A Concept for Command and Control

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A concept for command and control (C2) is an effort to envision the future operational environment accurately and develop general requirements for C2. It represents an attempt to break with Cold War and Industrial Age paradigms and instead meet the future on its own terms. The writers of this article strive to find the balance between developing technology on the one hand and the essential humanity of conflict on the other. Above all, they call for flexibility, because the future operational environment will offer myriad, diverse challenges and conditions. The goal is a future C2 system of systems that facilitates strategic, operational, and tactical success.

INTRODUCTION

Zephyr Field, Jefferson Parrish, Louisiana: The closing days of August 2005 witness one of the largest efforts in the U.S. Coast Guard's history—the rescue or evacuation of more than 33,000 people stranded by Hurricane Katrina. The Coast Guardsmen were experts at saving lives in the littorals, but they lacked detailed knowledge of the flooded sections of New Orleans where they had to save lives. The solution was to partner rescue teams with local responders, such as the State Police, Department of Wildlife and Fisheries, and New Orleans fire officials, who knew the area. The bravery and determination of the rescuers were the stuff of legend (Fig. 1), but operations were hampered because of confused command and control (C2) at the higher levels. Two different agencies—the Coast Guard and the Louisiana National Guard—ran separate and parallel efforts. The hurricane itself aggravated the situation by destroying or disrupting most of the communications infrastructure that rescuers needed. Coast Guardsmen anticipated the problem and prestocked radios, cell phones, and other

Figure 1. U.S. Coast Guard conducting rescue operations in the wake of Hurricane Katrina. (Source: U.S. Coast Guard. Reprinted from Ref. 1.)

Figure 2. U.S. soldier on patrol in Iraq. (Photograph by Cpl. Shane S. Keller, U.S. Marine Corps.)[2]

gear. When voice communications failed, they relied on text messages and commercial email accounts. The men and women on the ground, piloting the boats, and flying the aircraft overcame challenges with brash determination and improvisation, but in the wake of the third-worst hurricane ever to make landfall in the United States, it was clear that the C2 system failed to perform to standard.[1]

Al Anbar Province, Iraq, Summer 2007 (Fig. 2): An Army captain approaches a village in which insurgent activity has been reported overnight. Armed with a Table of Organization and Equipment that was designed for high-intensity conventional war on the plains of Europe, the captain will have to innovate and adapt. Decades before, planners anticipated the officer's needs and built a C2 system that would serve him by linking him with his superior headquarters, his subordinate platoon leaders, and his supporting artillery and mortars. Now on the edge of the village, as he and his driver scan the road for improvised explosive devices (IEDs), the captain has altogether different requirements. He needs to consult with local sheiks and municipal officials. Because he doesn't speak much Arabic, he needs the services of a translator. He wants to maintain links to the local mullah—an influential man whose good will is far more powerful than a battery of self-propelled artillery. The captain also worries about a team of medical interns who are visiting the village. They seemed less than enthusiastic about cooperating with his troops for their own security, and he hasn't heard from them for hours. Frustrated, he realizes that the network of people he must coordinate, integrate, and negotiate with are not reachable by radio. There are problems with C2 here that will be surmounted only by determination and imagination. (Many sources that describe the complexities of counterinsurgency in Iraq exist. A good general source is part II of *The Iraq Study Group Report*.[3])

These two examples of modern military operations demonstrate the criticality and changing nature of C2. In past ages, C2 was at times a simple matter of trumpet calls, battle flags, and screaming noncommissioned officers. Of greater importance was the sheer mass of the armies and navies and the martial prowess of their constituent soldiers and sailors. Today success in battle is more about detection than mass, and success in war more focused on complex integrations of civilian and military, state and nonstate entities, culture and governance, and economies and ideology. The complexity

of warfare has pushed the discipline of C2 to the front of the stage. Failures and shortcomings are part of any endeavor in war, but if we fail to get C2 right, the entire system can collapse.[4]

The purpose of this article is to share the insights of recent conceptual work within APL that describes the future operational environment and the C2 requirements that result. The article writers' aim was to facilitate efforts within the Laboratory and within the defense community by undergirding them with a solid vision of future requirements.

THE C2 CONCEPT

The APL team that wrote this essay was composed of former Army, Navy, and Air Force officers with backgrounds and experience in operations, intelligence, and C2. They set out to apply an engineering perspective to the evolving challenge of modern C2 in an effort to share within APL and the wider defense community the need for a new understanding of a very old art. This document looks to the future and specifically to the future operational environment. That is to say it does not look to the past, with the possible exception of the very recent past. One of the problems with current concepts of C2 is that they draw from World War II or Cold War experiences, most of which are sprinting into irrelevance. (See van Creveld's *Command in War*.[5] Although van Creveld anticipated the complexity and change within command processes, his examples draw too heavily on European and Israeli Industrial Age warfare. See also Builder, Bankes, and Nordin.[6])

This is not to deprecate the study of history; indeed, several of this article's writers have advanced degrees in history. Rather it is to point out that, in periods of military revolution, an overreliance on past concepts can lead to inaccurate understanding of the future and sometimes to disaster. If the information age truly has revolutionary aspects to it—a point of debate among theorists—then certainly C2 lies at the heart of that revolution. The technological opportunities and operational challenges boggle the mind and excite the spirit. The goal of this C2 article's writing team was to assess the future operational environment accurately and then propose requirements that match that assessment.

