is seen throughout this research. The second event was an informal briefing given by Colonel Bart Krawetz to ARI. In this briefing, Colonel Krawetz introduced the concept of battlefield momentum and its use in battle management. This concept was the beginning of the concept of power distribution and my interpretation of command as the control element in the evolution of that power distribution.

My research eventually focused on two areas. The first was a search for a unifying concept to explain strategy and combat operations. The second was an attempt to understand C^3I in terms of this concept. The five chapters of this study trace my investigations and conclusions in these areas.

Chapter I summarizes the work of the military theorists I found most useful and discusses the American approach to war. Challenges to this approach by advocates of "maneuver warfare" also receive attention. These summaries form the basis for later comments on the nature of war and the combat operations command process.

Chapter II introduces the basic definitions, functions, and process of C^3I. I then modify a conceptual model of the C^3I process to produce a conceptual model of the combat operations process. The detailed discussion of the decision and force application functions within this process introduces two additional conceptual models. The power distribution model describes combat in terms of the location of sources of power and the ability of these power sources to apply military force. This model includes the evolution of this power distribution due to maneuver and actual combat interactions. This power distribution model is the basis for the discussion of command in Chapter III. The second model is introduced in the military problem-solving process model. This model, applied to the problem of controlling the evolution of the power distribution, provides the framework for the investigation of effective command of the combat operations process.

Chapter III looks at the concept of command in combat operations. It identifies and discusses the implications of the stochastic nature of combat operations—the unpredictability of combat results and the uncertain, probabilistic nature of combat. Theoretical concepts are illustrated using simple military examples. As a result of these observations, the chapter defines military command as control of the evolution of the power distribution, and it links strategy to the problem of influencing this evolution into desirable patterns.

Chapter IV expands upon this last concept by using the military problem-solving process model as a guide to effective command. Combat is viewed as a "dialetic" between problem solvers, and the military problem-solving process model is used to suggest ways to facilitate friendly problem solving and disrupt enemy problem solving. The chapter examines the military theories presented Chapter I within this framework.

The final chapter examines more closely the role of C^3I within the combat operations process. It stresses the inseparability of C^3I and combat operations by examining the combat operations process model and the military problem-solving process model. Addressing the question of the proper role of C^3I within the combat operations process, the chapter shows that the answer to this question depends upon the perceived fundamental nature of combat operations and upon the perceived desirable military command style. It concludes with an argument that a distributed C^3I architecture designed to exploit the stochastic nature of combat is best suited to the true nature of combat and the strengths of American fighting units.

This research has significantly changed my original perceptions of C^3I and the combat operations process. A particular revelation to me was the profound influence of the stochastic nature of combat upon the evaluation of command decisions. This has caused me to question the blind application of techniques developed to deal with deterministic or moderately stochastic processes to combat operations. It has also provided me with a handle to begin wrestling with the difficult concepts of strategic flexibility, responsiveness, and adaptability. This study in no way provides final answers. I hope that it will stimulate useful and thoughtful discussions among the strategists who guide combat operations, the operational planners who give the strategies form, and the analysts who are asked to evaluate proposals concerning combat operations.

My year at the Airpower Research Institute was a great opportunity for me. I thank the Air Force Systems Command for selecting me as its research associate and for giving me the freedom to follow a sometimes wandering eclectic approach to the study of combat operations and C^3I.

The excellent facilities and people at Air University contributed much to my research. The Air War College and Air Command and Staff College were sources of insight through their courses and their excellent guest speaker programs. The facilities and staff of the Air University Library eased the burden of research. And the most valuable resource was the Airpower Research Institute itself—the permanent staff, the word processing center, the editors, and, above all, my fellow research associates. I thank them all. My thanks also to my wife, Tish, and daughter, Christina, who make everything worthwhile.

George E. Orr

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Chapter I

Combat Operations

An attempt to understand C^3I and combat operations should begin with the time-tested theories of military theorists. The term "combat operations" in this study denotes all of the activities involved in the application of military force. It does not encompass the nonmilitary instruments of national power but does include much more than just the battle—the actual physical clash of armed forces.

> In war conducted by military forces the act of battle is a phase limited in time, a culminating point. The forces to be engaged must first be brought within range of each other and naturally each side will try to go into battle in conditions most favorable to itself. The sum total of the dispositions and maneuvers which go to make up this process is known as "operations."[1]

This study includes both operations in this sense and battle in the concept of combat operations. This chapter presents a summary of the work of Sun Tzu, Carl von Clausewitz, and Andre Beaufre. These theorists are most relevant to the work presented in later chapters. The chapter also reviews the uniquely American approach to war, along with challenges to this approach advanced by advocates of "maneuver warfare." These summaries provide a basis for evaluating the combat operations process model and problem-solving approach to military theory presented in later chapters.

Sun Tzu

Sun Tzu's *The Art of War* is believed to date from around 400–320 BC. It was introduced to the West in 1772 in a translation by a Jesuit missionary. In a more recent translation, Samuel B. Griffith notes that Sun Tzu was

> not interested in the elaboration of involved stratagems or in superficial and transitory techniques. His purpose was to develop a systematic treatise to guide rulers and generals in the intelligent prosecution of successful war. He believed that the skillful strategist should be able to subdue the enemy's army without engaging it, to take his cities

> without laying siege to them, and to overthrow his State without bloodying swords.[2]

Much is covered in this poetic and terse work. Sun Tzu was writing for a vastly different time and military system, so there is some danger of reading more into his statements than was there originally. Even so, the seemingly "modern" flavor of many of his observations is impressive. The organization of *The Art of War* also presents some difficulties since observations about issues of current interest are somewhat scattered. This review regroups observations to show Sun Tzu's thoughts on the objectives of war, civil-military relations, principles of war, and tactical matters.

Objectives of War

Sun Tzu stresses the vital importance of war to the very survival of the state and commends its careful study.[3] This emphasis is due to his recognition that war in his day was no longer a game played by rulers but was now a serious instrument of national power. Victory was the main object,[4] but a quick decision was essential since "there has never been a protracted war from which a country has benefited."[5] His advice on the employment of military force holds strongly today: "If not in the interests of the state, do not act. If you cannot succeed, do not use troops. If you are not in danger, do not fight."[6]

Civil-Military Relationships

Sun Tzu recognized the control of the ruler over the army but interpreted the relations between ruler and general in the manner of General Douglas MacArthur. The ruler deliberates upon the plans, and the good general executes them.[7] Sun Tzu was acutely aware of the troubles that result when the ruler interferes with the general's command, and he listed many in detail.[8] He was also, to continue the MacArthur parallel, very aware of character flaws in generals which could lead to disaster.[9] He is quite clear on the relationship, however, when he states that "there are occasions when the commands of the sovereign need not be obeyed."[10]

Principles of War

The principles advanced by Sun Tzu emphasize deception, shaping enemy perceptions, knowledge of your own and your enemy's situation, and the use of normal and extraordinary force in battle. "All warfare is deception,"[11] says Sun Tzu, and his tactical prescriptions reinforce this idea again and again. His goal is to confound his enemy so much that even mistakes by his troops will be seen by the enemy as traps to be avoided! He advocates heavy use of secret agents, traps, and maneuvers to determine the enemy disposition or shape while concealing his own. He recommends dispersion and concentration to give the appearance of confusion and chaos while masking strength.[12] Knowledge is the key to success. As Sun Tzu says, "Know the enemy and know yourself; in a hundred battles you will never be in peril."[13]

The concepts of normal force (direct or *Cheng)* and extraordinary force (indirect or Ch'i) are crucial in Sun Tzu's system. The normal force sends strength against strength and is used to fix or distract the enemy. The extraordinary force sends strength against weakness in unexpected places at unexpected times. If a *Ch'i* maneuver is detected and countered, it automatically becomes a *Cheng* maneuver. "Generally, in battle, use the normal force to engage; use the extraordinary to win."[14] These two forces combine in patterns, that shape and decide battles. "In battle there are only the normal and extraordinary forces, but their combinations are limitless; none can comprehend them all. For these two forces are mutually reproductive; their interaction as endless as that of interlocked rings. Who can determine where one ends and the begins?"[15]

The principles advanced were to be employed to take the enemy state intact, not to ruin it. Capture of the enemy's army, not its destruction, was the goal. "For to win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill."[6] To accomplish this, Sun Tzu lists objectives in priority order. Attacking the enemy's strategy is of first importance, followed by disrupting his alliances. In third place is attacking his army, and a poor last, to be used only when there is no alternative, in attacking his cities.[17]

Sun Tzu also warns about failure to carry through. "Now to win battles and take your objectives, but to fail to exploit these achievements is ominous and may be described as 'wasteful delay.'" He characterizes a successful campaign as having been carefully prepared through deception, misdirection, and political, maneuvering before it begins. "Thus a victorious army wins its victories before seeking battle; an army destined to defeat fights in hope of winning."[18] Sun Tzu's operational art is designed to help in this preparation.

Tactical Principles

Four of Sun Tzu's major tactical principles—adaptability, initiative, concentration and dispersion, and unpredictability—are of concern to modern military forces. Many other current issues are also anticipated to some degree.

Adaptability or responsiveness to the enemy situation is crucial. War has no fixed form, so the ability to improvise according to the enemy situation is essential. "Now the crux of military operations lies in the pretense of accommodating one's self to the designs of the enemy."[19] "The doctrine of war is to follow the enemy situation in order to decide on battle."[20] "And as water has no constant form there are in war no constant conditions. Thus, one able to gain victory by modifying his tactics in accordance with the enemy situation may be said to be divine."[21]

Responsiveness to the enemy did not translate into passive defense. Initiative could be gained by forcing the enemy into disadvantageous situations. Sometimes this could be accomplished by seizing something he valued highly. At other times apparently easy targets or other advantages could be offered. The sudden appearance of troops at unexpected places could force a hasty redeployment. Dispersal and concentration of forces could have the same effect. The ultimate purpose was to bring the enemy to the field of battle, not to be brought by him.[22] Concentration and dispersion were key tactics. They could be used to create changes in the situation to deceive the enemy and to force him to respond. Rapid concentration from a dispersed deployment could create local numerical superiorities giving victory. Such an ability to concentrate effectively could even nullify an overall numerical advantage. Similarly, lack of knowledge of the actual point of attack could force the defender to weaken himself by defending points selectively or spreading himself too thin by defending all points of attack. An attacker with the ability to determine the actual situation could use concentration with decisive effect.[23]

Unpredictability was crucial in a strategy founded on deception. Apparent confusion and disorder made maneuvers hard to understand and counter. Great discipline and strength were required to maintain such an appearance. The ultimate aim was to have no detectable "shape" so the enemy's efforts to determine your situation were sure to fail. Success was assured by attacking where the enemy did not defend and by defending where he could not, or dared not, attack. Against the skilled general, the enemy did not know where to defend or where to attack. And the general tried to keep it that way by never repeating successful tactics or revealing the pattern of his methods.[24]

Sun Tzu stressed many other tactical principles that apply today. "Speed is the essence of war. Take advantage of the enemy's unpreparedness; travel by unexpected routes and strike him where he has taken no precautions."[25] He also stressed the value of momentum and timing, of interdiction tactics, of deep penetration into enemy territory to disrupt and confound, and of economy of force.[26]

Sun Tzu also concerned himself with matters of command and control. He advocated a hierarchial organization to allow many to be controlled as easily as a few. Signals to coordinate separate units in battle were essential. Hopefully modern electronic warfare will not cause us to revert to banners, flags, gongs, drums, torches, and bells, but it is nice to know such techniques have Sun Tzu's blessing![27]

Several of Sun Tzu's recommendations reflect special conditions within the military forces of the day. Soldiers could not always be trusted to fight when threatened with possible death. Hence, "to assemble the army and throw it into a desperate position is the business of the general." A necessary tactic is to arrange situations in which one's own troops have no escape because this results in "utmost efforts." For the same reason, when surrounding an enemy army, one should leave an escape route so the enemy can run rather than fight. On the other hand, if his troops are surrounded and left an escape route, the general was advised to shut off the escape route himself. Such maneuvering was required in a world of mercenary soldiers who frequently switched sides and could not be trusted by their commanders![28]

The general style of warfare described by Sun Tzu prevailed until the end of the 18th century. The techniques employed in Europe during this period are virtually indistinguishable from those advocated by Sun Tzu used in China. But advances in weapon technology and changes in political structure inevitably change the way wars are fought. The increased firepower provided by the extensive deployment of firearms, coupled with other changes in weapon technology and political structure, revolutionized the art of war, especially in the hands of the greatest master of the techniques of the time, Napoleon. Napoleon's early successes, and his later difficulties, created great turmoil and confusion among theorists of war. Out of the chaos of this period arose Carl von Clausewitz, perhaps the greatest student of military theory of all times.

Carl von Clausewitz

Carl von Clausewitz was an early 19th century soldier in the Prussian and Russian armies and a scholar whose keen observations on the nature of war are influential today. Clausewitz was impressed with the successes of the revolutionary armies of France and recognized the changes in warfare signaled law by their appearance. Clausewitz gathered his observations into a book which he was writing at the time of his death in 1831. His wife published his unfinished manuscripts. *On War,* in the translation by Michael Howard and Peter Paret, is the basis following review of Clausewitz's work.

Clausewitz was profoundly impressed with three aspects of war: its fundamentally violent nature, its inevitable association with chance and uncertainty, and its intimate relation with politics. His observations and analyses of these three aspects of war form a large portion of the body of his book.

Starting from the notion that war is an "act of force to compel our enemy to do our will," Clausewitz concludes—somewhat in opposition to the view expressed by Sun Tzu and practiced independently by 18th century warriors in Europe—that violence carried to extremes is the fundamental, unavoidable essence of war considered in the abstract.

> Kind-hearted people might of course think there was some ingenious way to disarm or defeat an enemy without too much bloodshed, and might imagine this is the true goal of the art of war. Pleasant as it sounds, it is a fallacy that must be exposed: war is such a dangerous business that the mistakes which come from kindness are the very worst.
>
> If one side uses force without compunction, undeterred by the bloodshed, it involves while the other side refrains, the first will gain the upper hand. That side will force the other to follow suit; each will drive its opponent towards extremes, and the only limiting factors are the counterpoises inherent in war.
>
> To introduce the principle of moderation into the theory of war itself would always lead to logical absurdity.
>
> War is an act of force, and there is no logical limit to the application of that force.[29]

Thus, Clausewitz regarded the fundamental nature of war as a clash of unlimited violence between opponents, involving maximum exertion on each side, culminating in a great decisive struggle from which one arose victorious. He immediately observed that actual wars never seem to fit this model of pure war and set out to discover why violence is limited in actual war. He observed that reality differs from the model in that war is never an isolated act, that war does not consist of a single short blow, and that the results in war are never final. Then he introduced his two other dominant themes: the inevitable association of war with chance and the intimate relation of war and politics.

The unavoidable presence of chance, uncontrollable and unpredictable elements in war, meant that the probabilities of real life replaced the extremes and absolutes required by theory. Dealing with such uncertainty and chance then became the primary duty of the commander.

> No other human activity is so continuously or universally bound up with chance. And through the element of chance, guesswork and luck come to play a great part in war.

> The art of war . . . must always leave a margin for uncertainty. . . . With uncertainty in one scale, courage and self-confidence must be thrown into the other to correct the balance.[30]

This total permeation of warfare by chance led Clausewitz to compare war to gambling. Yet he acknowledged its deadly serious purpose in the intelligent pursuit of the purposes of policy.

> War is an act of policy. . . . War is a pulsation of violence, variable in strength and therefore variable in the speed with which it explodes and discharges its energy. War moves on its goal with varying speeds; but it always lasts long enough for influence to be exerted on the goal and for its own course to be changed in one way or another—long enough, in other words, to remain subject to the action of a superior intelligence. . . . If we keep in mind that war springs from some political purpose, it is natural that the prime cause of its existence will remain the supreme consideration in conducting it. That, however, does not imply that the political aim is a tyrant. It must adapt itself to its chosen means, a process which can radically change it; yet the political aim remains the first consideration. Policy, then, will permeate all military operations, and, in so far as their violent nature will admit, it will have a continuous influence on them.[31]

This theme of political dominance of the military is found throughout Clausewitz's book. He continually stressed that war cannot be considered an entity in itself. "We maintain, on the contrary, that war is simply a continuation of political intercourse, with the addition of other means."[32]

Clausewitz summarized his views on war in these words:

> War is more than a true chameleon that slightly adapts its characteristics to the given case. As a total phenomenon its dominant tendencies always make war a remarkable trinity—composed of primordial violence, hatred and enmity which are to be regarded as a blind natural force; of the play of chance and probability within which the creative spirit is free to roam; and of its element of subordination, as an instrument of policy, which makes it subject to reason alone.[33]

Having established a framework for war, Clausewitz directed his attention to questions on the best way to wage war within its overall political guidance. He identified three broad objectives for the use of military force. First is the destruction of enemy fighting forces. By this he meant that "they must be put in such a condition that they can no longer carry on the fight."[34] Secondly, there is the occupation the enemy country to prevent fresh military forces from being raised. Finally, the enemy's will must be broken. Clausewitz noted that this aim of disarming the enemy is a theoretical goal which must not be given the force of law or considered a precondition for peace. He further notes that the inability to carry on the fight as grounds for making peace can also be replaced by knowledge of the improbability of victory or of the unacceptable cost of victory.[35] These relate directly to modern concepts of deterrence. Clausewitz, having noted alternatives, concentrated on the goal of disarming the enemy throughout his book. This seems to be based upon the positive approach implied in this goal in contrast to the other negative objectives.

Clausewitz suggested a number of objectives to "make success more likely." First are objectives leading directly to the enemy's collapse. These include destruction of his armed forces and conquest of his territory. Other operations have direct political impact. These include disrupting or paralyzing enemy alliances or gaining new allies for ourselves. Other means to induce the enemy to expend great effort are also suggested. These include invasion which requires great effort to expel, giving priority to operations increasing enemy suffering, and, most importantly, operations designed to wear down the enemy.

> We can now see that in war many roads lead to success, and that they do not all involve the opponent's outright defeat. They range from the destruction of the enemy's forces, the conquest of his territories, to a temporary occupation or invasion, to projects with an immediate political purpose, and finally to passively awaiting the enemy's attacks.[36]

Clausewitz extensively discussed the means available to achieve these objectives. He distinguished between tactics, which involve the use of armed forces in engagements, and strategy, which combines engagements to obtain the political object of the war. In tactics, then, the means are properly trained, equipped, and supported fighting men; while in strategy, the means are coordinated tactical successes. "The original means of strategy is victory—that is, tactical success; its ends, in the final analysis, are those objects which will lead directly to peace."[37]

Clausewitz, in the course of his analyses, introduced two further concepts of value today. One he refers to as "friction" for explaining why things fail to work out as planned. The other key concept for decisive victory he refers to as "center of gravity."

Friction, in Clausewitz's terms, is "the force that makes the apparently easy so difficult." It is the product of the many small mistakes, delays, miscalculations, and conflicts that occur in any large organization. When considered in conjunction with the chance and uncertainty that penetrates every military action, friction is the most important factor in actual military operations. Most of Clausewitz's tactical prescriptions can be viewed as attempts to overcome friction. There is, in Clausewitz's view, only one true lubricant, and that is combat experience. Training and exercises are only poor substitutes for actually experiencing the chaos of battle.

The concept of "center of gravity" is related to Clausewitz's analysis of requirements for the defeat of the enemy. Such requirements are not constant but depend upon the actual situation.

> What the theorist has to say here is this: one must keep the dominant characteristics of both belligerents in mind. Out of these characteristics a certain center of gravity develops, the hub of all power and movement, on which everything depends. That is the point against which all our energies should be directed.[38]

Such centers of gravity vary over history. The army of Alexander was his center of gravity. In countries subject to civil strife, the capital is frequently the center of gravity. For smaller countries defended by a larger one, the army of the protector is usually a center of gravity. In popular uprisings, it may be the personalities of leaders. Identification of the proper center of gravity, then, is the key problem for the military commander.

Clausewitz dealt with many of the strategic and tactical principles covered by Sun Tzu. A review of some of these principles follows. Clausewitz stressed the advantage of defense over offense. This asymmetry, supported by historical data, is one of his explanations for the intermittent nature of engagements as opposed to the continuous effort predicted by the model of pure war. Clausewitz's concept of defense, it should be noted, is not static but is a "shield made up of well-directed blows." The principal advantage of the defense is that the defender benefits from the time which is allowed to pass unused by the attacker. Any error in the attacker's plan also benefits the defender. Clausewitz's belief that defense should be converted to offense when possible corresponds to that of Sun Tzu.

Another problem for the attacker is related to Clausewitz's concept of the "culminating point of battle." According to Clausewitz, any attack consumes energy and thus diminishes in force as it progresses. Then comes a crucial point in the advance when the attacker can convert to defense with enough strength remaining to hold his gains. This crucial point is the "culminating point of attack." A miscalculation here opens the attacker to a decisive counterattack. These determinations are extremely difficult, and hence cause great problems for the attacker.

Clausewitz addresses the question of numerical superiority in several places. Sun Tzu greatly downplayed the need for numerical superiority, and Clausewitz agrees that superiority is not an absolute requirement.

> But superiority varies in degree. It can be two to one, or three or four to one, and so on; it can obviously reach the point where it is overwhelming. In this sense superiority of numbers admittedly is the most important factor in the outcome of an engagement, so long as it is great enough to counterbalance all other contributing circumstances. It thus follows that as many troops as possible should be brought into the engagement at the decisive point.[39]

Surprise was one of Sun Tzu's key principles. Clausewitz acknowledged that surprise—which depends on secrecy, speed, and conditions beyond the commander's control—can be useful but contended that it is not decisive.

> But while the wish to achieve surprise is common, and, indeed, indispensable, and while it is true that it will never be completely ineffective, it is equally true that by its very nature surprise can rarely be *outstandingly* successful. It would be a mistake, therefore, to regard

> surprise as a key element of success in war. The principle is highly attractive in theory, but in practice it is often held up by the friction of the whole machine.[40]

Cunning was another of Sun Tzu's key principles. Clausewitz is very negative on concepts such as cunning or stratagems.

> Yet however much one longs to see opposing generals vie with one another in craft, cleverness, and cunning, the fact remains that these qualities do not figure prominently in the history of war. . . . We conclude that an accurate and penetrating understanding is a more useful and essential asset for the commander than any gift for cunning.[41]

To replace surprise and cunning as the basis for victory, Clausewitz proposes concentration of forces.