One trend line that plagues modern concepts derives from Cold War paradigms: the deification of speed at the expense of understanding. Describing a vision of future warfare and the C2 systems needed to practice it, one writer put it this way: "An information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization."[7] Although not without merit, the problem with this perspective is that it views C2 as if it were all about targeting and rapidly unfolding industrial-age warfare. Instead, the complexities of counterterrorism, counterinsurgency, and tangential operations today relegate kinetic targeting to a small but important fraction of critical activities. Of far greater import are cultural understanding, building relationships, logistics, and institutional patience. The prevailing theories of a revolution in military affairs in the 1990s that in turn gave birth to network-centric warfare crashed unexpectedly into complexity and chaos theory after 9/11.[8] A good concept for future C2 needs to forego an approach based on computer-enhanced targeting and embrace a more realistic and inclusive strategic environment. Most importantly, it must find balance along the dialectic of technological potential and the irrationality of the human heart. As French soldier and writer Ardant du Picq noted: "It is then essential to work for the development of the moral forces of the nation. They alone will sustain the soldier in the distressing test of battle where death comes unseen."[9]

The scope of the C2 concept expressed in this article is ambitious: from platform to coalition, from local to global, from peacetime disaster relief to full-scale war. The writers looked at Marine special operators training Nigerian cadres on the edges of the southern Sahara and submarine commanders sneaking through the cold, black waters of the western Pacific. They looked at joint teams of technicians aboard P3C Orion aircraft over the Mediterranean and nine-man infantry squads packed into Stryker fighting vehicles on the streets of Mosul. They considered the needs of medical relief expeditions, long-range strike raiders, peacekeepers, and interagency task forces. (For a look at the diversity of requirements within the modern U.S. military, see Kaplan.[10,11])

A C2 concept must start with a definition of "command and control," and, because C2 touches on many other disciplines, the concept must describe its scope and limitations up front. We define C2 as the arrangement of personnel, training, information management, doctrine, equipment, and facilities essential for the commander or other decision maker to conduct operations. As the name makes clear, C2 involves the distinct but related functions of both command and control. (The definitions for C2, command, and control derive from the *Department of Defense Dictionary of Military and Associated Terms*.[12])

Command is the authority that a commander in the armed forces lawfully exercises over subordinates by virtue of rank or assignment; command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. The reader will note that this traditional definition

relies heavily on military terminology. Our C2 concept uses this terminology as a starting point but not an end point. In fact, C2 must transcend military organizations and doctrine, because future operations will involve interagency, coalition, nongovernmental, and private entities. Future "commanders" will include nonuniformed men and women, and an effective future concept anticipates and calls for C2 systems that will serve them.

Control is the regulation of forces and battlefield operating systems to accomplish the mission in accordance with the commander's intent. As above, this definition is traditional, military, and Newtonian. This article's writers employ it as a launching pad to investigate the more holistic requirements of the future. Control in tomorrow's operations will include informal personal relationships with private volunteer organizations that are providing food and clothing to indigenous populations. It will include political networks involving local sheiks, religious figures, and even gang leaders. The C2 system must transcend the Cold War focus on military organization and graduate to the complexity of real-world challenges.

C2 conceptual efforts relate closely to another key discipline: intelligence, surveillance, and reconnaissance (ISR). Indeed, the two are inseparable in operations. ISR informs every activity within C2, and C2 in turn directs ISR. To find the exact seam between the two functions would be an artificial and useless endeavor, but the writers of this article focused on C2 and not on ISR. Although one of the four major functions of C2—situation awareness—absolutely depends on ISR; the article does not address this sister discipline except where it is unavoidable. This is not to diminish its importance, but rather to keep the focus on C2 issues.

THE FUTURE OPERATIONAL ENVIRONMENT

The future operational environment will be complex, diverse, and always in flux. It will feature multidimensional challenges and opportunities and the paradox of interacting opposites.[13] Future operations will unfold along a wide spectrum of conflict, from routine peaceful competition on the one end to full-scale, high-intensity warfare on the other. The spectrum includes conventional and unconventional operations, domestic and foreign operations, manned and unmanned platforms, and the full range of missions from disaster relief to war. These various scenarios and missions could occur simultaneously. For example, a disaster relief operation might unfold in the midst of internecine conflict among armed factions, or a large-scale conventional military operation might quickly evolve into a humanitarian mission. Future commanders will have to deal simultaneously with a wide range of scenarios, each requiring both common and different command challenges. (Throughout this article, we will be using the term "commander" in its military context. However, the operational environment and opposing interactions will impact civilian first responders and other key decision makers as well.) Therefore, future C2 must be flexible enough for decision makers to conduct operations under all conditions.

The future operational environment will be what it will be and not what we want it to be. This point is at once obvious and critical to proper conceptualization. It is in the nature of people to suppose that the future will be like the past, even the distant past, and that what worked before will work again tomorrow. It is in the nature of the military industrial complex to build materiel and invest billions of dollars into a "future" that often looks suspiciously like the past. An honest and perspicuous understanding of future trend lines stands as a bulwark against this entrenched conservatism. So what will the future look like?

Asymmetric Warfare

U.S. superiority in modern joint warfare, demonstrated during the Persian Gulf War of 1991, operations in Kosovo, and the conventional phase of Operation Iraqi Freedom, will encourage future adversaries to adopt asymmetric capabilities designed to dislocate American strengths. Dislocation is "the art of rendering enemy strength irrelevant."[14] This trend is neither new nor surprising. Asymmetric warfare has always been a part of human history. Those who cannot directly oppose the strength of their adversaries have often relied on guerilla fighting, terrorism, or other forms of attack. However, the technological and cultural complexities of modern civilization, especially Western liberal democracies, have created new vulnerabilities and targets of attack. Critical features of modern societies—such as communications and power grids, transportation systems, and computer networks—are inviting targets for those adversaries employing either traditional sabotage techniques or new forms of attack, such as biological warfare, nuclear terrorism, and cyber attack.

The Defense Department's focus on asymmetric warfare does not rule out the possibility of renewed conventional threats. The American military is obliged to continuously hone their readiness for a resurgence of symmetrical opponents. However, the post-Cold War world offers an unprecedented host of adversaries determined to drive around our strengths rather than facing them head-on. The tool kits of these opponents include not only the irregular warfare that 19th century guerillas practiced against Napoleon but also a panoply of methods by which they can obviate set-piece battles and attack critical infrastructure or population centers. Asymmetric means include lethal chemicals, harmful biological agents, and invasive or destructive computer

code. Alternately, the asymmetrical aspect derives from the target type rather than the weapon. For example, attacks in crowded markets or theaters or schoolyards are asymmetric in that they seek to create political and social provocation and are far removed from conventional battlefields. Other aspects of asymmetry concern the agent employed in attacks. When a state conducts warfare by proxy—e.g., prompting a nonstate militia or insurgents to attack an adversary—it creates an asymmetric advantage.

A discipline related to, although not synonymous with, asymmetric warfare is that of unrestricted warfare. APL sponsors annual symposia on the subject and publishes the proceedings.[15,16]

Nonstate Actors

Since the Peace of Westphalia in 1648, states have been the principal actors in world affairs and the primary purveyors of organized violence. However, today global communications, transportation, banking systems, computer networks, and modern weaponry have facilitated the rise of nonstate adversaries (e.g., groups of individuals united by political convictions or religious beliefs, as well as criminal organizations) and enabled them to strike across borders or around the globe. Future conflict will almost certainly involve a mixture of sovereign state and nonstate threats, each having complex and shadowy connections with other powers. An early example of this was the alliance between North Vietnam and the Vietcong during the French and American struggles there. More recently, Syria and Iran have sponsored and supported nonstate terrorist groups as part of their respective foreign policies.

War in the Information Age

The pervasiveness of global news media leads to a transparency of operations with almost instantaneous political ramifications worldwide. Both state and nonstate adversaries will seek to magnify their power through the manipulation of media and the iconography of future conflicts. Commanders will operate in an environment in which decisions and actions will be subjected to immediate reporting, scrutiny, and analysis by a global audience. More than in any previous period, members of the media are not simply neutral observers but are active participants in conflict.[17]

Ecology and Disaster Relief

Global communications have also magnified the importance and urgency of human disasters, mandating a high-tempo response from those nations able and willing to help. Because they sometimes take place in areas of political or religious upheaval, relief operations will remain closely linked to military and security operations. The presence and reach of U.S. forces around the world makes these forces likely first responders to natural disasters. Coupled with the growing influence of natural disasters is the increasing visibility and importance of manmade disasters. In the wake of concerns over global warming, the international focus on ecological issues will undoubtedly shape future military and interagency operations.

Interagency Operations

A key feature of the future operational environment will be the number and diversity of participants. The battlespace will include journalists, nongovernmental and private organizations, armed neutrals, noncombatants, criminal networks, and, as described above, a global audience. Joint and coalition forces will routinely operate with other agencies of the U.S. government, principally the Departments of State, Justice, and Commerce; the Central Intelligence Agency; the Federal Bureau of Investigation; and the U.S. Agency for International Development. Within theaters of operations, these interagency forces also will integrate their efforts with foreign militaries, civilian agencies, and local officials. They will likely have numerous interactions with nongovernmental and private volunteer organizations. Integrating these disparate organizations cannot be thought of as an "add-on" to C2 concepts, but rather as the heart of the matter. Post-Cold War dynamics point clearly to the increasing need for cooperation among all elements of the government. ("The most interesting and challenging endeavors are those that involve a collection of military and civilian sovereign entities with overlapping interests that can best be met by sharing information and collaboration that cuts across the boundaries of the individual entities," Ref. 4, p. 8.)

The Interaction of Opposites

In addition to the characteristics described above, the future operational environment features a phenomenon that has perhaps always pertained to warfare but will be even more pronounced in the future: the interaction of opposing ideas and conditions. The following six sets of opposites offer a spectrum of possible characteristics pertaining to the operational environment. An understanding of these dichotomies leads to a richer and more accurate perception of real-world conflicts.

Conventional and Unconventional Warfare

The future operational environment will include both conventional and unconventional warfare (Fig. 3). It is tempting to emphasize the importance of one type of warfare over the other, but the two have coexisted throughout history. Decision makers will need

Figure 3. Conventional and unconventional warfare.

Figure 4. Hierarchy and anarchy.

a balanced perspective and will need to addresses the threats and operational methods of both.

Conventional warfare focuses on the destruction of enemy forces and sources of military power. It requires the orchestration of the forces being brought to bear, supported by communications, engineering, logistics, and all the various elements found in joint and coalition forces. Conventional conflict places a premium on detecting, tracking, engaging, and assessing battle damage against enemy forces and infrastructure. The presumption of conventional warfare is that once the adversary loses his military power, he will no longer have the means, or the will, to continue the conflict.