> The best strategy is always *to be very strong;* first in general, and then at the decisive point. Apart from the effort needed to create military strength, which does not always emanate from the general, there is no higher and simpler law of strategy than that of *keeping one's forces concentrated*.[42]

Clausewitz's emphasis on the necessity of concentrating forces at the decisive point determined his concept of the proper use of strategic reserves and economy of force. To Clausewitz, the strategic reserve makes sense only until the decisive point has been found and exposed. All available troops should then be committed to the decisive battle. This for Clausewitz is economy of force.

> When the time for action comes, the first requirement should be that all parts must act: even the least appropriate task will occupy some of the enemy's forces and reduce his overall strength, while completely inactive troops are neutralized for the time being.[43]

Clausewitz uses the concepts of direct and indirect action in a more restricted sense than Sun Tzu.

> These results, moreover, are of two kinds: direct and indirect. They are indirect if other things intrude and become the object of the engagement—things which cannot in themselves be considered to involve the destruction of the enemy's forces, but which lead up to it.[44]

Clausewitz summarized his philosophy of the use of battles in Chapter 11 of Book 4. For all wars, the destruction of the enemy force is the overriding principle. This usually involves fighting, and usually requires major engagements involving all forces for major successes. The greatest successes follow great battles, which are the only ones the commander in chief personally directs. Clausewitz noted that historians had tried to disprove this thesis, but insisted that "recent history" had proven him correct.

Clausewitz voiced very definite opinions about the value of theory to the military commander. He felt that theory is a valuable starting point for study, not a compilation of answers. Indeed he felt that theory could never adequately solve the problem of war.

> Given the nature of the subject, we must remind ourselves that it is simply not possible to construct a model for the art of war that can serve as a scaffolding on which the commander can rely for support at any time. Whenever he has to fall back on his innate talent, he will find himself outside the model and in conflict with it; no matter how versatile the code, the situation will always lead to the consequences we have already alluded to: *talent and genius operate outside the rules, and theory conflicts with practice.*[45]

Clausewitz summarized his own viewpoint by insisting on clear objectives and then laying out tasks for the military to achieve these objectives.

> No one starts a war—or rather, no one in his senses ought to do so—without first being clear in his mind what he intends to achieve by that war and how he intends to conduct it. The former is its political purpose; the latter its operational objective.[46]

Once the objectives are identified, all military action depends on two great principles.

> The first principle is that the ultimate substance of enemy strength must be traced back to the fewest possible sources, and ideally to one alone. The attack on these sources must be compressed into the fewest possible actions—again, ideally, one. Finally, all minor actions must be subordinated as much as possible. In short the first principle is: act with the utmost concentration.
>
> The second principle is: act with utmost speed. No halt or detour must be permitted without good cause.[47]

The principles and prescriptions laid down by Clausewitz have had great influence on later military thinkers, especially those on the European continent. Further changes in weapons technology and political structure have, however, caused still more significant changes in concepts of combat operations. Andre Beaufre, a French general, has been intimately involved in this period of dynamic change and has written several insightful books on military strategy.

Andre Beaufre

General Andre Beaufre served on the French general staff from the mid-1930s to the mid-1960s. He had major responsibilities in World War II, in Algeria, in the Suez expedition, and in the North Atlantic Treaty Organization (NATO). As a result, he personally experienced many dramatic changes in warfare. He recorded his observations in several books. Three of them—*Introduction to Strategy, Deterrence and Strategy,* and *Strategy of Action*—form the foundation of his views on war. These works are the basis for this review.[48]

Beaufre presents an interesting analysis of the evolution of concepts of battle and operations which reviews and extends the views of Sun Tzu and Clausewitz. Beaufre notes that the

> capacity of armed forces to produce decision varied fundamentally throughout history depending upon operational capabilities at the time and these, in turn, depended upon the armament, equipment, tactics, and supply procedures of the opposing sides.[49]

Battle was, of course, not a simple matter. Battles were preceded by a preparatory phase consisting of feints and harassing actions. These actions were designed to pin down the enemy force; to shake morale by means of fear, fatigue and losses; and then to concentrate against the decisive point on a flank or in the center. The preparatory maneuver was designed to cause the enemy to spend reserves either by committing them in false directions or frittering them away in local actions. This pattern formed the basic principles used by Beaufre (and attributed to Marshal Ferdinand Foch of France). The concept is that victory results from a successful preparatory maneuver which allows the culminating decisive attack. This was termed "freedom of action." Since blocking the enemy's preparatory maneuver was required, forces had to be divided for blocking, preparatory, and decisive actions. An optimal allocation was called "economy of force." Beaufre's abstract formula for victory was "to reach the decisive point thanks to the freedom of action gained by sound economy of force."[50]

The essence of this prescription is simple, but Beaufre recognizes Clausewitzian friction as a primary factor. He stresses this friction along with psychological aspects of warfare throughout his work.

> More therefore than all plans and schemes based on material factors, the art of battle consists in maintaining and strengthening the psychological cohesion of one's own troops while at the same time disrupting that of the enemy's. *The psychological factor is therefore all-important.*[51]

Beaufre's analysis of combat operations provides a framework for the use of the military in pursuit of national objectives. Beaufre emphasizes the integration of politics and the military even more than Clausewitz. He insists on the concept of "total strategy," incorporating all instruments of national power. Total strategy is defined as the art of applying force so that it makes the most effective contribution towards achieving the ends set by political policy. It is the "art of the dialectic of two opposing wills using force to resolve their disputes."[52]

This strategy must govern action in a complex international environment. Beaufre considers the typical situation to involve a protagonist, A_1, along with his allies A_2, A_3, etc. Opposed to this group is a second group—B_1, B_2, B_3, etc. Finally, sitting on the sidelines is a third group of uncommitted parties—C_1, C_2, C_3, etc. A_1's problem is, with the support of the other As, to convince the Bs to conform to his wishes, while insuring that the Cs either assist the As or at least refrain from interfering. Beaufre notes that the Cs can be decisive except in the unusual case when the As have power exceeding the combined power of the Bs and Cs. Hence, the As must work hard to win over Cs, and so must the Bs.

This sets the stage for Beaufre's notion of *direct and indirect modes of strategy*. In the direct mode, the As directly confront the Bs. Stable results depend upon agreement or inactivity on the part of the Cs. The use of rapid decisive action to present a *fait accompli* is desirable. In the indirect mode, the As and Bs do not directly confront one another, but instead act on the Cs to obtain their support. Indirect action usually requires a considerable expenditure of time, but it may reverse the balance of force. In certain cases, it may lead to a form of conflict by proxy.

The relative balance of power between the parties determines the basic pattern of the conflict. If the As are superior to the Bs and rapid military decision seems possible, A uses indirect confrontation (economic, diplomatic, and so forth) to insure the neutrality of the Cs. Meanwhile, the As attempt to exploit their superiority by direct and, if possible, rapid confrontation action against the Bs.

If the As are greatly inferior to the Bs but have superior moral reserves, the As use direct confrontation only to gain time and prolong the conflict. Meanwhile, they will use an intensive indirect confrontation to cause the Cs to intervene on the As behalf.

If the As and Bs are approximately equal in power, the As seek to tip the balance of power by attracting Cs to their cause. When the balance is shifted, direct confrontation will be attempted.[53]

In another place, Beaufre expands upon this interplay between direct and indirect confrontation in a manner that resembles Sun Tzu's discussion of *cheng* and *ch'i*. All strategy for Beaufre boils down to an attempt to maintain freedom of action while restricting the freedom of action of the opponent. Applied in an indirect manner, strategy usually involves the coordination of an exterior maneuver designed to fix or restrict the enemy, with an interior maneuver used to achieve an objective. Exterior maneuvers are applied on a worldwide scale and serve to restrict the freedom of action of the opponent through political, economic, or diplomatic means.

The exterior maneuver prepares the way for the interior maneuver, which is one of two types. The first is very rapid actions to gain limited objectives, interspersed with negotiations. Such piecemeal strategies have been quite successful. The second type is a prolonged conflict, counting on erosion to weaken the enemy. It depends heavily on relative material and psychological strength.[54]

Considering the patterns of conflict previously introduced in the military context, Beaufre notes that an army with superior resources and adequate striking power will act offensively, aiming for a Clausewitzian decisive battle. This is an *offensive strategy using a direct approach*. Its objective is to concentrate the maximum resources against the enemy's center of gravity.

If superiority is less clear, or if direct offensive action seems less likely to succeed, two alternatives are suggested. The first is wearing down the enemy by defensive action followed by a counteroffensive. This *direct offensive/defensive strategy* is based on luring the attack past the Clausewitzian culminating point of the battle. A second approach is to throw the enemy off balance by a diversionary offensive prior to the real action. This is a *direct strategy with an indirect approach* of the type advocated by Liddell Hart.

Finally, if military resources are inadequate, military action will play only an auxiliary role. Maneuver will be one of *total strategy in the indirect mode*, the decision being obtained by a suitable combination of political, economic, and diplomatic action.

Beaufre's observations apply to all conflicts. The development of nuclear weapons, however, had a profound effect on military theorists. Earl Ziemke notes that since August 1945 many have regarded past military history as being of little value. He cites the reaction of J. F. C. Fuller.

> Fuller relegated the whole of warfare as it had been known to "the dustbin of obsolete things," there to join "witchcraft, cannibalism, and other outgrown social institutions." The theory of war seemed no more lasting than a mushroom cloud.[55]

While not taking as extreme an attitude as Fuller, Beaufre acknowledged the fundamental change in warfare caused by the development of nuclear weapons and associated long-range delivery systems. These developments meant that "there is now no relationship between power and size of forces."[56] Traditional defensive methods, indeed conventional armies themselves, seem useless at first glance. Further analysis led Beaufre to reject this notion.

Beaufre contended that there are only four possible forms of nuclear strategy. These are as follows:

1. Preventive destruction of enemy weapons (the direct offensive method).
2. The interception of enemy nuclear weapons in transit (the defensive method).
3. Physical protection against the effects of nuclear explosives (a further defensive method).
4. The threat of retaliation (an indirect offensive method).[57]

The United States had the ability to employ preventive destruction as a strategy in its early days of nuclear superiority. This favorable situation did not last long, however. Technical problems in intercepting and destroying enemy weapons have prevented the second strategy from being effective, although new technologies may be reopening this strategic possibility in the future. Physical protection seemed to be a reasonable approach until the development of thermonuclear weapons. The tremendous increase in destructive power greatly reduces the value of physical protection, and many sources now conclude that such a strategy is not economically feasible. As a result, Beaufre concludes that the only true protection is the threat of retaliation. Hence the emphasis on deterrence.

Beaufre notes that deterrence is based upon great destructive capability, high accuracy, and an adequate ability to penetrate. In an age where offensive systems are vulnerable and an enemy's first strike can have significant effect, however, Beaufre notes that "the deterrent effect therefore depends not upon the capacity of the striking force but upon its residual capacity after it has absorbed the first strike; in other words, on its survival capability."[58] This has led to very complex and expensive survival tactics such as aircraft on alert, ballistic missile submarines on alert at sea, and ballistic missiles constantly ready to fire. The overall object has been psychological: to produce an effect upon the enemy's thinking that will prevent his use of a first strike force.

Over the years, there has been much debate over the proper way to insure this deterrence. Beaufre concludes that "in the final analysis the essential factor in deterrence is uncertainty. Uncertainty must therefore be the aim of a special form of tactics, the object being to increase, or at the least to maintain uncertainty."[59]

This deterrent effect, of course, is not limited to one side. Eventually, both sides obtain a posture sufficient to deter, and a sort of stability sets in until a technological or other breakthrough disturbs the stability. During such periods of stability, both sides are deterred and, in effect, nuclear weapons are unusable. In this case, conventional force postures again become all important.

Beaufre believed that this situation, seen most directly in the nuclear case, was true at all levels of conflict. He defined five "levels of action" (complete peace, cold war at the level of insidious intervention, cold war at the level of overt intervention, conventional war, and nuclear war)—all roughly corresponding to US "spectrum of conflict" ideas. Forces designed for operation within each level oppose each other in one of three situations: unstable situations with balance in our favor, unstable situations with balance in their favor, and relatively stable situations where balance is about equal. Unstable situations, according to Beaufre, were those where one side or another had high expectation of success. This stability had to be measured for each level separately. Two implications arose. First was what Beaufre called *inherent stability of action*. This meant that forces employed at each level tend to reach a sort of rough balance unless disturbed by deliberate action on one party's part. The second concept was that favorable instability at a given level of action is required in order to significantly impact situations at lower levels. That is, relative balance at the nuclear warfare level effectively removes nuclear weapons as a major factor at the conventional level, while a clear superiority at the nuclear level could create advantages at lower levels.[60] Other theorists have taken exception to this view. Beaufre, at any rate, is led by his analysis to conclude that strategy cannot be purely military but must be a total strategy, incorporating all instruments of national power (political, economic, and military) operating simultaneously at all levels of action.

Beaufre proposed a three-stage process for developing the total strategy he advocated. This consisted of a political analysis of the situation, a strategic analysis of possible courses of action, and a detailed individual analysis of any chosen plan of action. The political analysis begins with identification of the political objectives of all parties to a potential conflict—allies, adversaries, and neutrals. These objectives must be carefully examined to find weaknesses or vulnerable points. These most often show up in conflicts between objectives.

Two types of conclusions arise from this political analysis. Comparisons of the political objectives of different parties will isolate the true sources of conflict. Estimates of the priority given to each objective, by each state, will help determine the probable strength or violence of the conflict. Purely political action to resolve conflicts at this level may avoid military confrontation altogether. The second type of conclusion involves contradictions that may appear within the objectives of a single state. These internal contradictions are very important since they imply choices must be made which are sometimes very difficult and may potentially inhibit action altogether. Only three types of decisions are possible to resolve these contradictions:

1. Forego one of the objectives, making the necessary sacrifices.
2. Find a compromise solution, eliminating the contradiction.
3. Make no decision (or postpone the decision), accepting paralysis.

In each case, the contradiction forms a vulnerable point. Attacking one point of an internal contradiction can produce paralysis in the enemy.

From these observations, Beaufre derives the concept of *maneuver at the level of the policy decision*,[61] based on exploiting the similarities and contradictions between the political motives of the various parties involved. The best policy-level decision maximizes our freedom of policy decision, while minimizing that of the enemy. This involves eliminating one's own internal contradictions while creating or exploiting contradictions for the enemy. Beaufre illustrates this process in his book, using several excellent examples from the political maneuvering that preceded World War II.[62] Beaufre concluded that the political analysis should produce two results. First, it should indicate whether the solution of the problem can be facilitated by modification or change of priorities in our own objectives. Secondly, it should indicate which of the objectives are to be our strategic objectives, as indicated by the interplay of the political objectives. The selection of strategic objectives sets the stage for the second step in Beaufre's process—analysis of means to accomplish the strategic objective.

Strategic analysis is concerned with the choice of procedures to be used in obtaining the objectives determined by political analysis. There are two distinct but interdependent sequences of reasoning involved. The first consists of a listing of the vulnerable points of the enemy, together with the means by which these vulnerable points may be attacked (in the total, not just military sense). These vulnerable points are inherent weaknesses such as divided internal public opinion, inadequate military or financial resources, geographical areas difficult to defend, or internal contradictions likely to inhibit action. Alternately, they may be enemy political objectives to which opposition can be aroused. A comparison of these vulnerabilities, and the resources available, will form the "keyboard" on which actions will be played. A similar analysis must be made of our own vulnerable points and enemy resources, and of possible third party vulnerabilities and means to attack them. This stage of analysis ends when we determine the extent to which direct confrontation will be used in attacking enemy vulnerabilities and covering one's own, and how indirect confrontation will be used against third parties to cause them to react against one's enemy and prevent them from reacting against us.

The second sequence is a diagnosis of the potential for action at each level of action under current conditions. This includes an analysis of the stability at each level, the possible consequences of escalation, and other possible interactions among levels. These two sequences of reasoning combine to produce a proposed plan of action.

The final step in Beaufre's strategic planning process consists of a detailed analysis of the proposed plan of action. This consists of a detailed forecast of the development of the maneuver in light of possible reactions on the part of the enemy or third parties and in light of possible changes in objective. The result will be a complete set of contingency plans for dealing with the situation.

Beaufre's contributions to strategic thought, as reviewed above, are extensive and not easy to summarize. The basic operational aim is to achieve victory at the decisive point through freedom of action achieved by proper economy of force. The overarching concepts are the need to integrate all national instruments of power into a cohesive total strategy and the recognition of the relevance of both direct and indirect modes of strategy in a multipolar conflict environment. Overall, Beaufre seeks to implement a Clausewitzian program, but in an environment with vastly changed political structure and weapons technology. His prescriptions for strategy formulation are as clear and concise as any found in the current military literature.

The military theories of Sun Tzu, Clausewitz, and Beaufre reviewed above are very general in nature. In the following pages the American approach to war is discussed, along with challenges to this traditional style.

The American Style of War

While the American military has largely operated within the Clausewitzian model of combat operations, at least since the American Civil War, the unique circumstances of the United States have resulted in a distinctly American approach to war. This approach has come under attack from many sources recently. The next few pages describe the American approach, its origins, and recent challenges to it.

The Traditional Approach

Russell F. Weigley's *The American Way of War*[63] seems to be the most extensive and widely quoted look at American interpretations of basic military theories. Weigley considers Ulysses S. Grant to be the originator and model for the American style of war. Grant accepted the Napoleonic (and Clausewitzian) strategy of annihilating the enemy's military forces as the key to victory. He had no illusions, however, about being able to force a single decisive battle in the age of rifled firearms.

Hence, in the American Civil War, he pursued a strategy designed to use the greater resources of the Union to exhaust the Confederacy. Grant said that

> he would fight all the time, every day, keeping the enemy army always within his own army's grip, allowing the enemy no opportunity for deceptive maneuver, but always pounding away until his own superior resources permitted the Federal armies to survive while the enemy army at last disintegrated.[64]

Grant's concepts became typical of subsequent American military involvements. American Army planners in World War II believed that

> an army strong enough to choose the strategy of annihilation should always choose it, because the most certain and probably the most rapid route to victory lay through the destruction of the enemy's armed forces. To destroy the enemy army, the only proven way remained the application of mass and concentration in the manner of U. S. Grant.[65]

Colin S. Gray, in an excellent article on American national style in strategy, makes the same point.

> Super abundance of military resources, not to mention the debilitating requirements of coalition management, led the Western Allies, in effect, to pursue a strategy of attrition instead of annihilation through maneuver. Attrition, of course, is the risk-minimizing option, since the larger side must win (provided the adversary does not have available any annihilation options of his own).[66]

This American tendency towards attrition warfare was coupled with a growing dependence on and fascination with high technology weapons. This tendency was clearly evident with the development of airpower. In a review of American air doctrine,[67] Barry D. Watts notes four fundamental early beliefs that emerged concerning airpower. First, technological advances had produced offensive weapons of such destructive power as to change the dominant form if not the nature of total war between industrialized nations. Secondly, since there was no effective defense against these weapons, modern forces could swiftly apply overwhelming firepower directly on the vital centers of the enemy's society. Thirdly, the strategy involved in applying these forces was basically that of selecting key targets and allocating forces to impose a desired level of destruction. Finally, deterrence becomes the only reasonable approach to defense in this situation.

These observations by Watts show the strong influence of technology on military thinking. Similar views may be found in many other sources. *The Strategy of Technology* by Stefan T. Possony and J. E. Pournelle, typical of these sources, looks to technology as the decisive element in future wars.[68] The reduction of strategy to targeting as indicated by Watts introduced powerful and pervasive techniques aimed at increasing force efficiency. These techniques, so appropriate and successful in the strategic bombardment area, have also been applied to many other aspects of combat.

The American approach to war, characterized by attrition-based strategies and dependence on the efficient employment of high technology weapons, has come under fire recently. A principal challenge has been raised by advocates of "maneuver warfare."

Maneuver Warfare

Several critics of the traditional American way of war base their objections on the perceived preference of American conventional warfare strategy for attrition-based methods. These critics contend that such strategies are too costly and ineffective in the modern era and that alternatives to such strategies can be found in maneuver warfare.

The basic theory for maneuver warfare is based on the work of Colonel John Boyd, a former Air Force pilot and aerial combat theorist whose ideas on aerial combat are a fundamental part of current Air Force tactical doctrine. Boyd has attempted to expand his observations on aerial combat into a general theory of warfare. He has yet to publish his results, although some of the ideas from a briefing he presents to interested parties have appeared in the literature.

James Fallows, in his book *National Defense,* summarizes the maneuver warfare aspects of Boyd's theories.

> His point of entry is to bring up these surprisingly frequent situations in which forces that were numerically weaker ended up carrying the day. The common pattern he extracts from these victories is that the commanders exploited the intangible factors of deception, surprise, confu-

> sion, to stay one step ahead of the enemy's thinking at all times, and then to attack the enemy where he was least prepared and weakest, rather than wade in head-on to match strength against strength. . . .
>
> This is of a piece with Boyd's larger contention that in any sort of conflict, what matters is "getting inside an adversary's O-O-D-A loop." This "loop" consists of cycles of *observing* (O) the enemy's actions, *orienting* (O) oneself to the unfolding situation, deciding (D) on a counter, and then *acting* (A). The principle is that the side which can complete these cycles more quickly will ultimately prevail. . . .
>
> The ultimate purpose of these maneuvers, in Boyd's view, is not to wear down the enemy's forces, but to destroy his view of the world . . . from Clausewitz, Boyd took the principle of reducing one's own "friction" (through simple equipment, decentralized commands, etc.) as one key to success. From Sun Tzu, he took the premise that the enemy could be destroyed if *his* friction was significantly increased.[69]

In his briefing,[70] Boyd attempts to extend the tactics he found so effective in aerial combat into an encompassing theory of strategy. A complete analysis of Boyd's theories, in particular his central concept of moral conflict, is beyond the scope of this study. His overall presentation is an enjoyable synthesis of the ideas of Sun Tzu and Clausewitz, with additional emphasis on defeating the decision process by operating faster than decisions can be made effectively by the enemy. His ideas on strategy deserve careful analysis. Hopefully, Boyd will publish his theories soon so that they may receive the careful analysis they deserve.