Unconventional warfare occurs when the adversary's military capabilities are insufficient to engage in direct, open warfare, but the adversary still has the will to fight. In such cases, the adversary resorts to guerilla operations, terrorism, piracy, and other illegal or irregular activities. Those fighting against an unconventional enemy cannot target and destroy enemy formations. They must focus on individuals and small groups of assailants and address a wide variety of threats: IEDs, suicide bombers, snipers, and possibly deadly toxins, biological agents, or cyber attacks. They must isolate the adversary from the local population by applying military force within a much broader political context. They must integrate military action with civil and police actions involving other U.S., coalition, international, and host-nation agencies.

Hierarchy and Anarchy

The future operational environment will contain conditions of both hierarchy and anarchy (Fig. 4). Hierarchy refers to the organization of forces according to a functional chain of command; relationships are well defined by law and tradition, and authority is commensurate with responsibility. Anarchy, however, refers to relationships wherein there is no clear authority or structure. The future operational environment will always include both hierarchical and anarchic relationships, and commanders must be flexible enough to recognize and operate within a mix of both conditions.

Normally, U.S. commanders will have a hierarchical relationship (direct legal authority) over assigned U.S. forces. U.S. commanders may have to engender cooperation from coalition forces, over whom they have limited or no formal authority but with whom they may share a common mission and perspective. These same commanders may have to interact with other agencies of the U.S. government, local officials, nongovernmental and private organizations, and religious leaders. Commanders may have little or no authority over these elements. Indeed, in the most "anarchic" relationships, these elements may openly oppose U.S. objectives. Nevertheless, commanders will have to engage in all of these relationships, both the hierarchical and the anarchical, in the battlespace.

Figure 5. Knowledge and uncertainty.

Knowledge and Uncertainty

The future operational environment will contain conditions of both knowledge and uncertainty (Fig. 5). During recent conventional operations in the first Gulf War, Kosovo, and Operation Iraqi Freedom, U.S. forces enjoyed an unprecedented level of knowledge about the battlespace. They achieved information superiority over their adversaries because of their superior ISR capabilities. In general, these experiences demonstrated that when a force has information superiority, it can move faster, strike more precisely, and better protect itself from enemy action. To achieve such results, modern C2 systems must not only give commanders a better view of the battlespace (e.g., a better knowledge of enemy strength, location, and intentions) but also have the decision mechanisms to rapidly convert that knowledge into action.

A resourceful, adaptive enemy will always try to deprive U.S. forces of their information advantage and limit their knowledge of the battlespace. Even during recent conventional conflicts when the United States enjoyed information superiority, adversaries successfully employed signals security, camouflage, concealment, and deception to degrade U.S. information gathering. In unconventional warfare, insurgents limit the amount of information that American forces can gather by blending in with the civilian populace, emerging only long enough to strike and then disappear. Examples of successful unconventional measures abound and include Serbian passive air defense measures, and cover and concealment of forces, and employment of decoys during the operations in Kosovo. During the U.S. invasion of Iraq, the Iraqi Army was able to disguise the movement of forces by using civilian buses and automobiles. The location of Saddam Hussein was never known accurately enough to target him until long after the fall of Baghdad.

Real-world operations never unfold under the conditions of complete knowledge or complete uncertainty. Commanders must address the flux between knowledge and uncertainty in the battlespace. They must garner, process, and exploit knowledge. They must also address uncertainty through contingency planning, flexible execution, and risk mitigation.

Centralized and Decentralized Control

Future commanders will employ both centralized and decentralized methods of C2, selecting the method that best addresses a particular situation (Fig. 6). Several factors—information flow, the mission, the size and nature of the area of operations, the training and capabilities of the force—will influence the degree to which a commander centralizes or decentralizes control.

Access to information will be the most critical consideration. In general, commanders will centralize C2 when they can quickly and accurately assess the situation and respond in a timely manner. When they cannot meet these criteria, they will normally decentralize C2. Because relevant information flow is always in flux, resulting in operations featuring a constantly changing balance between centralized and decentralized C2, the guiding principle will be that C2 authority and resources will follow the flow of relevant information.[18]

During the conventional phase of Operation Iraqi Freedom, senior-level commanders kept a fairly tight rein on operations, because they had the best information on the movements and dispositions of the enemy's

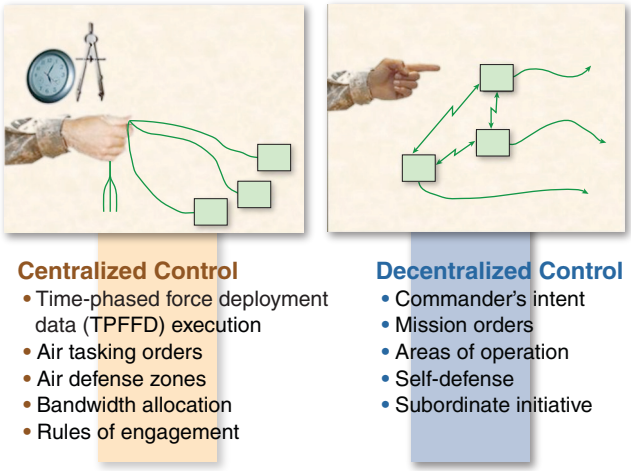

Figure 6. Centralized and decentralized control.

divisions. Success in the drive to Baghdad required careful synchronization of large-scale maneuvers and fires. Once the capital city fell and the focus evolved to population control and counterinsurgency, commanders opted for a much greater degree of decentralization. Small unit commanders and troops on the ground had much better knowledge of local conditions than their seniors in distant headquarters. Hence, they received greater decision-making authority. The future operational environment will likewise feature a constant ebb and flow between centralization and decentralization.