Maneuver warfare concepts, based largely upon Boyd's "fast transient maneuvers," have found support within the military and academic communities. These ideas have evolved into proposals to replace the traditional American emphasis on attrition warfare. Lieutenant General Raymond B. Furlong is one advocate of alternate approaches.

General Furlong addresses the firepower-attrition versus maneuver warfare issue (with slightly different terminology) in his article "Strategymaking for the 1980s," which appeared in the March 1979 issue of *Parameters: Journal of the US Army War College*. General Furlong begins by stressing the importance of determining the objective of military forces. He acknowledges that Clausewitz is correct and that war is "a continuation of political activity by other means," but he notes that this is not enough to define the military objective.

> Our object in war or strategy is the behavior of a limited number of people. We wish to conduct our affairs in such a way that these people will act in a way that we prefer—our goal in strategy is to influence human behavior in a way favorable to our objectives. I suggest, then, that our strategies ought to seek this as their principal object—the mind of the opposing commander.[71]

General Furlong next reviews elements of the Clausewitz and Boyd approaches to war. He concludes that two main techniques have been found to control opposing forces. The first is the Clausewitzian concept of physical destruction of the enemy. The second concept seeks to attack the mind of the enemy commander and render his forces powerless through disorganization rather than destruction. This encompasses the Sun Tzu and Boyd approaches as well as the approaches of Fuller and Liddell Hart.

Implicitly, General Furlong advocates disorganization rather than destruction as a basis for strategy. He acknowledges that real and hard questions concerning its effectiveness still must be answered. He also acknowledges that disorganization is far more risky than destruction. He advocates a careful analysis of potential capability and risk before adopting any concept as the basis of a strategy. He concludes in agreement with the generally expressed concern that a strategy of disorganization may be forced upon us by the current military balance of forces.[72]

Discussions of maneuver warfare concepts can be found throughout recent military literature. Basic positions of both advocates of traditional methods and advocates of disorganization are summarized in two articles in the *Air University Review's* Fire-Counterfire series.[73] A series of articles in the *Marine Corps Gazette* traces the Marine Corps' interest in and interpretation of these concepts.[74] These articles picture maneuver warfare as an alternative to attrition-based strategies using semiautonomous, extremely maneuverable forces to operate inside the enemy's observation-orientation-decision-action loop, rendering his forces ineffective and eventually disrupting the enemy commander's world view, causing the collapse of the enemy forces. Evaluation of the claims of the maneuver warfare advocates depends upon a detailed understanding of the combat operations process, and particularly the command decision function within that process. The next two chapters develop the techniques needed for such an analysis, as well as the analysis of the other military theories summarized above.

Notes

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6. Ibid., 142.
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13. Ibid., 84.
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Chapter II

C^3I and the Combat Operations Process

The last chapter introduced the basic concepts of combat operations as seen by Sun Tzu, Clausewitz, Beaufre, the traditional American approach, and maneuver warfare theorists. While there are common elements in all of these approaches, there are also clear and perhaps even contradicting differences. This study attempts to build a unifying explanation of combat operations and the combat operations planning process which incorporates all of the theories discussed. The individual theories presented previously can then be interpreted as those that place special emphasis on portions of the overall theoretical structure. The first step in this program is the definition of a conceptual combat operations process model. This model is designed to incorporate C^3I structures. Hence, this chapter begins with a brief discussion of C^3I and the C^3I process. A model of the C^3I process is then modified to produce the combat operations process model. This chapter discusses in great detail two functions within this model that are critical to subsequent sections. The power distribution model and the military problem-solving process model are developed in this discussion.

Command, Control, Communications, and Intelligence (C^3I)

> One of the least controversial things that can be said about command and control (C^2) 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.[1]

Command and control (C^2) and its derivatives command, control, and communications (C^3); command, control, communications, and computers (C^4); command, control, communications, and intelligence (C^3I); and command, control, communications, intelligence, and interoperability (C^3I^2) are not easy to define. A good starting point is the official Department of Defense (DOD) definition for command and control.

> Command and Control: The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.[2]

This definition, intended to apply to many diverse activities, does not completely specify two of its key concepts. What is the commander trying to get his assigned forces to do? And how is he to use the personnel, equipment, communications, facilities, and procedures placed at his disposal in order to do this? The difficult question of determining the function of command in combat operations is addressed in chapter III. The second question asks for a more precise definition of the process to be used by the commander. The remainder of this chapter addresses this question.

A lot of work has been done on defining the C^3I process. We will construct a conceptual model of the combat operations process using two of the conceptual models that have been developed. The models presented are attributed to Dr. Joel S. Lawson, Sr., Naval Electronic Systems Command, and are taken from his report entitled "The State Variables of a Command Control System."[3] This report also has other possible models and background on attempts to quantify and evaluate C^3I system performance.

Lawson's basic C^3 process model is shown in figure 1. There are five basic functions indicated, together with their interfaces to the environment. The SENSE function corresponds to all data-gathering activities (radar sites, forward observers, photo reconnaissance systems, and so forth). It is concerned with extracting signals from the environment. The PROCESS function acts upon these signals to attempt to extract meaning from them. External data, not directly from the environment, may be used. These may include intelligence analyses indicating patterns representative of division headquarters, etc. The PROCESS function produces event reports and status reports for use by later functions. The COMPARE function compares the state of the environment, as determined by reports from the process function, with a desired state as specified by some external source. Based upon this comparison, the DECIDE function determines what should be done to move the actual state to the desired state, and the ACT function

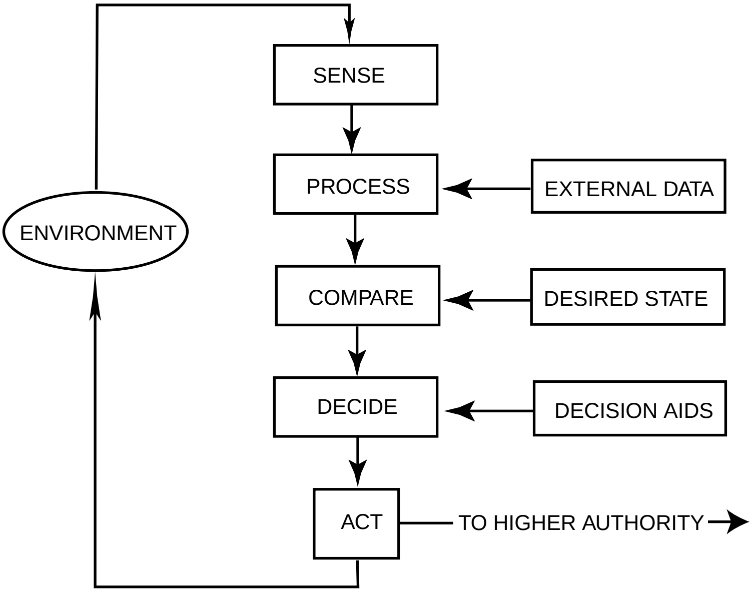

Figure 1. Lawson's C^2 Process Model

executes that decision. There is a clear relation between these concepts and the O-O-D-A loop concepts introduced by John Boyd.

Figure 2 shows Lawson's expanded C^3I model which explicitly shows the intelligence/analysis process interacting with the C^2 process. The two stated interfaces are in the PROCESS and DECISION blocks. Lawson emphasizes that projections (indicated by the ΔT block) should not be used by the C^2 process except as part of the decision process. The reason for this is his fear of creating unstable systems. Later analysis in this study shows that possible future force dispositions may be more important to the control of the combat operations process than is the current force disposition. Hence, Lawson's safety feature may not be practical. Lawson's model provides the starting point for the combat operations process model.

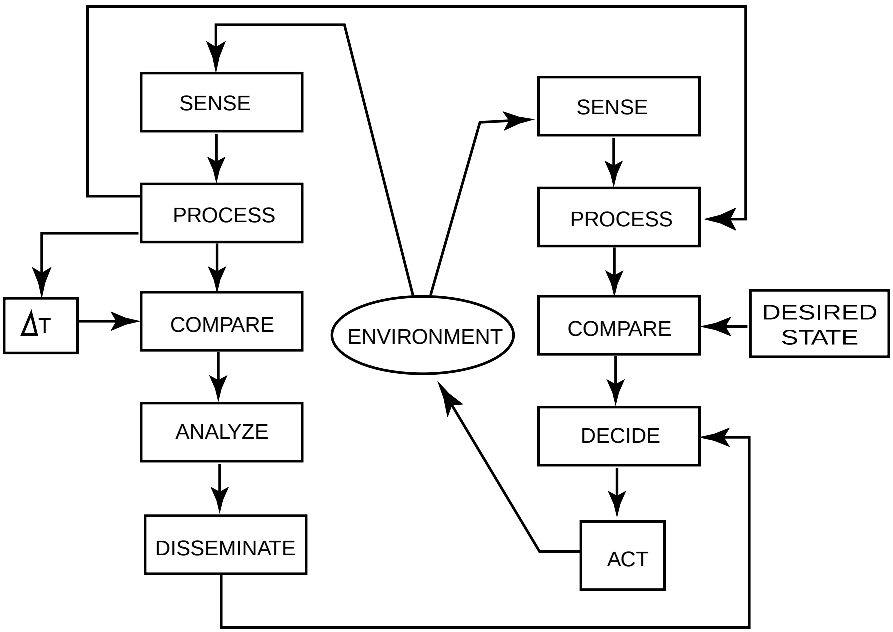

Figure 2. Lawson's C3I Process Model

THE COMBAT OPERATIONS PROCESS MODEL

This section defines a conceptual model of the combat operations process. The goal is not a model of great technical detail but rather a conceptual framework to be used in further study of combat operations. Several criteria were used in the development of this conceptual model. First, since the model is intended as a tool for studying the role of C3I in combat operations, the essential C3I functions must be represented. Secondly, the model must be simple. Very detailed complex models are already available. The CONSTANT QUEST Modeling Group, Phase 1 Report[4] describes several of these models and their application. Such models are invaluable for some purposes but are unsuited (and generally unavailable) for conceptual strategic studies. Finally, the model must be complete enough to explain, at least in broad terms, the principles and theories advanced by other writers. The basic O-O-D-A loop structure model suggested by John Boyd's work (see Figure 3) seems like a good candidate. However, a substantial expansion and clarification of the function blocks is required if the model is to be useful. Also needed is an examination of process vulnerability beyond that suggested by Boyd. The lack of explicit intelligence functions and of indicated uses of forecasts is also a weakness. Lawson's model of the C3I process (see figure 2) is also a good candidate. It also requires a substantial expansion and explanation of the function blocks. The major objection to Lawson's model is that it includes features extraneous to understanding the basic combat operations process.

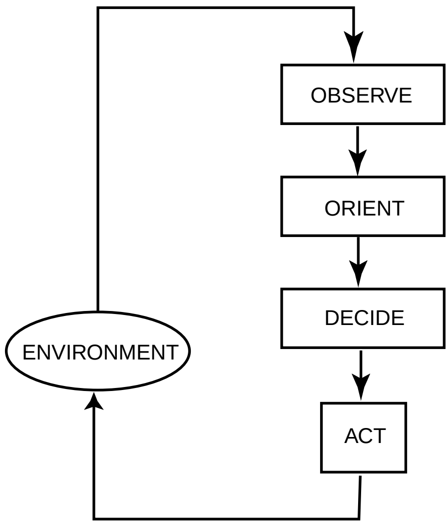

Figure 3. Boyd's O-O-D-A Loop Structure

Figure 4 shows the conceptual model developed for this analysis. Its kinship to the Boyd and Lawson models is clear. The essential differences are in the inclusion of explicit interfaces to higher and lower levels and the inclusion of a generic INTELLIGENCE/ANALYSIS block with extensive connections to other blocks. This process is intended to represent the combat operations process at any specified level of the military hierarchy. The details of the individual functions, and the emphasis placed on each, will vary according to level. The INTELLIGENCE/ANALYSIS function is not very important at the force application level, where direct action is taken to affect the environment (for example, a tank driver or aircraft pilot destroys an enemy tank or blows up a bridge). In this case, the conceptual model is essentially identical to Boyd's model with the SENSE function identified with Boyd's OBSERVE function, the PROCESS and INTELLIGENCE/ ANALYSIS function merged and identified with Boyd's ORIENT function, and the other functions being the same. At higher levels in the hierarchy, the identification is less exact. At higher command levels, for example, the INTELLIGENCE/ ANALYSIS function begins to operate separately (as in Lawson's C^3I process model), and actions tend to be information transfer and orders sent to lower levels or responses/ queries to high levels rather than direct physical interaction with the environment. All of the identified functions and data links are potentially present, at every level of the military structure. This model meets the first two criteria established above. The remainder of this chapter expands the functions in the conceptual model, especially the crucial (and somewhat cryptic) DECIDE and ACT blocks.

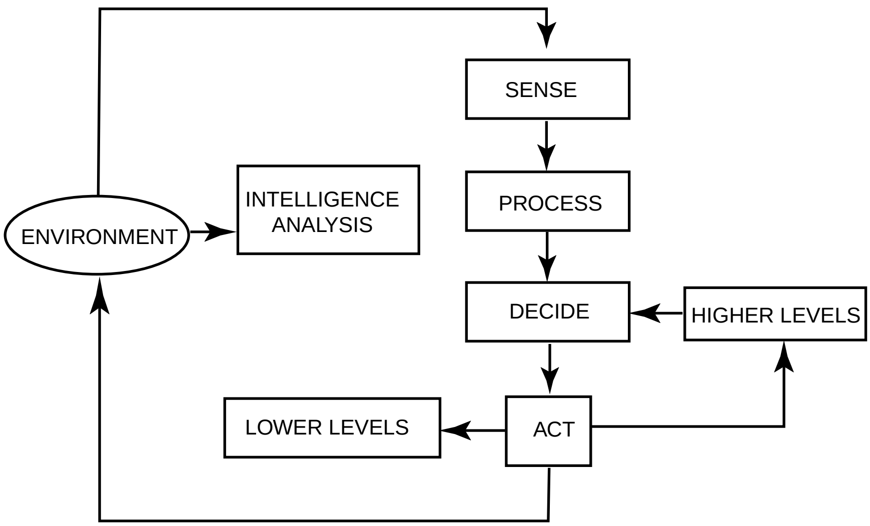

Figure 4. Conceptual Combat Operations Process Model

Expansion of the Process Model Functions

Three of the functions in the conceptual model are relatively easy to understand. They are the SENSE, PROCESS, and INTELLIGENCE/ANALYSIS functions.

The SENSE, PROCESS, and INTELLIGENCE/ANALYSIS Functions. The SENSE function involves all systems and procedures used to gather data from the environment. These include active systems (radars and potentially lasers) and passive systems based on varied optical, infrared, electromagnetic, and other physical phenomena. The goal is to provide continuous coverage of the environment under all conditions, with several different sensors gathering information about each event, if possible. The key parameters here are coverage and timeliness. The vulnerability of sensors to countermeasures is also crucial. A tremendous amount of technical effort has been invested in this area, with significant payoff.

The PROCESS function involves all the processes and procedures used to deduce the occurrence of specific significant events or situations from the data gathered from the environment, plus guidance and additional information from the INTELLIGENCE/ANALYSIS function. Indications from many sensors are gathered and used to match patterns known to indicate specific situations or events. Intelligence data and force status reports are also used. The PROCESS block also includes the task of displaying the results of the processing to the decisionmaker. Hence, raw data from the sensors, plus intelligence and analysis reports and guidance, are transformed by the PROCESS function into the event and status reports required by the DECIDE function.

The INTELLIGENCE/ANALYSIS function encompasses a variety of specialized processes and procedures. The exact details of these processes and procedures do not matter in the conceptual context of this model. Two essential tasks are performed. The first is the search, by both overt and covert means, for information concerning the organization, structure, capabilities, and intentions of potentially unfriendly forces. Information on political, economic, and other nonmilitary matters is also relevant. This information provides the framework for assigning meaning to observed activities and situations. The second essential task is forecasting changes in the current situation. These forecasts are critical in the decisionmaking process. The information and forecasts, developed by the INTELLIGENCE/ANALYSIS function, guide the SENSE function by indicating where to look and what to look for, guide the PROCESS function by helping to identify the patterns that signal specified events and situations, and guide the DECIDE function by providing assessments and forecasts of the situation and evaluation of the probable consequences of proposed actions. The key parameters are completeness, accuracy, and responsiveness. It should be noted that while some of the activity of this function occurs during the actual combat operations, much of the work is independent of the current situation. Careful preparation beforehand is the key to success.

The two remaining functions, ACT and DECIDE, are more difficult to describe simply. However, they are the keys to understanding combat effectiveness and will be discussed in some detail. We will first discuss the ACT function in general terms of power projection and then explore the DECIDE function.

The ACT Function. The ACT function involves the interface between the system being controlled by the commander or decisionmaker and the environment. It is the means used to force or influence changes in the environment that are determined to be desirable. This function is not intended to be restricted to coercive action. In fact, the general model applies to any political, economic, military, or other type of situation in which interaction with the environment is being directed and controlled.

An interesting first step in the analysis of this ACT or power projection function is in the book *Decisive Warfare—A Study in Military Theory* by Reginald Bretnor.[5] While this book falls far short of its implied promise to provide a quantified "equation of war," it does provide a great deal of insight into the factors that must be considered in evaluating a balance of power in any conflict. Bretnor contends that every force element is characterized by both its destructive power and its vulnerability. Therefore, the balance of power depends upon the complex interrelations between the destructive power of one side and the vulnerability of the other, and upon factors determining when and where destructive power can be expressed. Bretnor interprets various "principles of war" and military theories in terms of these destructive power and vulnerability interrelations.

Brentor's approach works reasonably well when the forces opposing one another can be viewed as two parties locked in single combat. However, when forces on both sides are widely distributed, the Bretnor approach becomes harder to apply and understand. Maneuver—the ability to shift resources to insure that the overall battle is made up of engagements favorable to a side—becomes crucial.

An abstract characterization of power projection with distributed sources of power is helpful here. Available forces have the ability to project power from a fixed location. There is a certain area, the *primary range of* the force, over which this power can be applied. As long as actual combat has not started, there is the possibility of maneuvering forces. This can greatly increase the potential area where the force can apply its power. This expanded area, which depends on the time horizon plus constraints on force maneuver, defines the *secondary range* of the force. Figure 5 pictures this situation. It must be noted that zones *of* influence over any time horizon greater than zero represent potential for force application only. That is to say that the secondary range is made up of the collection of all possible primary ranges at the time specified by the time horizon. Figure 5 illustrates this in the right-hand diagram, where three of the possible primary ranges making up the secondary range are explicitly pictured. The commander must determine for each *of* his units which of these future primary ranges he desires and must insure that the units move into proper position on time. This can present problems. If state 3 in the right-hand diagram of figure 5 is desired, for example, the commander may have to immediately issue orders to move since this state is at the edge of the secondary range. Mistakes in determining the desired state may be serious also. Orders stating movement towards state 1 and then changed to orders to move to state 3 may result in delays beyond the indicated time horizon in achieving he desired state. These considerations are important within the command function of combat operations. They will be discussed further in the next chapter. The total area contained in the secondary range of elements of a disturbed force defines the *zone of influence* of that force. When two parties are in a conflict, their zones of influence can overlap. This overlap defines the *zone of conflict*. Outside of the zone of conflit, each party *controls* the area within its zone of influence. Within the zone of conflict, control (which may vary in degree) depends upon the balance of power determined by Bretnor-style calculations.

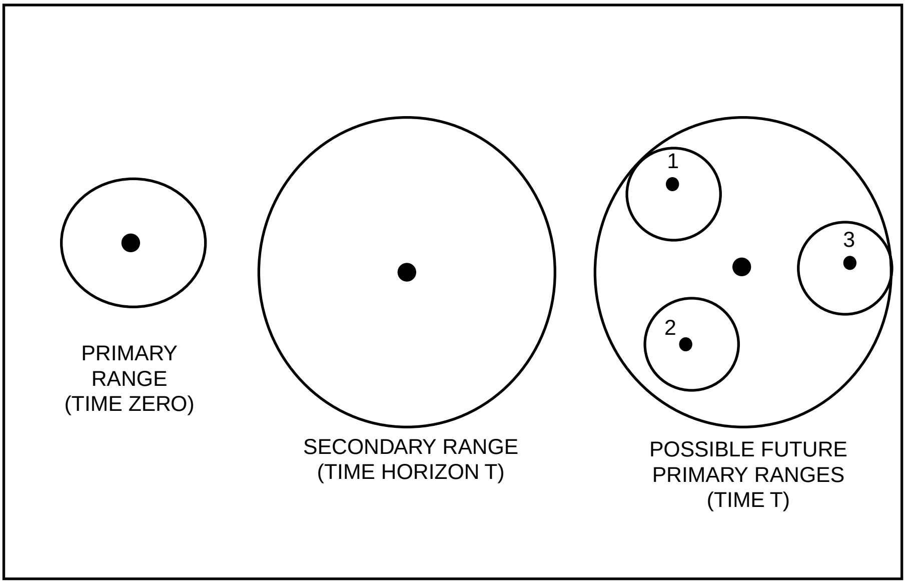

Figure 5. Primary and Secondary Range of Forces

A number of general factors for the ACT function can be easily identified. Basic force parameters are *lethality* and *vulnerability*, with *maneuverability* also being crucial on the battlefield. New technology is continuously altering these factors, and the ultimate force structure decision is usually based on tradeoffs between cost and marginal improvement in performance. Force *response time*, in a cumulative sense, is of great importance and may be the major factor in gaining victory (especially against statically superior forces). Longer-term concerns, such as *mobilization capability*, *logistic support requirements*, *and development and production lead times* can be important. *Flexibility*, also often cited as vital, can be defined in the dynamic framework provided above in terms of the effects on secondary range of initial commitment. For an inflexible system, the decision at time zero to go to state 1 may preclude any later decision to go to other states. For very flexible systems, initial commitment has far less limiting effect. Beaufre's notion of freedom of action corresponds closely to flexibility in this sense, or at least is enhanced significantly by it. The basic factors above, or rather any asymmetries between forces relative to these factors, are the keys to the generation of winning strategies.

The DECIDE Function. One more function needs to be explored before the combat operations process model can be used as a tool in strategic analysis. This DECIDE function is extremely complex and not very well understood. The following pages explore this function in detail. We will first review modern psychological theory to examine the processes involved in command. This is followed by a review of research in problem solving, which will help in developing a conceptual model of the military problem-solving process. The decision-making subprocess within this model is also examined in detail. Finally, specific work on military decisionmaking is reviewed. These discussions provide the basis for the studies of combat operations command reported in chapters III and IV.

a. *The Psychological Basis of Command.* Psychology is intimately related to discussion of C^3I functions and structures in the military in at least two important ways. First, the human mind provides the most effective command and control system found in nature, and the structures and processes used by the human brain in its functions provide valuable insights into the structures and processes that might be effective in controlling military operations. Even if vastly more efficient methods can be found for such control, human psychology cannot be ignored since any control process must ultimately interface with humans. The second important impact of psychology is the emphasis that many strategic theorists place on defeating the "mind of the commander." Evaluation of the feasibility and effectiveness of attacks upon the enemy commander's mind requires deep understanding of the psychological process employed by the commander in assessing the situation and deciding upon a course of action. The following paragraphs briefly review modern psychology to establish a framework for the command process.

Guy R. Lefrancois traces the development of modern psychology in an informative and entertaining book, *Psychological Theories and Learning: Kongor's Report.*[6] He traces the development of a scientific approach to psychology through the behaviorist, neobehaviorist, gestaltist, cognitive psychologist, and cybernetic schools. These schools differ primarily in the processes they seek to explain and the structures they hypothesize to implement these processes.

The behaviorist school arose in reaction to the "mentalist" school of psychology represented by Sigmund Freud. The behaviorists objected to the imprecision and nonmeasurable nature of the mentalist theories and constructs and sought to put psychology on a sound scientific basis by restricting attention to measurable phenomena. This led to stimulus-response explanations for behavior, with intervening processes ignored. Classical conditioning based on stimulus substitution resulted from this approach.

Stimulus substitution arises when a true stimulus, such as the appearance of food, is repeatedly paired with another stimulus, such as the ringing of a bell. Originally, the response (such as salivation in an animal) is due to the true stimulus, but eventually the paired stimulus by itself is sufficient to elicit the response. This phenomenon is known as classical conditioning. A similar concept known as operant conditioning was developed by B. F. Skinner.

Skinner's approach differs from classical conditioning in that a reward or reinforcement is presented at the completion of a desired response rather than being paired with a triggering stimulus. Skinner's operant conditioning has been widely employed in animal training experiments and provides a satisfactory explanation for many observed behaviors. Experimental work related to this approach relates to developing reinforcement schedules and "shaping" techniques which gradually, and in easy steps, results in desired changes in behavior. The influence of the school of psychology is clear in attempts to manipulate behavior through systems of reward and punishment. Operant conditioning proved to be an acceptable explanation for elementary behavior but was hard pressed to explain more complicated, purposeful behavior. The neobehaviorist school evolved to meet these difficulties.

The neobehaviorist differed from the behaviorist by making some attempts to describe the processes intervening between the stimulus and response. These explanations were rather involved and complicated at times but did provide some insight into the actual processes used by humans. These insights were based to some extent on the neurological and psychological knowledge of the day. Of particular interest were attempts to break down the stimulus-response activity into stages involving the interpretation of stimuli and the assignment of meaning to them. The introduction of concepts of meaning resulted in the development of the gestalt and cognitive schools of psychology.

Gestalt psychology is based upon the concept that the whole is more than the sum of its part in that the response to situations depends upon many factors which can be intuitively grasped but cannot be specifically identified. This theory places great emphasis on the role of insight and intuition in judgmental activities such as decisionmaking. It offers little hope for a formalization or mechanization of these processes, since response depends upon properties of the situation which *cannot* be consciously grasped but are subconsciously incorporated into responses. The gestalt psychologists have developed many interesting experiments to demonstrate these subconscious processes. A number of these are illustrated in the book *Human Information Processing: An Introduction to Psychology* by Peter H. Lindsay.[7] A somewhat less hopeless approach was developed by Kurt Lewin in his cognitive field theory. This theory interpreted human behavior in terms of a life space—the totality of personal knowledge, goals, perceived paths to goals, attractiveness of goals, and barriers to reaching the goals experienced by a person. In theory, complete knowledge of a person's life space allows accurate prediction of response to a given situation, although in practice the information gathering and processing requirements make predictions based on the theory impractical.

These difficulties led other psychologists to seek other explanations of behavior based upon more careful analysis of cognitive processes themselves.

These cognitive psychologists began to deal with the higher neural processes of perception, information processing, decisionmaking, and knowing. They specifically began to theorize and experiment with various data structures useful for representing knowledge and the implications of these structures. The cognitive psychologists tend to think in terms of processes compatible with what is known about the neurology of humans, but they frequently become involved in rather philosophical discussions of higher mental processes. The fundamental problem is explaining how the simple neurological structures found in the body can cooperate to perform the higher mental tasks noted above. Two principal operational answers can be found in the literature. These are the information-processing approach and the control theoretic approach.

The previously referenced book by Peter H. Lindsay and Donald A. Norman is an excellent introduction to the information-processing view of psychology. This book begins with a number of illustrations to show how elusive and difficult the problem of describing human perception and behavior really is. The general approach is to treat the human as an information-processing system and then to try to explain how the various subsystems such as vision, hearing, and touch are integrated to support the higher mental processes.

The higher mental processes, of course, consist of much more than simple perception, and explaining such processes is a challenge to the information processing school of psychology. One problem is determining how many subprocesses (image recognition, feature extraction, cognitive interpretation, and decisionmaking) are coordinated and controlled. One interesting model of this coordination process is known as Pandemonium. In essence, this model supposes that all of these processes identified above occur simultaneously and in parallel. Each process is viewed as the activity of a "demon." (This terminology can be traced back to work in data structuring and data base management by the artificial intelligence community. See Patrick Henry Winston's book *Artificial*

Intelligence for an explanation of concepts.[8]) The lowest level demons actually interact with the environment and then start "shouting" out what they see, hear, and so forth. Higher level demons listen to the commotion until they hear features and other characteristics they need to recognize. They then start shouting their conclusions. Redundant features and other characteristics are shouted a lot under this model and, hence, are more likely to be recognized. The name for the model is certainly descriptive! This model does explain many features of human information processing (the importance of redundancy, for example), but it fails to explain many other features such as the role of expectations and interactions between "demonic" processes.

A variant of the Pandemonium model, called the Specialist Demon model, explains the apparent cooperative and anticipatory nature of human information processing. This model again uses demons to represent the actors in the processes but specializes them to perform individual recognition, anticipation, and decision tasks. The model also adds the concepts of a supervisor demon (who directs attention); a long-term pool of common information (long-term memory); and a blackboard where individual specialist demons record their progress, expectations, and decisions in a manner available to all other demons (short-term memory). The blackboard is used by individual specialist demons to insure cooperative searches and decisions without direct communications, and by the supervisor demon to direct overall attention as desired. Clearly this is a much quieter concept than Pandemonium! This model also focuses attention on required features for cooperative distributed processing such as has been visualized for some C^3I applications. In this sense, the Specialist Demon model is a prototype for distributed C^3I systems and more generally for distributed operations and command. A more centrally controlled model of cognitive processes is given by the control theoretic approach. The use of the concepts developed in the mathematical theory of control processes (or control theory) in the description of human and animal behavior date back to the beginnings of the theory in Norbert Wiener's book *Cybernetics*.[9] Lefrancois notes the modern development of a control theoretic approach to psychology in the work of Miller, Galanter, and Pribram who use a simplified feedback control model as a basis for their descriptions of human behavior. An extensive and complex mathematical theory of control processes has been developed over the 30 years since Wiener's early efforts. The complexity of the mathematics involved and the measurement required by the theory have limited the application of the theory to very technical matters, especially in the field of tracking and guidance. A good but very technical review of modern estimation and control theory as applied to modeling human behavior is given by William B. Rouse.[10] A less technical introduction to basic concepts is Richard J. Jagicinski's article "A Qualitative Look at Feedback Control Theory as a Style of Describing Behavior," which appeared in the August 1977 issue of *Human Factors*.[11]

This theory is based upon the adaptive behavior provided by feedback control loops. In simple terms, a feedback control loop involves a desired state, a perceived actual state, and some mechanism to influence the actual state of the environment. The difference between the desired state and the perceived actual state is the perceived error, and the feedback control mechanism acts in such a way as to reduce the perceived error to zero. Many mechanisms found in nature or built by men have this basic structure. It is unclear whether the human brain is physically structured this way, but it is clear that feedback mechanisms provide good models for much of human behavior.

The C^2 process, C^3I process, combat operations process, and the Boyd O-O-D-A loop models discussed previously can all be viewed as feedback control mechanisms. The Boyd model and C^2 process model are simple feedback control loops conceptually. The presence of the intelligence/analysis function in the other models depends on the fact that feedback mechanisms can react to predicted future errors as well as to current errors. The feedback loop analogy must not be pressed too far, however. Simple feedback loops depend on essentially continuous control by the control mechanism. While this applies sometimes with the process models, control is not always continuous, especially at higher command levels. The lack of continuous control complicates matters, placing an increased burden on the intelligence/analysis functions which must predict more precisely the effect of control actions. The time delays involved at various stages in the process are also vital. Noninstantaneous reaction is the key element in Boyd's notion of the use of fast transient maneuvers to attack the control process.

The simple feedback processes discussed above provide a good model of simple behavior. The theory can be further expanded to model ever more complex behavior. The key concept is that of the hierarchial control system. The hierarchial control system differs from the simple control system in that it consists of two or more levels of cooperative control systems connected into an organized whole. A single control system at the highest level controls the overall behavior of the system. This system perceives the errors between the actual and observed state and acts to eliminate them. Instead of acting directly on the environment, the high-level system adjusts the desired states for the control systems at the next lower level of the control hierarchy. This process is repeated until the control mechanisms at the lowest level actually interact with the environment.

In this hierarchial control model, the mechanisms act independently, but overall behavior is determined by a predefined relation between the errors at any level and the desired state at the next lowest level. William T. Powers, in his book *Behavior: The Control of Perception*,[12] develops a nine-level hierarchial control system to totally describe human behavior. This book is recommended both for the details of this hierarchial model and for thoughtful discussions of the implications of this control theory formulation. This book also clearly demonstrates that the hierarchial control model provides a reasonable approach to C^3I system design. It is, in fact, the prototype for a highly centralized C^3I system.

The above survey of research in cognitive psychology indicates that both the Specialist Demon and the hierarchial control models provide reasonable theoretical bases for C^3I system structure. The choice of one structure over another will have to be based on other considerations. Primary among these considerations is the proper function of command and of associated C3I systems within the combat operations process. Questions of this proper function will be addressed in later chapters. But first, two fundamental aspects of command-problem solving and decisionmaking—must be examined in more detail.

b. *Problem Solving.* Duncan L. Dieterly, in his paper *Problem Solving and Decision Making: An Integration,*[13] describes problem solving and decisionmaking in terms of a state transition model proposed by W. R. Reitman.[14] According to this model, the basic decision-problem condition involves a state A, a state B, and a transition from state A to state B, as in figure 6. A problem then consists of finding the transition from state A to state B. Dieterly points out that things are not simple, however, since the states and transitions are not always known. In fact, eight basic problem models can be identified. These are indicated in figure 7 where solid lines indicate known states or transitions and broken lines unknown states or transitions.

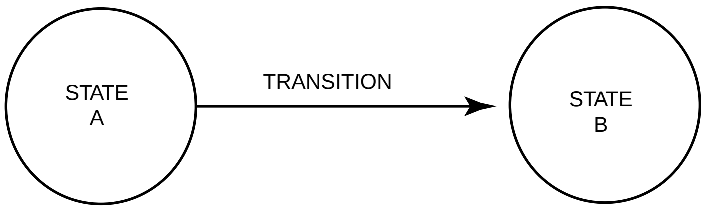

Figure 6. Basic Decision-Problem Condition

Each of these situations presents different difficulties. Dieterly calls model VIII the trivial problem (both states and transition known), and the problem solver's goal is to reduce all other models to this trivial case. Model I, called the intuitive model, is most difficult since there is no information initially. In general the problem-solving process starts with one of the cases and uncovers information to proceed to other cases, terminating in the trivial case VIII.

Real situations can be even more complicated than indicated since it is possible to have multiple states or transitions. Dieterly

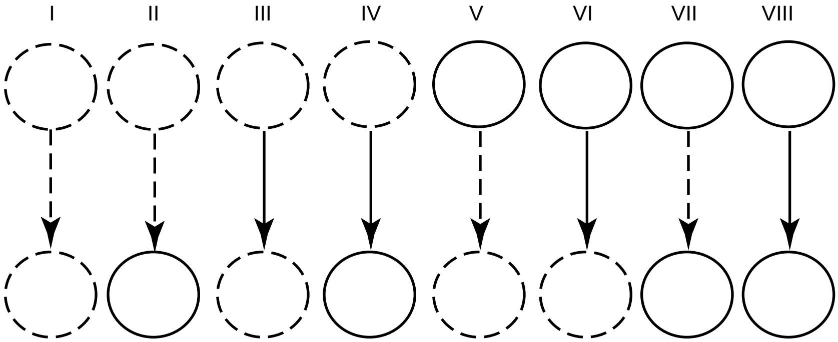

Figure 7. Decision-Problem Models

discusses five "classes of condition" as indicated in Figure 8. A multiple end state results when an action can have two or more results, as in random processes. A multiple transition occurs when two or more transitions or actions from an initial state result in the same end state. Multiple initial conditions occur when two or more initial states are transformed to the same final state. Combinations of these conditions could result in eight possible cases, although Dieterly restricts attention to the five in Figure 8. Each of the models in Figure 7 could have any of the

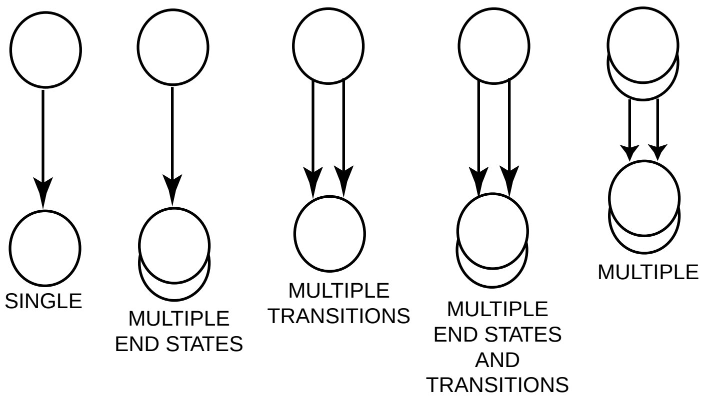

Figure 8. Dieterly's Classes of Conditions

conditions in Figure 8. Hence, Dieterly considers 40 possible problem situations. Somewhat different problem-solving techniques are indicated for each of these situations. Situations involving multiple states usually involve probability concepts. Situations involving multiple transitions require a choice for implementation and are usually associated with decisionmaking. The above technique is useful in describing the problem-solving process of a combat commander.

The military commander, charged with employing the forces at his command, starts with a multiple intuitive problem as in the left-hand side of Figure 9. The commander is not sure of his initial state, of the desired state, or of the desired transition. Through several processes he wishes to proceed to the extreme right-hand side and the desired final state. The first step consists of a parallel refinement of the initial state, desired state, and possible transitions. This involves clarification of the desired final state, clarification of the situation, and the generation and evaluation of possible plans of action.

Clarification of the desired final state, the most crucial and difficult part of the military decisionmaking process, involves a high-level interaction among political and military leaders to determine desired political objectives and the military objectives required to support these political objectives. The political leaders coordinate all their available instruments of power to accomplish the political objective. If use of the military instrument is indicated, the military commander will be assigned a military problem with assigned military objective, assigned resources, and possible constraints on the actions allowed to accomplish the objective. This problem assignment may be a complex interactive process. The situations and possible interactions at this level are so complex that heuristic, subjective approaches are almost universally used. There is some help available from sensors, displays, and intelligence/analysis functions, but decisions tend to be subjective and not always very well defined. The key problem is finding military objectives linked to the political objectives. While this may be straightforward in a few defensive situations (where the initial military objective is to defeat an opponent's attack), it is usually an extremely complex and uncertain process. The principles introduced in previous sections guide the choices at this stage. The essential result is to present the military commander with a multiple type II problem.

Clarification of the situation by identifying the friendly situation, the enemy situation, and constraints imposed by the environment transforms the commander's problem to a multiple transition type VII. The C3I sensor, correlation/fusion, and display technologies already discussed are key players in the clarification. Since the situation at some time in the future may also be of critical concern, intelligence/analysis functions are also vital. Completion (at least tentatively) of this situation assessment sets the stage for the possible action generation and evaluation process which completes the working refinement in Figure 9 and results in a planned action. The final stage in the military problemsolving process is execution of this planned action.

A crucial aspect of the military problem-solving process is the step from the fourth to the fifth state in Figure 9. This involves the selection of one of the proposed actions as the final plan. This aspect of problem solving is treated as the separate topic of decisionmaking in much of the literature of cognitive psychology.

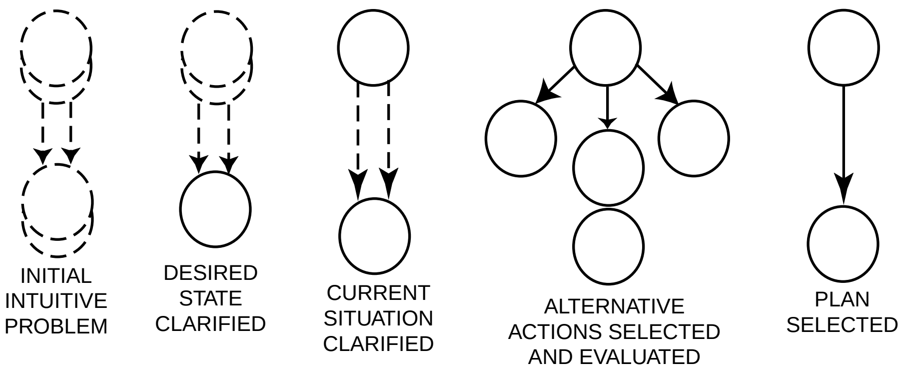

Figure 9. Military Problem-Solving Process

c. *Decisionmaking.* A tremendous amount has been written about the decisionmaking process. Much of this deals with organizational, political, and individual influences on decisionmaking. These are interesting areas of research, but of only indirect use in analyzing combat operations. The two areas that are of direct interest are research in utility-based decision methods and research in alternatives to utility-based decision methods.

Many good books describing the utility-based approach to decisionmaking are available. The book by R. Duncan Luce and Howard Raiffa[15] is a good technical treatment. A more elementary treatment is given by John R. Hayes.[16] The general approach is to select a set of alternative decisions to evaluate subjectively the utility (or value to the decisionmaker) of outcomes expected under each decision, and to select the decision maximizing the utility. In the event that outcomes depend upon circumstances not controlled by the decisionmaker, estimates of the probability of these circumstances are used to determine the expected value of the decision outcome and the expected values are used to make the decision. Clearly, this easily stated process can be very difficult in practice. Determining what alternate decisions to evaluate and the expected outcome of each decision can be very complicated. Determining the value or utility of the outcome can be even more troublesome. And estimating probabilities for external events is frequently more of an art than a science. But even if these difficulties can be overcome, serious objections to the utility-based theory remain.

William R. Ferrell[17] lists several objections to utility-based decision theory based upon experimental evidence. One big problem is that experiments fail to show any real consistency in the assignment of values. That is, preferences for outcomes determined by subjects using different methods are not consistent in the manner predicted by theory. Additionally, while theory assumes that probabilities of occurrence and values are independent, experiments show a dependence in the sense that larger than expected values are assigned to likely outcomes. Utility-based decision theories applied to decisions involving random elements usually assume the decision will be based on the expected value of the result. Experiments show that other factors may be important. Examples in the next chapter will illustrate this point. Utility assignments also seem to be influenced by the manner in which values are assigned. People have particular trouble with comparisons of sure things and bets. Multidimensional alternatives present tremendous problems, and actual assessments seem to depend on the range of alternatives considered. The overall potential complexity of the assumed process is also a source of problems. John D. Steinburner[18] notes that little conclusive evidence has been collected to show that decisionmakers actually make the detailed cost/benefit calculations required by the theory. The lack of proper sensitivity to new information, noted several times above, may be taken as evidence that such calculations, if made at all, are not very precise. Glenn H. Snyder and Paul Diesing reach the same conclusion in their book.[19] These problems have led some to formulate alternatives to utility-base decision theory in order to explain how reasonably accurate, flexible decisions can be made without the information-processing and computational capabilities implied by the utility-based approach.

Much of the work in this area dates from the principle of bounded rationality formulated by Herbert Simon.

> The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behavior in the real world—or even for a reasonable approximation to such objective rationality.[20]

As a consequence, Simon believed that man must use greatly simplified internal models of situations in order to deal with them. As a second consequence, he believed that limits and procedures used in practice were largely determined by social and even organizational forces.

As an application of bounded rationality, Simon developed a technique now called "satisficing" to evaluate multiattribute alternatives. This approach used a vector of values, one component for each attribute rather than a single utility. Each alternative was rated relative to each component on a limited scale (acceptable/unacceptable, or acceptable/irrelevant/unacceptable). The decision process examined alternatives sequentially until one with all components rated satisfactory were found. This alternative was then selected. Note that the order in which alternatives are examined could be critical here and that the solution is probably not "optimal." Many variations on this basic theme have been formulated.

An even more radical view of decisionmaking was advanced by Ashby (as reported by Steinburner). Ashby proposed that the decisionmaker made no calculations at all, assigned no payoff values. Instead, the decisionmaker harbors a set of behaviors ordered in some fashion related more to past performance than to the current problem. The effects of actions from this set of behavior are not known until after they are taken. The decisionmaker then monitors a small set of critical variables and attempts to keep these values within tolerable ranges. Ashby called this process "nonpurposeful adaptation." While the assumed process is probably too extreme, it contains very suggestive elements.

Such considerations have led Steinburner to propose what he terms the "cybernetic paradigm" as an alternative to utility-based theory. Using this theory, he attempts to explain how highly successful, adaptive behavior is possible without elaborate decisionmaking mechanisms. This model is based upon feedback effects similar to those seen in control theory; hence the reference to "cybernetics." The basic notion is that decisionmakers base their decisions upon a small number of easily monitored variables. These variables are then "controlled" by selecting from a small number of possible actions. The effects of actions, in terms of the controlled variables, are monitored and subsequent actions modified on the basis of observed effects. Uncertainty is automatically handled under this process. The decisionmaker avoids direct outcome predictions (which are quite sensitive to uncertainty) and instead concentrates on monitoring a few observed variables. Initial responses are established by prior experience, while the response set is modified by the "learning" that takes place as results of actions are observed. Hence, the cybernetic paradigm rejects the complex computational approach advocated by utility-based theories and instead uses control of a few variables via highly programmed response to solve decision problems. Steinburner argues that actual decision processes, especially the political decisions he reviews, can best be understood in relation to this control theoretic approach.