The mission will be a strong influence on the approach to command. When an impending operation has immediate and critical political implications, the commander may need to keep a tight rein on the activities of subordinates. Conversely, if the mission requires rapid movement and combat against a dispersed or moving enemy, the commander may decide to decentralize C2 to capitalize on subordinates' agility.

The nature of the terrain in the battlespace will affect the balance between centralization and decentralization. Open terrain, as well as the air and the ocean surface, can facilitate a centralized approach to achieve maximum synchronization among the joint arms. Close, complex terrain (e.g., urban or jungle) and subsurface seas that limit visibility, mobility, and communications will point to a greater degree of decentralization.

These and many other factors will influence how the commander chooses to structure C2. The path to success is to avoid selecting one extreme or the other and instead perceive the dynamic balance between both approaches. A key capability will be the speed and flexibility with which commanders can select and transition between centralized and decentralized control.

Concentration and Distribution of Combat Power

Future commanders will have to both concentrate and distribute combat power, selecting the method that best addresses a particular situation (Fig. 7). This decision is closely related to the commander's selection of centralized or decentralized control as well as the commander's knowledge and uncertainty about the enemy. When commanders have comprehensive knowledge of the enemy's dispositions, capabilities, and intentions, they can distribute combat power precisely according to purpose without having to worry too much about the enemy surprising them. When, however, they have only limited knowledge of the enemy, they may need to concentrate combat power as a hedge against uncertainty.

Throughout human history, concentration of combat power, which found expression in the classical principle of mass, was a preferred technique for defeating organized enemy forces on the battlefield. Its counterpart,

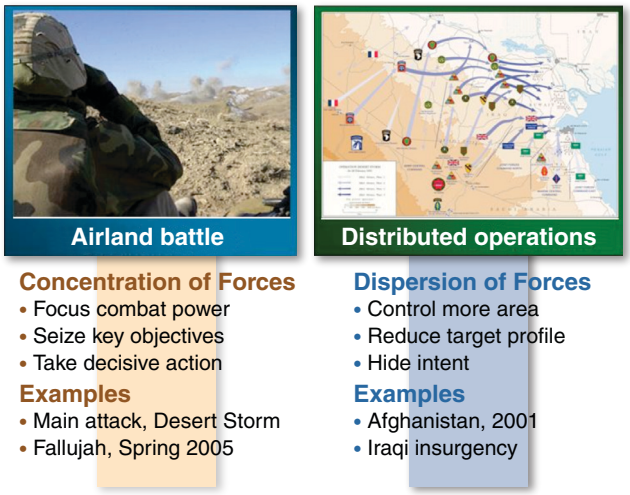

Figure 7. Concentration and distribution.

distribution, was needed for many ancillary tasks, such as population control, efficient movement over road networks, logistical replenishment, and protection from weapons of mass destruction (WMD). The key to success in the future operational environment is to appreciate the need for balance between the two extremes.

In general, when commanders lack knowledge of the enemy, they will place combat power in reserve as a hedge against uncertainty. At the other extreme, when commanders have precise knowledge of the enemy, they can most efficiently employ their forces by concentrating power at critical points and economizing forces elsewhere. As a rule of thumb, greater knowledge of the enemy leads to more efficient distribution of combat power. Future scenarios will exhibit a constant flux between concentration and distribution of combat power, and the C2 system must facilitate both as well as the transitions between the two.

Proactive and Reactive Decision Making

Future commanders will perform both proactive and reactive decision making (Fig. 8). When equipped with the information advantage, U.S. commanders prefer proactive decision making—taking the initiative to exert their will upon the enemy. However, in most operational environments, there are times when the commander must react to enemy initiative.

Proactive decision making works best against an enemy that can be readily anticipated, either because the enemy's fighting doctrine and organization are predictable or because the friendly force has the information advantage. U.S. forces have developed a targeting methodology that demonstrates proactive planning: decide–detect–deliver. The commander decides what effects he wants to achieve, directs his intelligence assets

Figure 8. Proactive and reactive decision making.

to detect the appropriate targets, and then delivers ordnance onto the targets.

Reactive decision making employs a different dynamic. It recognizes that knowledge of the enemy is scarce and that a commander must react to enemy action. This form of decision making acknowledges that the enemy sometimes has the initiative, particularly under the conditions of unconventional warfare, when the adversary is skilled at choosing the time and place of attacks. In such cases, the commander must respond quickly to engage the temporarily exposed insurgents and to thwart the enemy's plans. The methodology in this case switches to detect–decide–deliver.

A C2 system must enable both proactive and reactive decision making, supporting the rapid and flexible transition between the two.

The future operational environment will be rich with complexity, uncertainty, and challenges (Fig. 9). The interaction of opposite conditions and methods will define operational environments that may change from day to day and from hour to hour. Commanders and the C2 systems that support them must be flexible enough to adjust to the particular demands of the moment and robust enough to prevail in sustained operations.

If this assessment of the future operational environment is accurate, then how does it condition the development of requirements for joint, coalition, and interagency teams? In the final part of this article, we outline the general requirements for future C2 systems.