After the above review, it is natural to ask which decisionmaking approach is appropriate for military decisionmaking. As usual, there is no “correct” answer. The real question is when and under what circumstances each approach is possible and appropriate. This question hinges on the nature of the action being considered, the availability of feedback information, and the ability to predict outcomes.

Dennis K. Leedom in an article entitled “Representing Human Thought and Response in Military Conflict Simulation Models”[21] reviews research conclusions about military decisionmaking. He notes that many theorists believe that military problem solving or decisionmaking is a two-stage activity in which the first stage is recognizing the structure or class of the problem and the second stage is applying specific problem-solving techniques indicated by the problem structure. Specifically, he believes that problem solvers learn a number of problem-solving frameworks which contain procedural information including conditions which signal that the specific framework is the appropriate one to apply, types of information needed for the solution, procedures for generating alternate solutions, procedures for selecting among the alternatives, and procedures for implementing the solutions. This interpretation combines several of the approaches noted above, since construction of the frameworks can be utility-based while the actual procedures use alternate decision methods more suitable for combat conditions.

It is tempting to identify the utility-based, analytic approach to decisionmaking with “strategic” decisions and the control theory-based decisions with “tactical” decisions. This greatly oversimplifies, since elements of both approaches can be found at all levels of planning and decisionmaking. In terms of the problem-solving model proposed earlier in this chapter, the analytic approach is clearly involved in the evaluation and selection process that results in the initial plan. It is also involved in constructing contingency plans. The control theoretic approach is then appropriate during the execution phase where operations are directed to insure conformation to the plan. Throughout execution, the control theoretic approach is also appropriate in monitoring for the need to adjust or drastically change plans. This may be combined with the analytic approach at least to the extent of dependence on prediction of outcomes and future situations. Hence, both analytic and control theoretic approaches are interwoven throughout the combat operations decisionmaking process, with emphasis shifting according to command level and phase of operations.

The above analysis treats problem solving and decisionmaking from the standpoint of a single decisionmaker. Actually, problems tend to be distributed over a network of problem solvers in the military context, and this introduces additional complications.

d. *Distributed Problem Solving.* Distributed problem solving is the solution to problems through the use of multiple cooperative (usually physically separated) problem solvers. Truly distributed problem solving must be contrasted with centralized problem solving with remote execution. In true distributed problem solving, no one element has access to all the information which will be used in the eventual solution. The essential issues involve the decomposition of problems, insuring cooperation among problem-solving elements, managing communications, and dynamically adjusting the system problem statements in response to changes in the situation.

In the military context, distributed problem solving can be viewed in a hierarchial fashion, with a physical structure identical to that of a hierarchial control system. The difference is one of interpretation. Instead of each element being seen as a controller, each element is seen as a problem solver. This interpretation makes resource management constraint and scheduling questions easier to address. As an example, the national command authority may perceive a political problem. Through a means and ends analysis they develop goals which, if accomplished, should result in a favorable political result. These goals are then analyzed to produce subgoals which, together with resource allocations and constraints, form problems which are passed to the diplomatic, economic, and military instruments of power via various actual organizations. Each of these instruments repeats this process. The military instrument, in the form of the DOD for example, analyzes its assigned problem and develops subproblems which it passes on to the Army, Navy, and Air Force. Each subproblem consists of objectives, resource allocations, and constraints. Again and again, the process is repeated until the problem at lowest level is reduced to some simple action, such as delivering a bomb against a bridge.

Problem decomposition and resource allocation are not quite as clear as depicted. Each level formulates its plan to accomplish its assigned task and submits this plan to its supervisor level for approval. Some negotiated adjustments of objectives, resource allocation, and scheduling occurs during this iterative review process. Conflicts between elements are also identified and resolved. The final result of this process is an overall plan.

Once execution begins, dynamic adjustment of problems and plans at all levels begins. Actual results may create or eliminate problems, and the process continues until the original highest level problem is solved or terminated.

If the process described is truly distributed, high-level reviews are not reworkings of the details of the plans. Rather, these reviews concentrate on identifying and resolving possible conflicts and in insuring successful cooperative action. Hence, efforts concentrate on reviewing plans to make sure allocated resources are adequate, actions will be on schedule to insure cooperation with other activities, and constraints will not be violated. Care must also be taken to insure reasonable flexibility and adaptability in anticipating possible changes in objective, constraint, and resource allocation from higher levels. Careful management of communication is essential at all stages.

In a conflict situation, commanders at all levels must also continually monitor the aspects of their assigned problem which can be influenced by enemy action. Such actions may require adjustments in plans, which can propagate changes throughout the decision structure. Good plans will localize these effects as much as possible, but dynamic multilevel adjustment will sometimes be required. In the execution phase of the operation, many actions are occurring in parallel. Such parallel action is essential but can create problems and uncertainties. Proper problem decomposition minimizes interactions between these parallel processes and insures communication and conflict resolution adequate to successfully achieve overall objectives.

Several technical issues are introduced by distributed problem-solving hierarchies. These include determination of the logical role of communication, handling of unpredictable events and errors, fault tolerance, and graceful degradation. These issues and others are reviewed in an article by Richard F. Rashid.[22] Andrew S. Tandenbaum's book *Computer Networks* also contains much informative and valuable material.[23]

This chapter has developed the basic tools to be used in the remainder of this report. A conceptual model of the combat operations process was built based upon Boyd's O-O-D-A loop construct and Lawson's C^3I process model. Expansion of the functions in the combat operations process model resulted in the power distribution model as a description of force application potential and in the military problem-solving process model. These models are the key ingredients in the investigation of command of combat operations in chapter III and of effective command of combat operations in chapter IV. The psychological research reported also suggests two possible C^3I structures to assist the commander. One involves a distributed problem-solving network with command structure as suggested in the Specialist Demon model. The second is a highly centralized structure as suggested by the hierarchial control model. Selection of the most appropriate C^3I structure depends upon the results of the investigations in chapters III and IV. This is the subject of chapter V.

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Chapter III

Command of the Combat Operations Process

The goal of this research project is to understand combat operations, C^3I and the interactions between them. The process models developed in the previous chapter are helpful in this respect. They provide an excellent description of the activities involved, but they fall short of going beyond description to determine what the processes *should* be doing and how they *should* do it. The definition of C^3I in the last chapter links C^SI systems to the command function within the combat operations process. Command is the link between combat operations and C^3I, and it gives purpose to both. This chapter uses the tools developed in chapter II to investigate the proper function and purpose of command within the combat operations process.

This chapter argues that the nature of combat makes command of combat operations vastly different from other managerial or process control tasks. This means that techniques that are effective in these other situations are not as appropriate for the combat commander. The argument is based on three observations. First, the nature of combat is such that the commander's decisions do not always determine the results of the combat. The actual degree of control varies greatly with situation, and this fact has a major impact on the determination of the primary function of command. Secondly, even when the commander's decision does have significant impact, the probabilistic or stochastic nature of the combat process means that the commander is only influencing the probability of outcomes rather than directly controlling outcomes. The exact probabilistic nature of this process again has a major impact on the determination of the primary role of the commander. Finally, even the probabilistic structure of the combat process is unstable. This makes predictions of outcomes extremely difficult. These observations indicate that usual managerial and control techniques, which are essentially based on the notion of controlling outcomes or results, are insufficient to define the commander's function. The stochastic nature of combat and the varying degree of actual command decision impact on the combat process suggest that the primary function of command in combat is managing sources of potential power in order to be able to exploit opportunities as they arise. This task can be identified with management of the evolution of the power distribution. The chapter concludes with a discussion of the implications of the difference between the primary function of command in combat operations and command in noncombat situations.

The Purpose of Command

Identifying the purpose of command is a difficult task. It is not too hard to define the functions associated with command—controlling the movement of forces, directing maneuvers, allocating resources—but lists of this type fail to define purpose. The purpose of command is, of course, intimately related to the purpose of the activity commanded, hence the need for a closer look at command in the context of combat operations. Because of the complicated nature of combat operations, we will use greatly simplified examples of basic concepts.

Consider the conflict situation represented by Figure 10. Here the top row represents the world at the beginning of the conflict. The commander now initiates some action, and the world changes.

In this simplified example, suppose three possible new situations can occur as labeled S_1, S_2, or S_3. The enemy now responds to the commander's action and one of six possible results labeled R_1 through R_6 ends the conflict. Can the function of command be identified from this example?

The answer to this question depends upon the amount of impact the commander's decisions have upon the transition of the initial situation S_0 into one of the intermediate states S_1, S_2, or S_3. Suppose that the commander's decision completely determines which intermediate state will occur. In this case, the commander's problem is *determinant;* he is completely in control of the initial transition. The final result depends upon the enemy's response, but the commander, with the initiative as in this simplified example, can select the pair of possible results from which the actual result must come. If the commander assigns value to these outcomes (as in the numbers in parentheses in Figure 10), it is reasonable to assume that the enemy will respond to give the result of less value to the commander. (See Schelling's *Strategy of Conflict* for interesting discussion of cases where this may not be true.[1]) Hence, the commander should force the enemy to select from the pair in which the smaller number is greater than the smaller number in each of the other pairs. In the example, this means forcing S_1. Forcing S_2 in hopes of obtaining the most valuable result R_3 is useless since the enemy can force R_1 with a value less than would surely be obtained by forcing S_1. This, briefly, is the game theory approach to command in the determinant case.

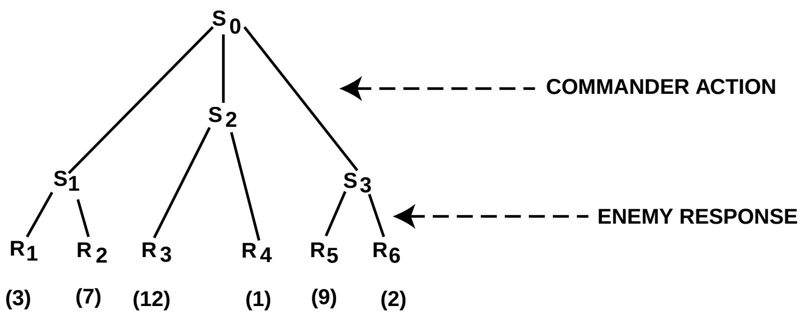

Figure 10. Simplified Conflict Analysis

In real life, however, and especially in combat situations, the commander's decisions may not completely determine which transition will occur. External circumstances beyond the control or knowledge of the commander may actually determine the transitions. Such conflicts are called *stochastic* because of the seemingly random nature of actual outcomes. It might seem that lack of control on the part of the commander negates his ability to command, and this is true to some extent. Frequently, however, the transitions involved in the stochastic process are governed by principles that can be affected by the commander's decisions. Manfred Eigen and Ruthild Winkler give many excellent examples to show how simple probabilistic laws lead to statistically predictable behavior.[2] This statistical predictability allows a variation of the game theory approach used in the determinant case to be applied.

Suppose in the example that the commander has two possible decisions—D_1 and D_2. Suppose, furthermore, that his competent team of analysts assures him that if he makes decision D_1 there is a 30 percent chance that transition to S_1 will occur, 30 percent chance that transition to S_2 will occur, and 40 percent chance that transition to S_2 will occur. Under decision D_2, they assure him, the corresponding chances are 70 percent, 20 percent, and 10 percent, respectively. The ability to estimate these transition probabilities depends upon the statistical predictability of the transitions. If the commander accepts these estimates as representing the actual process, it is reasonable for him to base his decision on the expected value of the decisions. Since decision D_1 will result in state S_1 30 percent of the time, and since the enemy is then expected to respond to force result R_1 with value 3, the contribution from state S_1 to the expected value is .3 x 3. Repeating this process for states S_2 and S_3 and summing gives the expected value of decision D_1 as .3 x 3 + .3 x 1 + .4 x 2 = 2.0. Similarly, the expected value of D_2 is .7 x 3 + .2 x 1 + . l x 2 = 2.5. Hence, it is reasonable for the commander to choose decision D_2. This expected value assumes that the enemy completely controls the transition from states S_1, S_2, or S_3 to the results. If this is not true, and if reliable estimates of the transition probabilities can be made, the expected value changes. For example, if the enemy has no real control and the transition probabilities are 50 percent, then there is a 50 percent chance of result R_1 from state S_1 and a 50 percent chance of result R_2. Using the process above, the contribution to the expected value from states S_1 is .3 x (.5 x 3 + .5 x 7). Summing over all states, the expected value for decision D_1 is .3 x (.5 x 3 +.5 x 7) +.3 x(.5 x 12 +.5 x l) + .4 x(.5 x 9 +.5 x 2) = 5.65. The expected value of decision D_2 is .7 x (.5 x 3 + .5 x 7) = .2 x (.5 x 12 + .5 x 1) = .l x (.5 x 9 + .5 x 2) = 5.35. D_1 is now the better decision. Note how this example shows both the value to the enemy of control and the sensitivity of the "best" decision to estimates of the transition probabilities. In the following discussion, we assume the enemy totally controls the second transition except where noted otherwise.

It is interesting to note that the commander in this case really should "expect" to receive the expected value 2.5 from this decision. In fact, he should be certain that he will receive a value of 1, 2, or 3 approximately 10 percent, 20 percent, and 70 percent of the time, respectively. (In the variant example, he expects values 1, 2, 3, 7, 9, and 12 approximately 15 percent, 20 percent, 15 percent, 15 percent, 20 percent, and 15 percent of the time, respectively.) Confusion concerning expected value, especially when large differences in value are involved, can occur easily. For example, suppose the values assigned to results in Figure 10 are changed so that R_1 is worth 4, R_2 is worth 7, R_3 is worth 1, R_4 is worth 2, R_5 is worth 2,000,000, and R_6 is worth 1,000,000. If decision D_1 now gives probable transitions to S_1, S_2, S_3, respectively, of 50 percent, 49 percent, and 1 percent while D_2 gives corresponding probabilities of 90 percent, 10 percent, and 0 percent, the expected value of D_1 is 10,002.49 and of D_2 is 3.7. Clearly D_1 is the correct decision. But on the other hand, suppose that a result with value 4 or more is sufficient to "win" while less must be considered a loss. Then decision D_1 wins slightly more than half the time, while D_2 wins 90 percent of the time. In such circumstances, expected value is not always selected as the criterion for choice. This illustrates one of the problems with utility-based decision theories mentioned in the last chapter and introduces the concept of risk associated with a decision.

To return to consideration of the purpose of command in the stochastic case, it is clear that stochastic cases can be distinguished according to the amount of influence of the commander's decision. If decision D_1 corresponds to transition probabilities of 90 percent, 10 percent, and 0 percent, respectively, while D_2 corresponds to probabilities of 0 percent, 10 percent, and 90 percent, then the commander's decision is quite significant. If the probabilities are 90 percent, 10 percent, 0 percent, and 89 percent, 11 percent, and 0 percent, the decision is not so significant. In the extreme case, the commander's decision has no influence at all, making the conflict *indeterminant* from the commander's view.

The discussion above was not intended to introduce the joys of game theory or statistical decision theory. It was intended to suggest the purpose of command. In the case of determinant conflict or stochastic conflict with significant impact of command decisions, it is legitimate to identify the purpose of command as the control of results. But if the conflict is indeterminant, or command decisions have no significant impact, this identification makes little sense. Command must involve something other than the management of results. A clue to what this something must be comes from a more realistic look at the commander's task.

In real life the combat commander is seldom faced with a single decision problem. Instead, he is faced with a succession of problems, many of them connected. Some of these problems respond significantly to the commander's decisions, but many do not. Successful commanders must strive to be in position to take advantage of opportunities to significantly control results when such opportunities arise. In the military combat context, such decisive opportunities may be rare. That is, the commander doesn't have a continuous opportunity to control the results of combat operations, but rather must decisively seize the few opportunities to influence battle outcomes that do occur. Clausewitz seems to hint at this situation.

> War, in its highest forms, is not an *infinite mass of minor events* analogous despite their diversity, which can be controlled with greater or lesser effectiveness depending on the methods applied. War consists rather of *single, great decisive actions* each of which needs to be handled individually.[3]

The conclusion to be drawn from these observations is that a primary function of command is deploying and maneuvering forces or other sources of potential power to be in the best possible position to exploit opportunities as they arise. This function can be viewed as controlling the power distribution.

Identification of the properties of combat operations that influence the impact of command decisions upon combat results suggests a dual function for command. Most of the time command is concerned with controlling the power distribution and thereby creating the opportunity for a decisive engagement where command decisions have significant impact. In those rare instances where decisive control of results is possible, command is concerned with controlling results to obtain the best results possible. This conclusion was based upon the analysis just completed of the impact of command decisions upon combat results. The same conclusion follows from an analysis of the nature of the combat process itself.

Systems Analysis, Administration and Architecture[4] by John W. Sutherland, presents an interesting discussion of the natures of systems and the implications of these natures. Sutherland identifies four principal types of systems: deterministic, moderately stochastic, severely stochastic, and indeterminant.

Deterministic systems are characterized by the fact that for any given initial condition there is one and only one outcome with any significant probability of occurrence. Common mechanical systems are primary examples of this type of system. Highly institutionalized social systems are others. The control systems presented in previous sections also belong in this category. Since each initial state corresponds to a unique output, system performance can be precisely controlled by manipulating the initial conditions. This leads naturally to efforts to optimize outcomes.

Moderately stochastic systems are characterized by the fact that only a limited number of qualitatively similar outcomes from a given initial condition have significant probability of occurrence. Examples of this type of process include genetic processes and other processes where only a small number of possible outcomes are possible. Variability in actual dimensions of machined parts or in a batter's performance during a baseball game are other examples. These processes involve highly constrained outputs, and hence attempts to control the system by manipulating the initial conditions are again reasonable. In most cases, control techniques are essentially the same as for deterministic systems, structural data can sometimes be deduced. Small amounts of data can be very misleading, however. Finally, for indeterminant systems, structural information is all important, with facts or data about initial conditions and results in the past valuable only as part of an exhaustive empirical learning process.

Sutherland also notes that the system objectives in interaction with the outside world, the advantages sought, and the probable sources of serious error differ according to system type. For deterministic systems, the objective is to establish essentially automatic responses to a limited, highly structured set of trigger stimuli. This results in rapid and effective response as long as environmental conditions remain relatively unchanged. The major problem with such systems is a rigidity in the face of major changes in the environment.

For moderately stochastic systems the objective is to establish a set of algorithmic responses (with general procedures specified, but not, implementation details) to a highly constrained set of stimuli and to maintain operational consistency throughout the system domain. This means that although responses may vary in exact detail according to previous responses, on the whole the same procedures are used to respond in all cases. Obtaining this objective means that the system operates with maximum interval efficiency and control in the face of routine but critical performance demands. The greatest danger is obsolescence in that the system may attempt to maintain internal consistency even when environmental conditions shift and make these internal procedures inadequate.

For severely stochastic systems, the objective is to make the most efficient use of resources in a succession of varying short-term situations and to rapidly and effectively take advantage of opportunities for exploitation. This approach achieves long-term efficiency by continually trading off internal consistency and mechanization for versatility and adaptivity to the external environment. The major potential problem is the possibility of misallocation of resources due to the time lag between recognition of a new opportunity and internal system readjustment. There is also some danger that the opponent (in conflict situations) may introduce an innovation or change in strategy that may degrade system performance.

Sutherland identifies the objective for indeterminate systems as insuring effective response to an unprecedented situation. Creativity rather than a mechanical approach to problems is to be encouraged. This results in adaptivity when faced with unusual and unpredictable outside forces or influences and encourages maximum structural and functional flexibility. The main dangers are the possible dissolution of the system, since the largely autonomous parts are only weakly controlled, and the high probability of error brought about by a constant quest for innovation.

Sutherland's analysis, applied to combat operations, suggests that control of the power distribution is the most important aspect of command even in those cases where command decisions can significantly influence combat results. This follows from the recognition that combat, especially physical engagement of forces, is severely stochastic or indeterminant in Sutherland's terms. Hence, the command objectives of the last two paragraphs are appropriate. But these objectives call for controlling the sources of potential power—that is, for controlling the power distribution and its evolution.

One final observation about the combat operations process reinforces again the basic concept developed above. This observation concerns the stability of the combat operations process stochastic structure and the implications of possible instabilities. The discussions above concerning the impact of command decisions upon results and concerning the stochastic nature of process outcomes apply to games such as backgammon or to athletic contests such as football as well as they apply to combat. But backgammon and football differ from combat in that their basic probability structure does not change significantly during the game, while in combat the most significant events involve changes in this basic stochastic structure.

Consider a simple example. Suppose two players toss a die. The first player wins a point when a 1, 2, or 3 appears on the top face and the second player wins a point when a 4, 5, or 6 appears. The game continues in this manner until one player is three points ahead, at which time he wins the game. This is an example of a game where the probability structure is stable in the sense that it does not depend on the previous outcomes in the game. Call this game G_1.

Now consider the following variant, G_2, of the game. When the players have the same number of points, the game is played as described above. However, when a player falls behind in this version, the probability structure changes. A player who is one point behind wins a point only when a 1 or 2 is thrown, and a player who is two points behind wins a point only when a 1 is thrown. This game is unstable in the sense that previous outcomes strongly influence the probability structure. These differences have a great impact on the expected results of play.

In both cases, each player has an even chance of winning. The expected length of the games vary drastically, however. In G_1, only one game in 10,000 is expected to last longer than 71 rounds. For G_2, only one game in 10,000 is expected to last longer than 27 rounds. Hence, G_2 is expected to produce a winner much more rapidly than G_1. Even more significant is the difference in implication of falling behind. In G_1, a player falling behind by one still can expect to win 33 percent of the time a player behind by two can be expected to win nearly 7 percent of the time. In G_2, on the other hand, a player behind by one is expected to win slightly less than 19 percent of the time and a player behind by two slightly more than 3 percent of the time. Clearly, it can be very dangerous to fall behind at any point in G_2.

Applying an analogy, most games and sports are designed so that the probability structures remain fairly stable throughout the game. Great changes in probability structure, as when the star quarterback is injured in a football game, are exceptions rather than usual events. In combat, however, the basic aim of destroying or disorienting the enemy's forces, if successful, results in possibly drastic changes in the stochastic nature of the subsequent conflict. This means that successful minor operations can rapidly snowball into the total collapse of the enemy. And this potential has profound influences on military commanders, since it suggests that management of risk is at least as important as the management of expected results.

This situation is perfectly exemplified in the contrast between the theoretical bases of attrition-based warfare and its alternatives. Attrition-style warfare is based upon the existence of a favorable overall probability structure. That is, superior resources combined with an acceptable force exchange ratio will surely eventually result in victory provided that this favorable situation can be made to endure long enough. Insuring that such advantages last long enough to be effective—that is to say, preserving the favorable probability structure—is the key objective of attrition-based strategies. Alternatives to such strategies, on the other hand, frequently involve risky operations or maneuvers which result in significant changes in subsequent probability structure. Such strategies are necessary when the time or resources for less risky approaches are unavailable. As in the example above, the consequences of failure can be severe.

From the perspective of a commander not forced into a particular strategy, the above observations highlight the importance of risk as a factor in evaluating proposed actions and strategies. The unstable nature of the combat operations process, as reflected in the significant tendency of serious failures to snowball into complete disasters, makes command of the combat operations process much more sensitive to risk than is command of more stable stochastic processes. This results in an orientation of combat commanders towards the management of risk. And how can this risk be managed? Once forces are committed, the stochastic processes take over and the commander has minimal influence. Hence, control must involve control of potential sources of power rather than direction of combat results. Again, the primary function of command of combat operations is intimately tied to control of the evolution of the power distribution.

All of these difficulties, combined with the multiple, sequential problem nature of combat, have significant implications for command. In deterministic or moderately stochastic cases, the worst case results from each stage can be used to estimate the initial conditions for the next stage, and hence an estimate of the result of a chain of such things as engagements and problems can be made. In more wildly stochastic cases, computation is not as feasible (all cases, not just the worst cases must be pursued) and is probably not as valuable. Chess is a good example of a deterministic conflict where detailed calculations to great depth are required (perhaps limited heuristically). Backgammon, on the other hand, is a good example of a stochastic conflict. Good play in backgammon depends largely upon an analysis of the position very similar to a power distribution analysis. It is interesting to note that although computer programs that play good chess have been developed, they have not been competitive at the highest human level. Backgammon programs, in contrast, are very competitive. This is a good example of the varying impact of “command decisions” in deterministic versus stochastic conflicts. This analogy will be considered again later.

Thus, examination of the command of combat operations from three different viewpoints has suggested that the primary purpose of command is controlling the evolution of the power distribution. This was suggested by the limited influence of command decisions under many circumstances, by the severely stochastic to indeterminate nature of the combat process, and by the implications of the need to manage risk in basically unstable processes. The implications of this interpretation of command in combat operations are examined in the remainder of this study.

Use of the Power Distribution

Combat tactics can reflect a recognition of this stochastic nature of combat. It is interesting in this respect to compare the German Blitzkrieg or infiltration tactics in World War II with US and USSR frontal assault tactics. The United States and the Soviet Union take a decidedly deterministic approach to such assaults. Attacks are generally focused on specific points perceived to offer the best chance of penetration. Once the battle begins, reserves are used largely to reinforce efforts that are not proceeding according to plan. This use of reserves is required to maintain the carefully scheduled progress required by rather rigid overall plans designed to optimize the use of available forces. The emphasis is on forcing the plan to be successful. The German Blitzkrieg and infiltration tactics, on the other hand, begin with a rather unfocused attack along a fairly broad front. As individual encounters are resolved, reserves and exploitation forces move rapidly to reinforce successful efforts. Such tactics require extremely responsive forces and flexible plans, which usually means giving a lot of authority and autonomy to local commanders. Reinforcements cause major breakthroughs to eventually occur. The exact point of breakthrough is not preplanned but arises from the stochastic nature of the individual fights.

The ability to exploit the stochastic nature of combat in this manner depends upon the ability to rapidly recognize opportunity and act to exploit it. Conceptually, this is near real-time control of the power distribution. The power distribution model, therefore, is an appropriate tool for the combat operations commander.

The power distribution model has been previously described, but in fairly abstract terms. Two examples of the possible use of this model may clarify things. First consider the situation in Figure 11. Here a red force of 200 men, initially located at position R_0 are attacking three towns—T_1, T_2, and T_3. A blue force of 100, initially located at position B_0, is tasked with defending the three towns. The only available roads are shown in the figure, and it requires one day to travel between any two connected labeled positions. The red forces require a 3:1 numerical advantage for a successful attack. With this ratio they have proved irresistible. The blue commander, therefore, must attempt to deploy his troops to prevent a successful 3:1 attack. He has a problem since there is no static allocation which can prevent red from seizing at least two towns. A balanced allocation of troops (say 33 to T_1, 33 to T_2, and 34 to T_3) can be countered by a 100-man attack on T_1

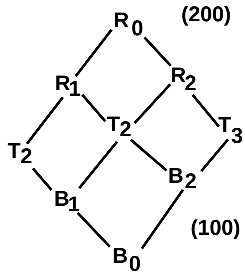

Figure 11. Troop Allocation Example

and a 100-man attack on T_2. Other static dispositions can be similarly countered. Blue must, therefore, be able to dynamically allocate troops in response to red moves. Suppose that the surveillance and mobility required for this dynamic allocation exists. Can blue successfully defend? The power distribution provides an answer. It takes two days for red to attack any town. In that time, he can move 200 men against any of the towns. It similarly takes blue two days to get defenders to any town, and in that time he can get 100 men to any specified town. Hence, the power distribution at the towns with a two-day horizon shows a 1 blue to 2 red ratio at each town. Under the rules specified, this is a successful defense. The power distribution is only a measure of potential, of course. Attacks with less than 3:1 odds could succeed, and attacks with even greater odds might fail. But preventing a ratio worse than 2:1 is the best blue can do. The power distribution model says blue can assure this.

But now suppose red is detected moving 50 men towards R_1 and 150 men towards R_2. This changes the two-day horizon power distribution since red can now attack T_1 with only 50 men, T_2 with 200, and T_3 with 150. Blue must react rapidly to prevent defeat. Sending his troops in proportions equal to the enemy will assure that the 2:1 ratio will not be exceeded. Hence, he should immediately send 25 men to B_1 and 75 men to B_2. The power distribution model has not, of course, resulted in phenomenal new insight in this case. It does, in this simplified example, guide a proper response. It would also point out the commander's error in using any other initial distribution of troops. If the blue commander sends 50 men to B_1 and 50 men to B_2, for example, red could force a 3:1 attack at T_3.

This example is more useful as an illustration of requirements. In the example, the available forces were adequate for a defense if properly and responsively maneuvered. If the power distribution shows this to be untrue, the commander is alerted to the need to take drastic steps or abandon the defense. Such drastic steps might include summoning reserves, launching a deep counterattack to reduce the odds, or using political maneuvers. At times, the blue commander may even be forced to accept combat under unfavorable odds.

The above example has illustrated a possible use of the power distribution in command. Figure 12 illustrates another potential use. In combat, there is usually a great deal of maneuver designed to achieve a favorable attacking position. The power distribution, with a sufficiently large-time horizon, can indicate where significant problems might arise, and hence help identify the possible focus of an attack.

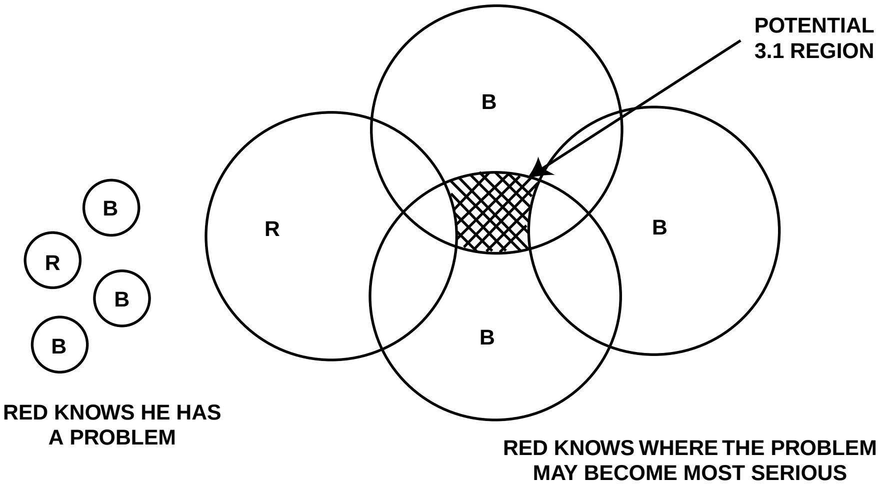

Figure 12. Locating Problem Regions

Implication of this Interpretation of Command

This chapter has argued that the primary purpose of command in combat operations is the control of the power distribution. This interpretation has several interesting implications. The most fundamental of these has to do with the evaluation of command decisions. A second involves the failure of analytical tools in combat evaluation. A third deals with problems within the military.

The evaluation of decisions after the fact has always been a dangerous business. Our culture, especially the civilian culture from which most critics come, is oriented towards deterministic or, at worst, moderately stochastic processes.

Deterministic explanations are advanced and expected for almost everything. News commentaries on the stock market are prime examples! As a result, decisions are almost invariably judged by results. This can be very misleading when stochastic processes are involved. Take, for example, a comparison of computer programs to play chess and to play backgammon. On the basis of results, the backgammon programs would be judged to be superior. Anyone who looks more closely into the matter will discover exactly the opposite to be true. Backgammon programs are primitive compared to chess programs. But the stochastic nature of backgammon masks the programs' mistakes, while human problems in handling random processes present unexpected opportunities. In chess, against a first-rate opponent, mistakes become all too obvious and results suffer. Judging decisions by results is reasonable in many cases, but it may be very dangerous where stochastic processes are involved.

The tendency to judge by results is important in another way. The fundamental basis of the analytical tools developed to deal with deterministic processes—optimization techniques, statistical decision theory, and utility based decision theories-is judging decisions by results. Hence, these tools do a poor job of reflecting the value of flexibility, adaptability, and responsiveness when used to analyze combat situations. This use of tools not truly suited to dealing with stochastic processes has resulted in all too many optimal and rapidly obsolete weapon systems. Unfortunately, mathematical tools more suited to deal with stochastic processes are difficult to understand and explain. Their results are often counterintuitive and grating upon those uncomfortable in the presence of randomness. Their frank admission that precision and certainty are not possible is too much for many decisionmakers to take. As a result, decisionmakers, and especially military decisionmakers, must be constantly alert for the application of inappropriate tools to the analysis of combat operations.

A final unfortunate implication is found within the military and in relations between the military and civilian political leaders. Political leaders are almost always drawn from the civilian culture and have usually distinguished themselves in occupations where the nature of the processes they controlled made judging decisions by results appropriate. Such leaders tend to keep their old evaluation patterns even when exposed to stochastic processes such as combat (or international politics which may even be indeterminant). The military has not helped things in the past, since differences between military and civilian activities have been minimized. New initiatives within the Air Force, such as Project Warrior, may signal the beginning of an attempt to undo some of this harm, but great damage has already occurred. The emphasis within the armed forces on civilian-oriented career management progressions is a result of these policies of the past. This emphasis will continue unless the military rediscovers the unique command qualities needed by combat commanders and convinces civilian leadership that such differences must be nurtured and rewarded. These key differences depend upon the distinction between command of a deterministic or near-deterministic process and command of a stochastic process such as combat.

This chapter has investigated command in the context of combat operations. It has examined the impact of command decisions on combat results, on the stochastic nature of the combat process, and on the importance of risk management in unstable stochastic processes. This examination has resulted in the conclusion that command of combat operations is primarily a matter of properly controlling the distribution of potential power. This chapter has also explored the implications of this interpretation, especially in a world where decisions are usually judged by results. It illustrated the use of the power distribution model as an aid to command and also introduced the command function of guiding the evolution of the power distribution. The next chapter pursues this concept further, developing some guidelines for influencing the power distribution.

Notes

1. Thomas C. Schelling, *The Strategy of Conflict* (Cambridge, Mass.: Harvard University Press, 1960).

2. Manfred Eigen and Ruthild Winkler, *Laws of the Game: How the Principles of Nature Govern Chance* (New York: Alfred A. Knopf, 1981).

3. Clausewitz, 153.

4. John W. Sutherland, *Systems: Analysis, Administration, and Architecture* (New York: Van Nostrand Reinhold Company, 1981).

Chapter IV

Effective Command of Combat Operations

This chapter uses the military problem-solving process model to develop guidelines for the commander attempting to influence the evolution of the power distribution. The combat operations process model is used in dealing with the factors specific to combat. The chapter then examines the military theories and proposals of chapter I within the framework given by the military problem-solving process. The basic approach of this chapter is related to the discipline called praxeology by its practitioners. This "science of efficient action," which dates from the work of the Polish logician Tadeusz Kotarbinski, "studies not behavior but action—not *how men behave, but how they must act, if they are to act effectively*."[1] Praxeologists believe that the requirements for effective action can be deduced from the underlying process structure. This approach will be taken in analyzing effective command in combat operations using the military problem-solving process model and the combat operations process model to provide the framework for deductions.

The Military Problem-Solving Process

The previous chapter identified the primary purpose of command of the combat operations process as control of the evolution of the power distribution. The transformation of the power distribution into a desired distribution presents the commander with a problem. The military problem-solving process in Figure 9 therefore applies. In the actual situation, of course, there are two opposed commanders with different goals. Hence, combat becomes a race to formulate and to solve the friendly problem while blocking the solution of the enemy problem. This is analogous to Beaufre's prescription for successfully completing the preparatory maneuver and decisive attack (the problem) while blocking the enemy's preparatory maneuver. The allocation of effort among these tasks is, as Beaufre notes, the key to victory.

The military problem-solving process in Figure 9 will guide the discussion in this chapter. Each stage in this process suggests possible approaches to a successful military operation. At the same time, each stage suggests actions that can disrupt the enemy process, effectively blocking his plan. Such actions help to define the ways to attack the enemy's strategy as suggested by Sun Tzu. The following paragraphs will trace through the military problem-solving process, discussing the command implications of actions at each stage.

Determination of the Desired Power Distribution

The first stage in the military problem-solving process is the determination of the desired power distribution. In Beaufre's terms, this amounts to determining the preparatory maneuver necessary to make the decisive attack possible. This, of course, assumes that the proper decisive attack has been formulated and may require the coordinated use of many nonmilitary instruments of power as well. This stage represents the most difficult stage in the combat operations planning process. The great difficulties are due to the need to determine military actions that will lead to desired political goals.

Military theory overlaps with political theory in the attempt to define the relation between military objectives and political objectives. The early Air Force studies of the effects of disrupting the enemy's "industrial web" and the extensive targeting studies that have followed are examples. The recently declassified PROJECT CONTROL study conducted under the leadership of Colonel Raymond S. Sleeper at the Air War College investigates this military political linkage in even more detail.[2] Such studies demonstrate the difficulty of this aspect of the planning and problem-solving process.

Studies such as those referenced, when applied to the general problem of command of combat operations, are suggestive but not very specific. In fact, the nature of the planning process for military operations is so dependent upon the exact situation involved that detailed prescriptions are impossible. The end-means analyses involved are very complex, and the success of actual decisionmakers in this regard is remarkable. Research suggests that these analyses are based upon vast stores of information on previous cause-effect relationship (sometimes called experience) and upon rather vague principles extracted from this information. These data and principles frequently lead to very good decisions, as judged by eventual results. They can also lead to very bad decisions, however, since cause-effect relations are easy to misinterpret, external circumstances which profoundly impact actual effects are seldom the same, and decisionmakers can easily fall prey to wishful thinking. The evaluation of decisions based on results can be misleading in this context since the dynamic nature of command allows many major errors to be corrected during later stages of the process if adequate attention is paid to feedback.

Attempts to disrupt the problem-solving process at this stage take two basic forms. Shifts in the deployment of forces or similar actions can affect the requirements for the preparatory maneuver or even shift the focus of the decisive attack. A more basic attack, however, is at the political level and focuses upon the enemy goal structure. The goal structures of parties in a conflict may offer opportunities to create difficulties which could translate into a favorable shift in the power distribution. Beaufre has suggested that an analysis of the objectives of all parties in a conflict (and neutral parties) is an essential part of the process of generating strategies. His observations were summarized in a previous chapter and will not be repeated here. In essence, he proposed that conflicts in goals were the keys to discovering effective political maneuvers. Three classes of conflict were noted. First were conflicts in objectives (or in importance attached to objectives) between opponents in a conflict. This analysis pinpoints actual areas of disagreement, highlighting the possibility of a political solution through compromise or modification of objectives. The fact that many objectives are involved and that they are frequently interrelated in complex ways makes this process very difficult in practice.

If a peaceful solution is not possible, this goal analysis can still be invaluable. Information about the importance attached to the objectives in question gives some indication of the intensity to be expected in the conflict and also the potential level of effort on each side. Misjudgments along these lines have created great problems in the past. Estimates on the importance attached to objectives can also guide indirect strategies.

The second class of conflicts, conflicts in goals between parties in an alliance, form the basis for direct and indirect attacks upon an alliance. Maneuvering one party of the alliance into satisfying a goal opposed to that of his partners can create strain within the alliance. Soviet manipulation of European desires for economic ties with the Soviets against American tendencies to make such ties subordinate to political objectives is an example of this type of leverage.

Finally, conflicts among the goals of a single nation may become sources of internal delay and paralysis, as indicated in several examples by Beaufre. Some such conflicts seem inevitable—such as the desire for military security versus the desire for economic well-being when resources are limited. It should be noted that two types of conflict can exist in a nation's goal structure. First, there can be universally accepted goals which cannot be simultaneously satisfied within available resource constraints. Secondly, there can be differences in goal structure between groups struggling for power within a nation. Recent internal US debates about the wisdom of a nuclear weapons freeze are a mild example of this type of conflict. Revolutionary warfare is an extreme example. It is interesting to note that internal goal conflicts offer the only reasonable explanation for the termination of conflicts (short of annihilation) under conditions clearly unfavorable to one party. The usual explanation that peace under somewhat unfavorable conditions is better than continuing the fight implies a tradeoff between internal goals.

One key question at this point concerns the possibility of actively creating conflicts within an enemy's goal structure. In some cases, existing conflicts, either between nations or within a nation, can be magnified and manipulated by judicious use of propaganda or by direct or indirect support of disruptive elements. Taking actions to insure that conflicting goals between allies are affected insures that such differences cannot be ignored and may cause serious problems. The Soviet pipeline deal in Western Europe is a good illustration of the problems that can be caused in this manner. Direct and indirect support for "armies of national liberation," a Soviet doctrine, is the most obvious example of this exploitation of goal conflicts. These examples, however, depend upon the existence of goal conflicts prior to attempts to exploit. If such conflicts do not exist, or cannot be detected, they must be created. This is a difficult process, but lies at the heart of the concepts of deterrence and of linkage. Linkage and deterrence depend upon building a goal conflict by connecting or linking events that may be logically independent in such a way that undesired actions which favorably advance one of the opponent's goals automatically cause a reaction that unfavorably affects another goal. Mutual assured destruction can be viewed in the sense of linking the desirable goal (from the enemy viewpoint) of disrupting or degrading friendly military or economic structure with the unfavorable reaction of destruction of large portions of his urban and industrial society. Military treaties can have the same effect. Parties cannot be conquered separately. Invasion of any of the participants to the treaty results in the entry of all parties into the war. Recent American attempts to link economic cooperation with political behavior have been less successful in using this technique. The problem with this way of creating goal conflicts is making the linkage real and credible in the eyes of the opponent. Some very interesting discussion of this topic can be found in Thomas Schelling's *The Strategy of Conflict.*[3] The book *Conflict Among Nations* by Snyder and Diesing also deals indirectly with this topic and more directly with the bargaining and information exchange process involved.[4] The approach to creating the paralysis and mistakes, which Beaufre notes frequently accompany goal conflicts, can indirectly have tremendous impact on power distributions. Problems within the military created by the budgetary constraints resulting from attempts to balance the conflicting (in the sense of requiring the same resources) goals of military strength and social welfare are evident. Hence, this can be a very powerful technique. For the most part, however, it does not directly involve combat operations. This apparent separation of techniques involving the creation and exploitation of goal structure conflicts from combat operations results in serious problems for nations which maintain strong distinctions between military and political action. Extremely close coordination between political and military planners is required if conflicts in the opponent's goal structure are to be exploited.

Determination of the Current Situation

Determination of the current situation is a key function of the C^3I system which supports the commander. Relevant functions include surveillance to locate and identify enemy units, intelligence-gathering activities, analysis of data to determine meaning and assess enemy capabilities and intent, and presentation of the situation in a form useful to the commander. Attempts to disrupt this step involve concealment, creation of ambiguity, and deception. Concealment involves using various means to prevent sensors from obtaining information about actual deployments, capabilities, or intentions. Ambiguity involves generating situations which can be interpreted in several contradictory ways by the enemy. This is most common with regard to intent but can be used relative to capabilities and deployments. A good knowledge of the enemy surveillance, intelligence-gathering, and analysis process is invaluable in this respect. Finally, deception involves creating a wrong conclusion by the enemy as to one's intent, capabilities, or deployment. This may involve controlling the data the enemy is allowed to collect or, more commonly, injecting false or misleading data into his C^3I system. All of these techniques can lead to a misinterpretation of the actual problem, and hence to inappropriate actions on the part of the enemy commander.

Determination and Evaluation of Possible Actions

This step in the military problem-solving process accounts for all limitations upon actions created by resource limitations and constraints (natural and political). These limitations upon possible action, together with the difference between the current and the desired power distributions, formally define the commander's problem. This formal definition must be followed by the generation and evaluation of possible actions. The consideration of possible actions can seldom be exhaustive; hence, this generation process is usually heuristic, guided again by experience and principles derived from experience. Possible actions frequently involve the coordinated use of separate forces for different purposes, and this can create complex resource allocation and scheduling conflicts which must be resolved in the planning process. Automated decision aids can be very useful in this task. Evaluation of proposed actions requires estimates of effectiveness, cost, and risk. These are extremely difficult to evaluate precisely but, fortunately, rather crude estimates suffice in the uncertain circumstances of combat. This step results in the set of alternatives with associated effectiveness, cost, and risk estimates needed for the next step in the process, which is the selection of the plan.