FUTURE REQUIREMENTS

The diversity of joint, coalition, and interagency forces in the future means that leaders and staffs will have specialized needs that apply only to their specific

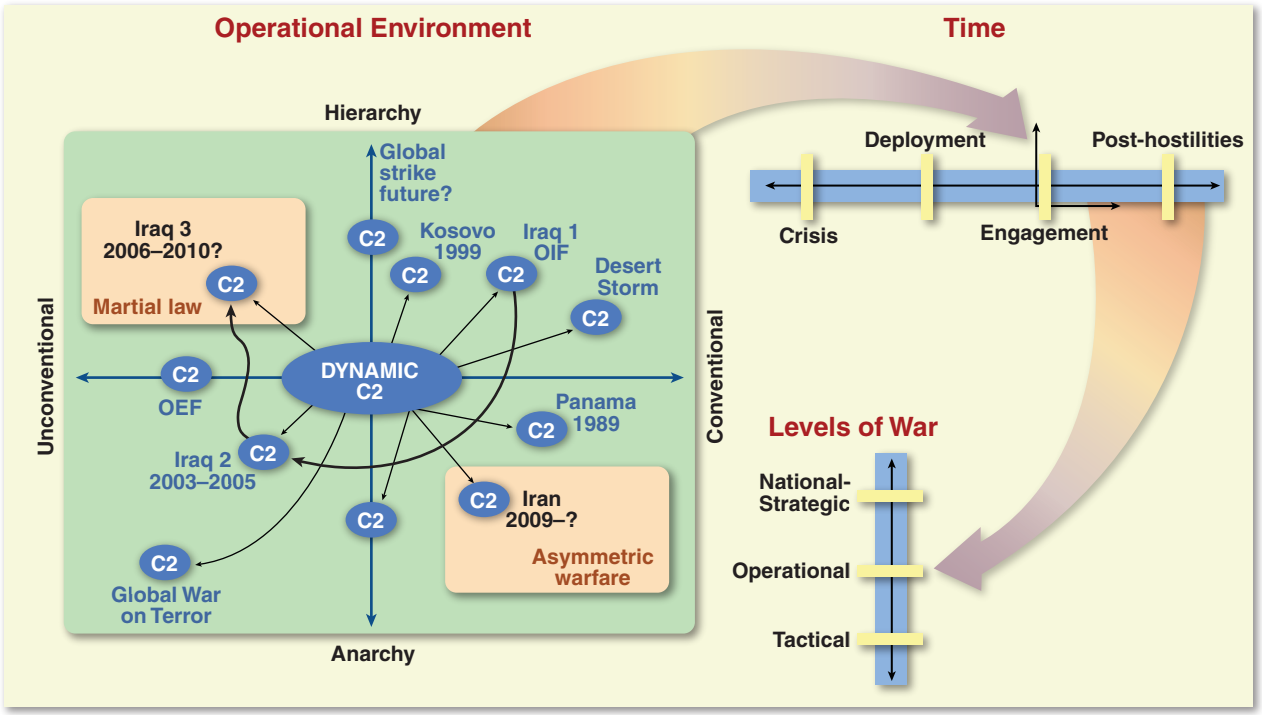

Figure 9. The future operational environment.

situations. At the same time, there is also much commonality of requirements. Specifically, there are a handful of functions that any future combatant will need whether he is operating from a nuclear attack submarine, an interagency intelligence collection center, an airborne C2 platform, or at the head of a nine-man squad on patrol. While recognizing the inevitable diversity of C2 requirements, our conceptual perspective focuses on those functions common to all.

There are four general C2 functions—situation awareness, planning, decision making, and execution. Although some specialized C2 elements may perform only one of these functions, the overall C2 system supporting a commander will likely perform all four. The following paragraphs will address each of these functions and suggest future capabilities in each area.

Situation Awareness

The foundation of any good decision is good information—what in modern parlance is called situation awareness. A C2 system must provide the commander with accurate, timely information on the enemy and friendly forces as well as other pertinent information on the operational environment. In addressing this function, the C2 system relies on and integrates with the ISR systems that support the force.

Different C2 Elements Have Different Information Needs

The breadth, depth, timeliness, and currency of the information depend highly on the particular needs of the commander involved. For example, an area air defense commander needs situation awareness over a large volume of air space. The information must be adequate (timely, accurate, and current) to support immediate decisions on whether to engage aerial targets. In contrast, military police brigade commanders supporting counterinsurgency operations are normally not concerned with the second-by-second situation in the air. However, they do need to know when and where the enemy has fired on friendly aircraft and any other intelligence on enemy activities. They need to know friendly convoy schedules, and receive reports on friendly military, local police, and reconstruction activities in their area of operations. They need to know the location of key installations, schools, hospitals, power stations, and communications towers. Other commanders, focused on functions such as close air support, medical operations, or mine clearing, will likewise have information needs focused on those functions. Each of these consumers of information is also a source of information.

A flexible C2 system must enable commanders to define their own information needs and quickly collect and assess that information. Likewise, the C2 system must quickly accept and assimilate information provided from the many sources within the battlespace. The challenge of collecting, storing, delivering, and fusing information is well understood but largely unresolved. Although engineers have made strides in fusing some types of sensor data (radar, electro-optical/infrared, and signature data), the capability to fuse other types of information—e.g., intelligence reports, police reports, and metadata—remains elusive. An equally important future capability is the characterization of information in more depth, indicating its age, the confidence placed in its accuracy, and the degree to which it conforms with or contradicts other information. Presenting large numbers of information feeds from related ISR systems to the depth described emphasizes the need for better characterization and visualization of information.

Multilevel Security

Any C2 system that collects and distributes information must have safeguards against enemy attack and exploitation. However, sharing information across different levels of security is a key desired capability. As noted above, future commanders will need to interact with many elements in the battlespace. The capability to grant access to selected intelligence and operational plans will improve the commander's ability to work with other agencies—particularly when performing disaster relief, such as the distribution of food and medical supplies in hostile environments. By enabling the commander to flexibly and securely share information, the C2 system can foster important relationships and extend the commander's knowledge and influence in the battlespace.

Shared Awareness and Understanding

Given that future commanders will work with extended teams that include coalition partners and others with various levels of security clearance, shared situation awareness/situational understanding will not be identical for all participants. Although emerging concepts of network-enabled warfare assume the desirability of shared situation awareness, it is conceivable that, under some circumstances, the commander will want to limit knowledge of certain aspects of the situation. Therefore, a flexible C2 system must not only enable shared awareness and understanding but also compartment particular information.

Planning

Planning both informs the commander's decisions and implements them. It generates courses of action as the basis for command decisions. Once a decision is made, planning produces the detailed information and orders needed to implement the decision. Planning may involve thousands of participants and span months and

years of preparation time, or it may involve only a few people over a few hours or days.

Future C2 systems can improve planning, in all its many variants, by giving planners better tools to develop, evaluate, and rehearse plans. The C2 system should give commanders and planners the requisite tools to perform accurate and timely estimates of required combat power, logistical support, and time needed for operations. The system should reduce or eliminate the requirement to manually research and produce information, automating processes wherever possible and allowing planners to focus on the implications of the information.

Course of Action Development

Course of action development lacks sufficient automated tools at the present. The future C2 system should function like an artist's palette, facilitating the rapid development of creative and effective courses of action. Computerized planning tools could improve the process by helping commanders and planners develop key information and identify critical capabilities and vulnerabilities in both the enemy and friendly forces. The accessibility of digitized terrain should lead to automated planning tools that analyze terrain and enemy dispositions, and then recommend avenues of approach. Automated comparisons of enemy and friendly capabilities and assessments of terrain, distances, timelines, force availability, and fuel consumption should shape (but not control) course of action development.

Collaboration

Collaboration plays a critical role in planning. No single organization has all the necessary information, all the capabilities, or all of the responsibilities. Commanders must address both hierarchical and anarchical relationships and operate under conditions of knowledge and uncertainty. Planning will take place in the same environment. Planning must cut across organizational boundaries, both vertically and horizontally, to share information and to synchronize action. Supported units and supporting units should be dynamically linked, sharing information throughout the planning process so that supporting functions (e.g., fire support, engineering, communications, and fuel) arrive at the right locations at the right times. Collaboration tools should be the most important tools in a planner's toolbox.

Melding Planning, Wargaming, and Rehearsal

Before the development of computer tools and digital networks, planning, wargaming, and rehearsal tended to be separate and sequential activities. Headquarters prepared plans, issued orders, and used rehearsals to instruct subordinate units and staffs on the plan. By the time rehearsals began, commanders tried to limit changes in the plan. Hence, these discrete steps in decision making did not overlap. In the future, tools and processes should meld these activities, allowing each to complement the other. Plans subjected to war games and rehearsals would benefit from the insights of those expected to execute the plans, identifying previously unforeseen events or considerations, which could be incorporated into revised plans. Likewise, those executing plans would have higher confidence in their value as a result of their validation through wargaming and rehearsal.

Obviously, some situations are more amenable to wargaming than others. Problems such as the configuration of theater air defenses, allocation of transportation assets, and placement of medical facilities might be assessed through modeling and simulation. Other activities involving the interaction of many elements, such as ground maneuver, would be more problematic to assess. Nevertheless, the visualization and step-by-step examination of such courses of action could identify choke points, key terrain, critical events, and synchronization issues.

Orders Preparation, Dissemination, and Presentation

The end product of the planning function is a set of comprehensive and executable plans, and the C2 system should facilitate rapid orders preparation, dissemination, and presentation. It should also allow for quick implementation of selected branches and sequels while the operation is unfolding. Because the future operational environment will include many disparate elements with which the commander must operate, the C2 system should be able to produce both electronic and hard-copy plans and orders as well.

Decision Making

Decision making is at the heart of C2. For simplicity of presentation, this article has generally identified the commander as the decision maker. In truth, commanders routinely delegate decision-making authority to many people whose decisions often are critical. In some cases, decisions emanate from committees or other groups rather than from one person. Indeed, with the development of the global information grid and its service-oriented architecture, distributed decision making should be routine. Whether directly supporting the commander's decisions, or those of others, future C2 systems must better inform and assist—not supplant—human judgment. The following topics highlight key capabilities of future C2 systems.

Proactive and Reactive Decision Making

As described above, commanders will conduct both proactive and reactive decision making. When they have the initiative, they can dictate the pace of battle and

force the enemy to react. When they do not have the initiative, they will be forced to react to enemy action. Future C2 systems must support both methods.

Speed of Decision

Speed of decision is a critical measure of decision making. The less time commanders consume in reaching decisions, the more time they leave to their staffs and subordinates for planning and execution. In proactive decision making, speed of decision allows the commander to maintain the pace of operations and to make decisions and execute them faster than the enemy can react to them. In reactive decision making, speed of decision may enable the commander to regain the initiative or at least mitigate the impact of enemy action. Future C2 systems must improve the speed of decision making.