We can identify several approaches to disrupting or complicating the military problem-solving process at this stage. These approaches can be broken into attacks upon problem constraints and attacks upon problem structure. The external maneuvers advocated by Beaufre as part of his strategy in the indirect mode are attacks of this type. Many of the indirect approaches advocated by Liddell Hart can also be interpreted in this way.[5] Attacks upon constraints can have surprising impact. Most problem solvers vastly underestimate the importance of constraints in problem solving. Changes in constraints that make previously effective solutions impossible are especially good at creating turmoil, confusion, and frustration. Unrecognized changes in constraint can even create panic.

Attacks upon problem structure are also very effective. Ideally, the commander would like for the evolving power distribution to present his opponent with unsolvable problems. In such cases, the enemy will be forced to yield or else battle under circumstances that are unfavorable. Intercontinental ballistic missile (ICBM) attacks currently present problems of this type. If a single insolvable problem capable of paralyzing enemy action cannot be found, the creation of two or more simultaneous problems which cannot be solved simultaneously can produce excellent results. This is the basis of General William T. Sherman’s prescription to place the enemy on the "horns of a dilemma," and in B. H. Liddell Hart's insistence that lines of operation must offer alternative objectives. The possibility of simultaneously threatening several targets, hence requiring the enemy to disperse his defense while the attack concentrates on a single target, is a key advantage of attack over defense in most cases. Dynamic response to threats using the ideas presented in the illustrated use of the power distribution in troop allocation is one possible countermeasure. A related approach involves the creation of simultaneous problems requiring differing techniques for solution. Here difficulties in countermeasure are substituted for difficulties in managing a single countermeasure in space and time. The US strategic TRIAD approach to nuclear deterrence illustrates these concepts.

If insolvable or multiple problems of the types discussed cannot be imposed, the creation of a shifting pattern of problems, each requiring substantial readjustment in solution technique, can be effective. At the tactical level, this is the essence of maneuver warfare. This technique is effective as long as problems can be shifted faster than the problem solver can respond, as long as new problems presenting significant new challenges can be forced, and as long as the shifting of problems does not wreck the friendly problem-solving process at the same time.

Finally, problem structure can sometimes be manipulated by obscuring actual or desired power distributions, as suggested above, or by manipulating the risks in possible actions, making results unpredictable. Certain proposals for MX missile basing, for example, are valuable since they make exact predictions of the effects of a preemptive strike very difficult. Such attacks may have widely varying effectiveness in these cases, and this uncertainty may have a significant deterring effect. In a similar manner, the apparently irrational ranting of political leaders may create fears that usual actions might result in undesired responses. This may prevent the usual actions. In some cases, this may be a very rational use of irrationality. It is, after all, impossible to predict the response of a mad man, and sometimes wiser to let him have his way.

All of these techniques create difficulties for the enemy commander. If he has time, he may attempt significant changes in his own plans, sometimes at the cost of great effort. Otherwise, his response may be inappropriate, offering opportunities to the alert and prepared commander. In the extreme, he may be paralyzed—incapable of action. This is the goal of proponents of disorganization rather than destruction as the central theme of combat. The effectiveness of techniques designed to "drive the enemy crazy" will be discussed in a later analysis of attacks on the DECIDE function.

Selection of a Plan

Research into the actual decisionmaking process was reviewed in the previous chapter. The best model of this process in the military context seems to be the two-stage, frame-based model. That is, the current situation and evaluation of the problem activate a standard set of appropriate alternative actions (with details of implementation to be filled in) together with evaluation criteria. This suggests that this stage of the process cannot the directly attacked but must be attacked through attacks upon inputs to the process, and perhaps through the creation of time pressures and stress. Utility-based analyses within the selection the selection process can be influenced by manipulating effectiveness, cost, and risk factors. The effect of such manipulation is difficult to predict. The effects of these types attacks will be discussed below is an evaluation of the DECIDE function within the combat operations process.

Execution of the Plan

The final stage is solving a military problem involves execution of the selected plan. This should be a dynamic process with minor alternations in plans made in real-time according to actual engagement outcomes and detected shifts in the power distribution. Good C^3I systems are essential at this point. The resulting real-time control lessens the dependence of combat operations upon precise estimates of the situation and probable outcomes. This control is the key to effectively managing battles in the chaotic and uncertain conditions of combat. The commander therefore attempts to insure the smooth operation of the combat operations process for his forces, while attempting to disrupt the enemy's process. The techniques involved can be summarized using the combat operations process model as a guide.

The SENSE Function. The SENSE function affects both range and power of combat forces. Sensors with greater range can extend the effective range of weapons in some cases. Better resolution and more timely data can increase weapon effectiveness, and hence combat power. Physical attacks upon sensors can be effective, but the usual multiplicity of sensors makes this more a harassment than an effective overall approach. Electronic attacks, jamming and the like, can be more effective since sensors do not have to be individually targeted. Although deception tactics enter at this point, either at a highly technical electronic warfare level or in terms of allowing misleading maneuvers and situations to be detected, such tactics are really attacks on other parts of the system. These can be quite effective, but as previously noted cannot be relied upon. The book, *The Strategy of Electromagnetic Combat*, is an excellent summary of possible attacks and counters relative to this function.[6]

The PROCESS Function. The PROCESS function receives data from various sensors, uses data to develop a picture of the actual situation, and displays results in forms useful to decisionmakers. Current work in correlation, pattern matching, and display technology promises improvements in this area. The principal gains are in making more data available sooner, in reducing the actual volume of data to usable quantities, and in presenting the data in easy to grasp displays. Physical attacks on facilities can create problems (especially if backup procedures are inadequate). Deceptive measures injected through the SENSE or INTELLIGENCE/ANALYSIS functions can cause errors in detecting and reporting events.

The INTELLIGENCE/ANALYSIS Function. The INTELLIGENCE/ANALYSIS function includes many diverse elements. We have noted systems for fusing intelligence and operational data for the commander's use. New sensors designed for gathering intelligence rather than monitoring a battlefield situation also increase capabilities. Real-time analysis capability, especially in support of battlefield decisions, is being developed or proposed. This function is difficult to attack directly, since much of the work is done remotely at times preceding the actual battle. Indirect attacks, and counters to them, seem more important. In particular, security measures are crucial and deception methods can be phenomenally effective, although they are not full-proof.

The DECIDE Function. The DECIDE function takes processed information, data and predictions from the INTELLIGENCE/ANALYSIS function, and goals or problems, resources, and constraints from higher levels in order to generate, evaluate, and select plans for execution by the ACT function. Modern improvements in decision aids have been noted previously. These can be very useful, but also dangerous if adequate backup procedures are not provided. Attacks upon this function are usually based upon exploiting human decisionmaking limitations, on creating difficult problem situations, or on creating stressful environments. Understanding the basis for these attacks is crucial for evaluating attempts to disrupt the DECIDE function. The next few sections discuss current research in these areas and then evaluate proposals to disrupt this function.

a. *Human Decisionmaking Characteristics and Limitations.* On the whole, human decisionmaking is remarkably good, showing great robustness and flexibility. There is, however, evidence of systematic bias in subjective judgment which can present significant problems. Proposed automated decision aids are sometimes designed to compensate for these systematic biases in human judgment. Two excellent references on this subject are William R. Ferrell[7] and Robin M. Hogarth.[8]

Ferrell and Hogarth identify information-processing characteristics of humans which lead to problems in complex decision situations. Ferrell identifies the "single channel" characteristic (a human can usually attend to only one or a small number of non-interacting processes at any one time), problems with maintaining vigilance or attention, limited short-term memory capacity, and a limited information-processing rate as the major limiting factors. Hogarth also stresses selective perception guided by expectations, the essentially sequential nature of processing (which leads to order dependence problems), and the active reconstruction features of memory access. These limitations show up in a number of characteristic errors.

Ferrell notes three general sources of error. These include the mismatch between learned responses and new situations, information overload, and inappropriate responses keyed by cues which correspond to previously learned situations but which are not appropriate in a new situation. These latter are very dangerous errors associated with well-practiced situations where initial cues trigger learned responses which are carried through even if inappropriate. Everyone who has set out an errand and suddenly found himself traveling along the route home has experienced this type of error. Such errors are only controlled by elaborate feedback procedures. Unfortunately, in the military context such careful control may not be practical because it tends to slow and hence to negate responses. Hogarth adds to this list errors related to the way date is presented. He notes, in particular, those difficulties caused by mixtures of quantitative and qualitative data, of negative and positive concepts, and of concrete and abstract examples.

Both Ferrell and Hogarth point that humans have the most trouble dealing with random processes. People do not like to deal with random events and frequently go out of their way to even deny the existence of randomness,. Several fallacies in reasoning are also widespread. The false "law of small numbers" and the "gambler's fallacy" are examples. The "law of small numbers" assumes that small samples from a distribution are representative of the distribution. In truth, small samples can have characteristics that differ drastically from the characteristics of the distribution. This obviously can lead to a serious problems, especially when information previously known about the distribution is ignored. The "gambler's fallacy" is a mistaken belief that a random process tends in the short run to act in a way to give average results. In fact, most random processes have no memory and thus past outcomes do not affect the future. Again, belief in this fallacy can cause serious problems.

Problems with random processes are so severe that many decisionmakers show a marked preference for deterministic models of uncertain accuracy over more accurate stochastic models. Unfortunately, decisionmakers seem to have great trouble dealing with uncertainty in the form also.

One important role of the decisionmaker is the supplier of subjective estimates of probability. While people are reasonably good at this in some situations, systematic biases are again evident. Ferrell and Hogarth identify four major biases. *Representativeness* is the bias that results from assuming that known information is in fact representative of the process being estimated. This is related to the "law of small numbers" discussed above. Problems result when the decisionmaker has only partial information but assumes complete information. This situation cannot always be avoided, and decisions cannot always be delayed until adequate information is available. Nonetheless, the decisionmaker should be aware of the possibility of this problem and guard against its consequences when possible.

Availability is the name given another bias. This is based on the fact that decisionmakers frequently make estimates of probability based not only on current data but also on their memories of past data. This can mean, however, that data which is easily recalled gets more weight than it deserves. This explains, for example, why people estimate that randomly selected words are more likely to begin with the letter "k" than to have "k" as the third letter. Most people recall far more examples of words that begin with a "k" and hence conclude that an initial "k" is more likely. In fact, words with a third letter "k" are more likely, but difficulty in recalling examples masks this fact.

A third bias is seen in the *overconfidence* that estimators usually have in their ability to drive subjective probability estimates. Even good estimators tend to seriously overestimate their own abilities. This can lead to serious problems.

The final bias identified is *overconservative revision* of estimates when given new data. People seldom revise estimates to the extent indicated by theory, as in Bayes Theorem. This means that excessive amounts of information are required to correct estimates or to detect changes.

All of these biases can be said to be errors under the controlled environments of psychological testing. One might argue that they are quite reasonable in the real world where distributions are seldom as stable as in the laboratory! In any event, random processes clearly cause significant problems. Much work in automating decision processes focuses upon this area.

b. *Situational Factor Impact in Decisionmaking.* It is clear that problem-type and situational factors, both environmental and psychological, greatly influence problem-solving and decisionmaking behavior. Since many proposals by "maneuver warfare" advocates and their like are designed to create complications and stress for the enemy commander, it is of great interest to study the effect of complicating factors and stress on decisionmaking. This section examines the impact of problem structure on problem-solving strategy and will show the shifts in emphasis associated with the structure. The next section will look at the effect of stress and coping behavior on decisionmaking.

Michael Sanderson, in his interesting book *What's the Problem Here, Time Saving Problem Solving Techniques for the Manager,*[9] identifies eight classes of problems requiring somewhat different approaches to solution. *Straightforward problems* call for creativity, careful planning and research, critical review, and decisive action. For *straightforward* problems under pressure, the problem solver must prepare for crisis and continually reassess the situation and progress. Caution and watchfulness are necessary to avoid blunders.

For *complex problems,* the emphasis shifts to decomposing the problem into simpler subproblems. The key is to find a focus and look for patterns. Examining subproblems for conflict and coverage and reviewing subproblem interactions are primary concerns. The discussion of distributed problem solving falls into this category.

Unpredictable problems have results that cannot be accurately forecast. Such unpredicatable results in crises; hence, a crisis plan is essential. The emphasis is on careful problem diagnostic and continual analysis. Careful building of crisis and contingency plans is critical. Reassessment should eventually result in the identification of a more definite problem type and to a reversion to the appropriate strategy. If the problem cannot be clarified, cybernetic decision techniques are required.

Fuzzy problems are those with unclear objectives and problem structure. The emphasis, of course, is on uncovering the real problem. Examination of basic concepts and ideas can be helpful, as can attempts to view the problem from other perspectives.

Complex, unpredictable, and fuzzy problems combine all the difficulties and techniques indicated above. The first priority is preparing for crisis and working on defining the problem. Careful planning and continuous reassessment is necessary.

Crises cause drastic changes in priorities. The immediate problem becomes one of figuring out what must be rescued or protected and figuring out how to do it. The basic idea is to salvage as much as possible and regroup for future operations. This means that work must be carefully prioritized with true essentials dealt with first. Careful examination to try to find opportunities in the midst of catastrophe is sometimes possible.

Sanderson's final category is the *intractable problem*. When faced with such a problem, the key is to attempt to clarify it. This requires an active search for facts and patterns. Reasonable actions should be attempted, more to learn about the actual problem than to solve it. Learning about the actual problem as a result of the action is the goal. The flavor here is that of Steinburner's cybernetic paradigm, with reasonable actions attempted and feedback on results used to refine and control subsequent actions. Eventually, the actual problem should become defined well enough to allow other strategies to be applied.

There is an obvious correlation between the problem types defined by Dieterly and the categories presented by Sanderson. Not all of the possible Dieterly types were covered by Sanderson, and Sanderson looks at pressures and factors external to the actual problem. A closer look at the psychological pressures that can affect the decisionmaker and the impact on decisions is available through work of Irving L. Janis and Leon Mann[10] and interpretations of this work by

Joseph G. Wohl.[11] Richard S. Lazarus[12] also deals with psychological stress and coping strategies. A review of this work will throw some light on the question of the effectiveness of strategies and tactics designed to "drive the enemy commander crazy."

c. *Stress in Decisionmaking.* Lazarus emphasizes that stress occurs as the result of a perceived threat. Individuals use coping processes to reduce or eliminate anticipated harm as seen in these threats. The degree of threat perceived, the environmental constraints present, and the individual's psychological structure determine the coping strategy that will be adapted. There are three key factors in that appraisal. Most important is the perceived balance of power between the harm-producing stimulus and counterharm resources. Second is the perceived imminence of the anticipated confrontation. Finally, there is the ambiguity of cues about whether there will be a harmful confrontation.

Lazarus sees threat increasing as the individual senses a loss of power to cope with danger. This sudden, drastic increase in perceived threat is seen in many of the dislocation tactics advocated by Liddell Hart such as cutting off enemy lines of retreat. In the face of a potent threat, imminence also increases threat. Surprise attacks sometimes demonstrate these effects. Ambiguity can also be crucial, as it prevents effective response in many cases. Some individuals are so intolerant to ambiguity that the mere presence of ambiguity is perceived as a threat.

Lazarus identifies three basic coping-reaction patterns. Direct actions include both attack patterns (with or without expressed anger) and avoidance patterns (with or without fear). Defensive reappraisals occur when a great threat is perceived but no direct coping strategy is viable. Such reappraisals can result in severe paranoia or other pathological conditions. Finally, anxiety-reaction patterns result when the agent of harm cannot be located or is ambiguous. Since there is no basis for attack, avoidance, or estimate of hopelessness, anxiety results. This can also occur when previously successful coping patterns break down.

The obvious danger in attempting to deliberately induce the stress and anxiety described by Lazarus is in the possibility that an attack pattern may be chosen as the response. If such attacks can be handled, then the possibility of seriously degrading enemy performance seems worthwhile. In very complex situations, however, the possible effects of a provoked (and perhaps not carefully reasoned) attack response must be carefully weighed before psychological attacks are initiated.

Janis and Mann identify five decisionmaking situations and associated coping behaviors in their analysis of the psychology of decisionmaking. As long as no serious risk in the current course of action is perceived, decisionmakers will continue their current actions under *unconflicted adherence*. If serious risk is perceived in the current course, but a new course without serious risk is seen, decisionmakers shift course under *unconflicted change*. In both cases, stress is low. If serious risks are perceived in both current and new courses and no better solution seems possible, *defensive avoidance* with probable continuation of current courses will be seen. Problems are essentially ignored or rationalized. Stress is variable, ranging from low to high depending on the perceived threat. The most interesting cases occur when serious risks are seen in the current and known alternative courses, but where the possibility of finding an acceptable solution is seen. If there seems to be time for an adequate search and evaluation of alternatives, a mildly stressful constructive coping behavior called *vigilance* results. If there does not seem to be enough time for a reasoned search, the result is *hypervigilance*, a state of high anxiety, panicked attempts at identifying alternatives rapidly, and potentially inappropriate responses.

Janis and Mann present many examples to illustrate the identified coping behaviors and possible effects. They also present diagnostic and consultative tools to identify and reduce nonrestrictive behavior. Wohl modifies the Janis-Mann model to the military and C^3I context and discusses information requirements and desires associated with each pattern. He also suggests ways that C^3I systems can guide commanders into constructive coping patterns.

d. Evaluation of Attacks on the DECIDE Function. The research cited above suggests that attacks on the DECIDE function will be of three types—attempts to exploit human limitations, attempts to create difficult problem situations and attempts to create and exploit stress. Attempts to exploit human limitations can be further divided into attempts to exploit the basic sources of error identified by Ferrell, attempts to introduce randomness, and attempts to exploit subjective biases.

We identified mismatches between learned responses and new situations and inappropriate responses cued by seemingly familiar situations as key sources of human error. These can be exploited by the introduction of such things as new weapons, or tactics, to produce surprising situations for which learned responses are inadequate. This means the enemy must improvise, which introduces the possibility of serious error on his part. If the new weapon or tactic is disguised, inappropriate responses on the part of the enemy may be triggered, magnifying his difficulties.

The introduction of randomness, in the sense of unpredictability at least, creates great problems for the enemy. Commanders do not usually deal well with randomness, and its presence frequently causes expensive and disruptive searches for data or triggers a sort of defensive avoidance that may result in missed opportunities or inappropriate action. Clausewitz uses the ability to deal effectively with the chance and uncertainty of war as a criterion for identifying great leaders. Lesser leaders may be identified by the lack of this ability. It should be noted that the nature of warfare already insures that randomness will be a dominant feature. Deception tactics can add some confusion but are not easy to evaluate. The main consideration should be to avoid resolving enemy uncertainty without good reason.

Finally, the human subjective biases of representativeness, availability, overconfidence, and overconservativeness revision of estimates—although hard to target directly—explain the effectiveness of deception techniques. Representatives results in a sometimes false belief that a small sample of data represents the true situation. Hence, small amounts of deceptive data can have very large effect, especially when it is more available than conflicting indicators. Overconfidence and over-conservative revision of estimates explain how sets of assumptions created through deceptive measures can persist even in the face of conflicting evidence.

Sanderson's classification of situational factors in problem solving and their impact on effectiveness is a good guide to exploiting enemy problem structure. The key is avoiding the presentation of straightforward problems. At the very least, the presentation of multiple simultaneous problems is needed. The goal is to create a crisis or intractable problem that will paralyze the enemy or cause him to divert resources that could be used to hurt one's forces. We have discussed techniques for creating complex, unpredictable problem structures. Creating time pressures results in crises and can be very effective.

These and other techniques can be effective in creating and exploiting stress. Lazarus' research quoted above shows that this stress results from a directly perceived threat, especially when accompanied by a sense of loss of control. The perceived balance of power, imminence of confrontation, and ambiguity of cues are important in determining actual levels of stress produced. Lazarus also shows that the impact of this stress is difficult to evaluate. It depends upon unobservables such as the character of the enemy commander and the coping patterns he adopts. Some of these patterns may result in violent reactions which are inacceptable in limited war situations. Hence, care is required in the application of these techniques designed to create stress on the enemy commander.

The work of Janis and Mann cited above also indicates that effective use of stress-producing techniques is tricky. The goal is to produce a prolonged state of hypervigilance in the enemy commander. This means he must perceive better ways of reacting to the enemy but must never have time to adequately implement these reactions. Maneuver warfare or disorganization advocates aim for this goal. Achieving it for more than just a brief time is a great challenge.

It is difficult to evaluate all of these techniques designed to attack the DECIDE function. Successful attempts to create a difficult problem structure for the enemy have the longest term effect but are not easy to achieve. The other methods have great potential but are very uncertain. Deception can be decisive, but it is difficult to monitor the effects of deception campaigns or to predict the overall effectiveness if they work. The stress-producing techniques can influence the enemy into inappropriate responses, but these must be rapidly exploited. Such techniques cannot always be applied, and hence they cannot be counted upon as the sole solution to military problems. Attacks upon the DECIDE function, coordinated with other attacks, can be devastating. By themselves, they are uncertain and of doubtful value.

The ACT Function

Actions taken relative to the ACT function are the most visible causes of change in power distribution. Changes in force quality through increased range, lessened vulnerability, or increased lethality cause obvious shifts in primary range. Changes in mobility and responsiveness cause changes in secondary ranges. Support requirements can have the same effect. Many measures can also affect flexibility, allowing recovery from early commitment as previously described. Most of these changes involve the introduction of high technology systems. The high costs of such systems tend to mean limited numbers of deployed systems. Numbers can be an important factor in power distribution management, however. Greater numbers of systems, in particular, allow larger numbers of problems to be addressed simultaneously at widely dispersed locations, even though with reduced effectiveness. This ability to disperse power can be crucial. This includes taking on the enemy strength or avoiding strength and striking at “softer” targets. If enemy forces cannot be destroyed without unacceptable losses, they may be delayed or disrupted, destroying the momentum of the attack. Indirect actions include the imposition of constraints on enemy freedom of action, as by mining operations or the construction of barriers. Many other tactics such as the creation of shifting, multiple problems affect this level as well. The major driver, however, is weapon and delivery system technology coupled with C^3I systems that allow effective employment.