Quality of Decision

The value of quick decisions is directly related to the quality of those decisions. Military history has many examples of bad decisions made quickly and good decisions that arrived too late. The essence of command is balancing speed of decision with quality of decision; future C2 systems should assist decision makers in achieving that balance. Decision aids should help calculate decision timelines, identifying when decision making must occur, assessing the likely trade-offs between hasty and deliberate decisions, and, when possible, evaluating the quality of decisions. Evaluating the quality of decisions is no simple task, but it supports two essential tasks of command: to learn from successes and failures, and to adapt. Decisions involving well-defined procedures and measures are more amenable to assessment. For example, air-battle-management decisions in which friendly aircraft are vectored to intercept enemy aircraft have well-defined procedures; are driven by key, discrete measures (altitude, range, speed, weapons load, engagement range, etc.); and have definitive, measurable results (target intercept and kill). With the aid of sensor logs, these events can be reconstructed and assessed. Other decisions, particularly those involving many subordinate decision makers, uncertain measures, and uncertain results, are much more problematic to assess. For example, judging the quality of decisions within a 6-month counterinsurgency operation is difficult because it is challenging to reconstruct those decisions, let alone define measurable results and ascribe quality. Future C2 systems should support this process of evaluation, learning, and adaptation.

ISR Integration

ISR directly affects both the speed and quality of a decision. The C2 system should integrate closely with the ISR process—both assimilating its output and providing it input in the form of direction and feedback.

Execution

Execution refers to the actual conduct of operations. Battlefield "friction," enemy opposition, and changes in the environment cause operations to deviate from plans. (Friction is a termed used by Karl von Clausewitz[19] to describe the myriad factors in war that combine to delay, disrupt, or derail an operation.) As an operation unfolds, the commander strives to assess its course and accomplish his intent through rapid and effective orders.

Integration of Functions

In many ways, execution is the integration of the first three functions of C2: situation awareness, planning, and decision making. In considering these functions, one could infer—incorrectly—that they occur in sequence: situation awareness informs planning and planning informs decision making. In fact, all three happen at once. During execution, the integration of the three functions intensifies. Situation awareness continuously reveals how well the plan is progressing and whether new planning and decision making is needed. Likewise, planning and decision making continuously focus situation awareness assets (directing intelligence collections, assessing target damage, assessing force capability, etc.) in anticipation of future needs.

During execution, the functions of situation awareness, planning, and decision making take on greater urgency. Many of the topics described above (timeliness of information, collaboration, rehearsal, speed of decision, and quality of decision) place a greater premium on responsiveness.

Mobile C2

Commanders are more than decision makers; they are leaders who must train, lead, and inspire. They must see and be seen across the battlespace—particularly during execution. They must be mobile within the battlespace: able to meet face to face with subordinates and superiors, and able to see key situations firsthand. Future C2 systems must permit commanders to exercise C2 on the move by providing situation awareness, planning, and decision-making capability wherever the commander chooses to go, aboard whatever conveyance he/she selects. It should also give the commander virtual presence at decisive points in the battlespace.

CONCLUSION

Arabian Sea, January 2015: Pursuant to U.N. Security Council Resolution 2760, coalition forces commence

operations to expel terrorist forces from the Persian Gulf region and secure oil facilities and shipping recently seized.

About 1000 miles east of the Horn of Africa, on board the U.S.S. *John C. Stennis*, an American admiral receives flash traffic from the Commander, U.S. Seventh Fleet, designating the admiral as the commander of Joint Task Force (JTF) Eagle for operations in the Persian Gulf. Along with the *Stennis* carrier battle group, the JTF would initially include five U.S. Air Force expeditionary air wings and four air groups flying support from bases in the Crimea, along with an Army brigade combat team from Fort Bliss, Texas. The Army contingent would be reinforced with another two brigades and a Marine Expeditionary Unit within 2 weeks. Once the reinforcing ground forces were assigned, the admiral also will get corps headquarters to help command the ground effort in Iraq. Forty-three minutes after receiving the order, the commander assembled his joint task force command group on the network. The Joint Force Air Component Commander and the Maritime Component Commander had a video link, but the commander of the Special Operations Task Force was audio only. The State Department, the Director of National Intelligence staff, the Central Intelligence Agency, planners from the Joint Staff, and the country team in Iraq were on the network. The Army colonel in command of the 11th Brigade Combat Team, en route to the region from Europe, had logged in, too.

"Gentlemen, ladies, welcome to Joint Task Force Eagle," the colonel said.

In the ether stretching from the continental United States 6000 miles to a turbulent Middle Eastern province, men and women from the joint military services, other agencies of the U.S. government, and their coalition partners were collaborating. A team was forming.[20]

This essay is an effort to envision the future operational environment accurately and develop general requirements for C2. It represents a determined effort to break with Cold War and Industrial Age paradigms and instead meet the future on its own terms. Our goal is to find the balance between developing technology on the one hand and the essential humanity of conflict on the other. Above all, the article calls for flexibility, because the future operational environment will offer myriad, diverse challenges and conditions. The goal is a future C2 system that facilitates strategic, operational, and tactical success.

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[20]This vignette is a modified excerpt from an unpublished novella written by Robert R. Leonhard as part of an APL effort to support modernization efforts for the Department of Defense.

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