Communications Links and Interfaces

The communications links within the system and interfacing the system with other instruments of national power are the final elements to be considered. Recent efforts have focused on providing reliable, survivable, enduring, secure communications with two-way voice communication over long ranges as a goal. Communications links of this type greatly increase the cohesion of troops, extend the effective range of systems by allowing meeting, allow use of remote computing power and expertise, and enhance coordination of actions. Attacks include destruction of links, jamming, exploiting, and deceiving. These can create very serious problems. The actual impact of this disruption depends upon the military control structure. For highly centralized systems, it can be devastating. For decentralized systems, the impact is much less. The ability to exploit communications traffic can offer considerable advantages. Hence, there is always a tradeoff between disruption and exploitation. Communication can also be deceived by injection of false or repeated information into the system. While such attempts can be dealt with, considerable extra expense and complexity is generally involved. Unfortunately, such consideration also sometimes required dedicated military equipment and prevent less expensive use of commercial systems.

Military Theory in the Problem-Solving Formulation

The problem-solving approach to command of combat operations presented in this chapter provides guidelines to the commander attempting to control the evolution of the power distribution. In a sense, these guidelines provide a general military theory. Specific strategies, adapted to specific situations, are created from these guidelines by selecting from the many available approaches those which seem to offer the best chance of success. This choice must be based upon an estimation of the effectiveness of each approach in a specific situation, along with the probable effort required, the enemy's ability to counter, and the probable effort required to counter. These estimates should also be made from the enemy's viewpoint. They provide a basis for estimating advantageous approaches and hence for developing effective strategies.

The military theories introduced in chapter I can be interpreted as different emphasis upon specific aspects of the problem of controlling the power distribution. Sun Tzu concentrates upon complicating the enemy's problems, emphasizing deception. His goal is to present a sudden insolvable problem to the enemy so that surrender occurs without actual battle. Clausewitz, on the other hand, concentrates on simplifying his own problems by overcoming friction and focusing effort on the enemy's center of gravity and upon disrupting the enemy's problem-solving process by disrupting his ACT function. Beaufre emphasizes the political interactions and constraints with special attention upon goal structure conflicts to determine political maneuver and upon strategy in the indirect mode to manipulate constraints. The traditional American approach to war attempts to emphasize the enemy decision process (deterrence), to complicate the enemy problem-solving structure (TRIAD), and to manage risk in conventional conflicts (attrition-based strategies). All of these theories incorporate elements from throughout the problem-solving process, of course, but the special emphasis give them their distinctive flavors.

The final theory presented in chapter I, maneuver warfare, is harder to evaluate. Most discussions of maneuver warfare deal with basic concepts rather than implementations, yet the ultimate value of maneuver warfare depends upon the practicality and effectiveness of the implementation. Interpretation of maneuver warfare in terms of a mobile defense of Europe, for example, suggests significant problems and dangers. John Mearsheimer's article "Maneuver, Mobile Defense, and the NATO Central Front" is an excellent look at this issue."[13] At the tactical level, maneuver warfare concentrates on disruption of the enemy's ability to generate and execute plans, mainly depending on the rapid shifting of problems through fast transient maneuvers. No one can argue against such an ability. The feasibility of maintaining the required tempo over long periods of time and against an enemy expecting such a technique can be questioned, however. The successful solution of just one of these shifting problems could be fatal! Claims that maneuver warfare tactics will paralyze the enemy decision process seem questionable in the light of the research reviewed above. It does seem that such techniques may result in inappropriate responses by the enemy. Successful implementation of a maneuver warfare strategy will depend much more on the ability to rapidly exploit such opportunities than upon the prospect of totally disrupting the enemy's decision process.

The capabilities required by the maneuver warfare approach do fit well into a power distribution control approach. The mobility and maneuverability advocated, especially if combined with the ability to rapidly dig into prepared positions, would make the commander's control of the power distribution much easier. Such capabilities would also be well suited to exploit unexpected opportunities. Maneuver forces also have the potential of disrupting the enemy's attempt to control risk with an attrition-based strategy. Hence, the debate and thought incited by the maneuver warfare advocates is good. Blind acceptance of their concepts without careful examination of the implementation and required tradeoffs is dangerous.

This chapter has used the military problem-solving process model to provide a framework for effective command of the combat operations process. It presented guidelines for developing strategies based on the idea of combat as a conflict between problem solvers. Past military theories fit into this overall framework, their distinctive flavor arising from the aspects of the problem-solving process they emphasized. The next chapter turns to the principal tool used by the commander in his control of the power distribution—the C^3I system.

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Chapter V

C^3I in Combat Operations

The previous chapters have identified command of the combat operations process with guiding the evolution of the power distribution and have presented guidelines for this task based upon the military problem-solving process. The C^3I system available to the commander is a vital tool in the command process. This chapter examines C^3I in more detail, looking at C^3I functions in terms of the combat operations process model and in terms of the military problem-solving process model. Finally, it considers the question of the proper function and form of the C^3I system. The answer to this question depends upon the perceived desirable military command style. The chapter presents opposing positions on these fundamental issues and explores their implications for C^3I system development.

C^3I in the Combat Operations Process

The combat operations process model developed in Chapter II incorporates most of the features of Lawson's C^3I process model. Consequently, it directly defines many C^3I functions in combat operations. The description of the combat operations process model discussed these C^3I functions in detail, and those descriptions will not be repeated here. The principal functions noted involved communications systems, surveillance systems, data-processing and display systems, and automated decision aids. There are many articles in the current literature which describe current and proposed C^3I systems. A recent unclassified article by General Robert T. Marsh describes progress and plans within the Air Force.[1] This article points out several future trends in C^3I system development. These include systems to vastly extend surveillance coverage area, automated tools to aid in routine command functions, automated processing and display systems, and real-time computerized decision aids. The technology described or projected shows that development in several directions is possible. The extended range and resolution of projected systems suggests a trend towards wide area battle management. New communication capabilities may allow powerful centralized battle management on a global scale. On the other hand, there is also existing or projected technology for developing truly distributed communications, surveillance, and battle management systems. These tendencies seem to clash. Maturing technologies may force a choice between approaches. This choice and its implications will be studied in light of previously derived conclusions about the nature of command in combat operations.

There is much discussion of the proper function of C^3I in the in the literature. There is also evidence of significant differences of opinion. Major General Jasper A. Welch emphasizes aspects of C^3I that reduce friction within the commander's force structure and that help insure that force application will have some effect. He acknowledges the potential of C^3I systems to promote the efficient use of forces in limited circumstances, but deemphasizes this aspect of C^3I performance.[2] Welch, in another article, also discusses the usefulness of C^3I in resolving the ambiguities that prevent command decisions. F. M. Synder takes a similar position in his discussions of C^3I systems and the reduction of uncertainty.[3] Determination of the operational requirement for certainty depends upon an interpretation of the command function in combat operations which is not directly addressed in these articles. The articles give the distinct impression that combat results can be managed provided enough precise data can be obtained. This deterministic interpretation of combat operations is even more evident in an article by John A. Modrick. It advocates automation of the combat operations decision problem to the point of reducing the commander's role to oversight and override as the solution to decision problems in the high tempo, modern battlefied.[4] Such automation seems dependent on a near deterministic interpretation of combat operations.

Evaluation of proposals and observations such as those presented above requires some systematic framework to provide a basis for judgment. The combat operations process model provides one such basis and reinforces General Welch's emphasis on reducing friction and promoting effectiveness. Evaluation of the other points discussed can best be handled within the framework provided by the military problem-solving process model.

C^3I in the Military Problem-Solving Process

This study has identified command of the combat operations process with control of the evolution of the power distribution and has used the military problem-solving process model to develop guidelines for this task. The concepts involved in the power distribution model and the military problem-solving model applied to the command problem give insight into the role of C^3I. Command interpreted as a control of the evolution of the power distribution emphasizes the role of C^3I systems in determining the power distribution, rapidly detecting changes in the distribution, and forecasting the evolution of the distribution under actual or hypothetical circumstances. Actual emphasis depends upon the phase of the military problem-solving process being considered.

Determination of the desired power distribution depends upon military objectives which depend, in turn, on political objectives and the influence of possible military actions on these objectives. This determination largely transcends the combat operations process. However, C^3I emphasis upon the intelligence/analysis function and upon communication between political and military leaders is clear.

Determination of the current power distribution and its evolution involves C^3I capabilities most directly. Global surveillance is most important in this phase. Detection and identification of enemy units, combined with friendly force status information, determines the geometric force distribution. Estimates of capability and intent provided by the intelligence function help convert this geometric force distribution into a power distribution. Detected changes in this power distribution, or proposed actions by friendly forces, are used by the analysis function to predict the evolution of the power distribution.

The generation and evaluation of possible actions continues this analysis process with emphasis on determining problem structure and constraints. The intelligence/analysis function is again crucial, as are the processing, display, and decision aid systems. C^3I systems have indirect influences here in that some C^3I systems change problem constraints. Long-range surveillance and communications systems, for example, allow strategies which are impossible in their absence.

The selection of a plan depends upon the results of previous phases and upon the ability of the C^3I system to present results in a form useful to the commander. The ability to quickly respond to questions about the cost, effectiveness, and risk of alternate actions and to gather data needed to resolve uncertainties expressed by the commander is also important.

Execution of the plan again involves C^3I systems directly. The emphasis is on monitoring progress and upon adapting to changing circumstances. Communications and surveillance systems to provide feedback are essential. Real-time intelligence/analysis aids allow better use of feedback and promote the ability to exploit unexpected opportunities. In this phase there is great emphasis on local communications and surveillance to insure coordination of forces and to reduce friction.

This analysis of C^3I within the framework of the military problem-solving process shows the intimate relationship between C^3I and combat operations. The commander's task of guiding the evolution of the power distribution is essentially impossible without an effective C^3I system. And a C^3I system takes its purpose from the process it is helping to control. The proper concerns of the C^3I system is this process and the proper implementation of the C^3I system are still unclear, however. These issues require a determination of the fundamental nature of combat operations and of the desirable style of military command.

C^3I and the Nature of Combat Operations

The dependence of the proper role of C^3I upon the nature of the combat operations process has been discussed in the preceding sections. Few will argue with the observation that combat is a stochastic process in that great uncertainties in the actual situation on the battlefield are everpresent and that combat results are difficult to predict. There is implicit argument, however, as to the reasons for this stochastic appearance. Some seem to argue that this stochastic nature is a fundamental aspect of combat. Others argue that the apparent randomness results from a lack of knowledge and that techniques to supply that knowledge will make combat operations predictable.

An analogous situation can be found with the uncertainty principle in quantum mechanics. This principle, which states that it is impossible to simultaneously determine both the position and momentum of a particle, has been recognized as apparently valid for more than 50 years. But "it was generally assumed that statistical uncertainty was not a fact of nature but arose from a lack of detailed knowledge, knowledge that could eventually be uncovered."[5] It took many years for physicists to abandon the search for this hidden knowledge and to turn to studying of the implication of the principle.

Today the writings of many experts on C^3I seem to parallel the efforts of the early phycists. Welch, Synder, and Modrick all seem to be searching for the C^3I system that will resolve all uncertainties and make combat operations into a predictable process. The analogy with quantum mechanics should not be pushed too far at this point. While the research in this study strongly suggests that the combat operations process is fundamentally stochastic, no definite proof of that proposition has been given. Arguments that combat operations process; deterministic and stochastic. The perception of the true nature of this process has significant impact on decisions about the proper role of C^3I.

If combat operations is fundamentally deterministic, or nearly so, then emphasis on aspects of C^3I systems which resolve uncertainty and provide detailed resolution of the battlefield is justified. Such resolution would permit accurate prediction of combat results (provided for combat operations process is correctly understood!) and would justify battle management systems that attempt to optimize results.

If, on the other hand, combat operations is fundamentally stochastic, C^3I emphasis should shift towards aspects that help in the management of the power distribution. Such emphasis would stress systems to determine the power distribution, changes in this distribution, and the probable evolution of the distribution. Decisions would not be evaluated in terms of the result they would produce, but rather in terms of their ability to affect the probabilities that govern the evolution of the power distribution. Detailed prediction of results would be required only in the rare events that are strongly dependent on command decision. At all other times, management of the power distribution would be stressed.

The exact nature of the combat operations and current C^3I systems is not as simple as pictured above. This study contends that combat operations is fundamentally stochastic. Nevertheless, C^3I system improvements can certainly resolve a great deal of the uncertainty that currently exists in battle. The impact of the stochastic nature of combat operations occurs when C^3I systems begins to reach the limits of their resolution. For example, is it difficult to have systems that can locate and identify a truck convey, or is it useful to develop systems that can distinguish individual trucks? Such a capability has obvious targeting implications, but would such knowledge make combat operations more predictable? And can combat operations results be predicted with sufficient accuracy to justify, global battle management systems that rely upon, deterministic or near-deterministic optimization tools to justify their development and use? The answers to these questions depend upon analysis and judgment beyond the scope of this study.

While the fundamental nature of combat may have great impact on future combat operations, the direct impact on C^3I systems is not immediate. Technology is just beginning to promise the systems that may depend upon an understanding of and an ability to exploit opportunities expected in a stochastic environment. A shift away from the current largely deterministic view of war depends upon force structure changes and changes in tactical style far more than upon new C^3I capabilities. Maneuver forces and infiltration style tactics, for example, may be required to exploit stochastic situations. Simple changes in C^3I system are inadequate.

Issues related to the fundamental nature of combat are crucial in attempts to develop useful automated decision aids.

These automated decision aids are unquestionably valuable in helping with routine tasks and in engagements at the tactical level. Automated command systems for large-scale warfare, on the other hand, may be less valuable. Feasibility is always in question in such cases, but beyond that are questions of necessity and value. Such systems potentially represent loss of control not only in the absence of men at key decision points but also in loss of understanding of the dynamics and purpose of combat operations. These far-term concerns depend upon the evolution of technology. Understanding of the fundamental nature of combat operations, and the implications of this nature upon C3I system requirements, is the key to guiding technology as opposed to being guided by technology.

C3I and the Desired Style of Military Command

Military command style is a reverence to the many somewhat arbitrary choices concerning the ways to employ available technical means within the military command structure. Two opposed visions of the proper character and style of military command can be identified. These two opposed visions are the highly centralized command style illustrated by the hierarchical control model and the decentralized style illustrated by the distributed problem-solving or Specialist Demon models.

The hierarchical control style of command attempts to turn the entire military force (or the entire national system) into an extension of the commander. Subordinate levels respond in precise and standardized ways to his orders and provide him with the data necessary to directly control the entire military apparatus. The emphasis is upon connectivity between levels in the hierarchy, upon global information gathering or upon passing locally obtained information to higher levels, and upon centralized management of the global battle. While this goal may not be attained, and some processing and decision-making must be delegated, such deviations from the concept of personal control by the commander are accepted only as necessary evils.

The distributed problem-solving style, on the other hand, views the commander as controlling only in the sense of directing a cooperative problem-solving effort. His duties are to in decompose and allocate subproblems to lower levels, to allocate resources to be used in these solutions, to determine and propagate constraints on acceptable solutions, and to monitor constantly subordinate activity. He is not to second-guess chosen methods of solution but to detect and manage conflicts that may arise from such attempted solutions. The emphasis in this style is on autonomous operation at all levels, upon the development of distributed systems and architectures, upon networking to share the elements needed to detect and resolve possible conflicts, and upon distributed decisionmaking processes. The pictures of these styles are too extreme in each case. Most actual structures will lie somewhere between these extremes. Yet, simultaneous tendencies in both directions can be seen in current and proposed development programs.

Arguments can certainly be made for each of these styles. The hierarchical control style provides a much greater and more predictable degree of control by higher levels. Many potential conflicts between lower-level elements can be eliminated by such direct control. The essential removal of the true commander from the heat of battle offers many advantages. The entire style seems much more efficient since such things as optimal allocations can be centrally planned. The distributed problem-solving style, on the other hand, seems better suited to the realities of actual combat. Autonomous operations at lower levels prevent a total concentration if vulnerability in a centralized command center. The distributed system structure provides for more graceful degradation of function if force elements are destroyed or misapplied. And the parallel operation of independent decision makers at many levels may be more effective and timely than the highly centralized decisions of the hierarchical control style. The basic dilemma now facing the C³I development community seems focused on whether it is possible or wise to attempt to produce C³I systems capable of supporting both of these styles of military command. The solution to this dilemma depends upon the style of military command desired.

This dilemma poses a fairly immediate problem in the Air Force C^3I system development. Current work in strategy system C^3I seems to fit directly into the highly centralized command style. Global surveillance and communication support this style which is very appropriate for the currently perceived strategic mission. Current work at the tactical level, however, concentrates significant effort on distributed system architectures and hardware. Again the needs of the currently perceived tactical mission make this distributed command style appropriate. Data overload, system vulnerability, and graceful degradation issues, in particular, drive tactical users to distributed command styles and systems. Problems can arise at the boundary between strategic and tactical missions. Furthermore, the very systems being used to extend centralized control over strategic systems such as global surveillance and global communications are removing many of the distinctions between strategic and tactical missions. If strategic systems capable of attacking nonfixed targets are developed, distinctions between strategic and tactical missions become even more artificial. The key problem is that systems being developed and produced now may determine the command style of the future by default. Such systems may be too expensive to replace and too inflexible to adapt.

Similar problems can be seen in commanding forces involved in combat across the conflict spectrum. Highly centralized command of forces engaged in low-intensity combat may be very appropriate. The force sizes, situations, and response times involved make such control feasible. The extreme political sensitivity of such conflicts may also make this command style appropriate. As the level of conflict increases, such centralized command becomes more difficult and less effective. Data overload and response time problems may mean that decisionmaking must be delegated, making distributed command styles more appropriate. Vulnerability of centralized control facilities operating within the range of enemy weapons may also dictate such a style. The key question becomes whether any single C^3I system architecture can function effectively across the entire conflict spectrum and under either centralized or distributed command styles. If technologically feasible, is such a system practical and affordable? These questions introduce a dilemma which must be addressed using considerations beyond those previously discussed.

An approach to the solution of this dilemma is suggested in a paper by Brigadier General Robert D. Eaglet.[6] This paper contends that the C^3I structure adopted by a nation should support those national characteristics of its greatest strength. General Eaglet's analysis of combat in which inferior forces manage to win in spite of the odds against them suggest that ingenuity, initiative, and esprit de corps have been keys in most of these cases. These are qualities Americans like to identify as national strengths, and the military command style most appropriate for America should be designed to capitalize upon these strengths. A hierarchical control style seems to stifle all three characteristics. The emphasis on standardized responses to orders tends to downgrade ingenuity. Dependence upon higher levels for decisions or approval tends to downgrade initiative. And the view of the entire military apparatus as an extension of the commander tends to lessen the unit identification that supports the esprit de corps needed for stubborn resistance in desperate circumstances. The distributed problem-solving style, on the other hand, seems to support these characteristics. Subordinates have wide latitude in their actions within specified constraints and resource allocations. In such circumstances, ingenuity and initiative are not only encouraged but even absolutely required. Independent unit action also promotes the identification that leads to esprit de corps. Implementation of such a military command style, especially such a national command style, does present problems.

The fundamental problem seems to be in a perceived loss of control by higher level decisionmakers. With modern technology suggesting that a hierarchical control style may actually be possible, any deliberate attempt to shift towards a distributed problem-solving style may be viewed as loss of control. The refocus of command effort required—from detailed direction of subordinates to emphasis on problem definition, decomposition, and allocation—is also uncomfortable. Commanders with competence in the lower-level activities may find it difficult to let go and face new higher-level challenges for which they may be less prepared. Commanders without such expertise may find control of lower-level elements so fascinating that they lose sight of their true function. In neither case is a deliberate move away from the ability to directly control easy. Ultimately, the problem may be a simple one of trust. It is difficult to trust oneself to handle new and strange duties without the comfort of falling back into previous successful patterns, and it is difficult to completely trust one's subordinates. Yet, such trust is the essential element in the distributed problem-solving style of military command.

Summary

This study has investigated the combat operations process, the function of command in this process, and the proper role of C^3I in supporting the commander. The power distribution model, the combat operations process model, and the military problem-solving process model were developed during the research as tools to aid the understanding of these concepts. Four basic conclusions were developed:

1. Command in combat operations should be viewed as control of evolving power distribution.
2. Military theory can be developed in terms of opposing commanders attempting to simultaneously guide the evolution of the power distribution. The military problem-solving process model applied to this case provides a framework for understanding and evaluating military theory.
3. C^3I is an integral part of the combat operations process. The proper role of C^3I depends upon the fundamental nature of combat operations and upon the desired style of military command.
4. A distributed C^3I system designed to exploit the stochastic nature of combat operations and the strengths of American fighting units is best suited to the realities of warfare and the American character.

I have found the research reported here to be interesting and valuable. The implication of the stochastic nature of combat operations upon the function of command, in particular, was a revelation to me. Much work remains to determine if the theoretical framework presented in this report can be expanded into useful guides for strategy making and system development. I hope that the results presented will stimulate thoughtful and useful discussions among strategists, operational planners who give form to these strategies, and analysts who are asked to evaluate the resulting plans.

Notes

1. Robert T. Marsh, "Command, Control and Communications in the Future," *Supplement to the Air Force Policy Letter for Commanders,* August 1980, 30-40.
2. Jasper A. Welch, Jr., "C^3 Systems: The Efficiency Connection," *Supplement to the Air Force Policy Letter for Commanders,* December 1977, 30-38.
3. Jasper A. Welch, Jr., "Some Random Thoughts on C^3," in *Decision Information,* edited by Chris P. Tsokos and Robert M. Thrall (New York: Academic Press, 1979), 349ff; and F. M. Snyder, "Command and Control and Uncertainty," *Naval War College Review* 32 (March-April 1979):109-113.
4. John A. Modrick, "Decision Support in a Battlefield Environment," in *Decision Information,* edited by Chris P. Tsokos and Robert M. Thrall (New York: Academic Press, 1979), 457, 471.
5. Eigen and Winkler, *Laws of the Game,* 21.
6. Robert D. Eaglet, "C^3—How Much Is Enough?," draft paper, HQ AFSC, Andrews AFB, D.C., May 1982.

GLOSSARY

A

AFSC .... Air Force Systems Command
ARI .... Airpower Research Institute

C

C^2 .... command and control
C^3 .... command, control and communications
C^4 .... command, control, communications, and computers
C^3I .... command, control, communications, and intelligence
C^3I^2 .... command, control, communications, intelligence and Interoperability

D

DOD .... Department of Defense

I

ICBM .... intercontinental ballistic missiles

N

NATO .... North Atlantic Treaty Organization

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