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NETWORK-CENTRIC WARFARE AND THE OPERATIONAL CONCEPTS OF WAR: A SYNERGISTIC EFFECT

by

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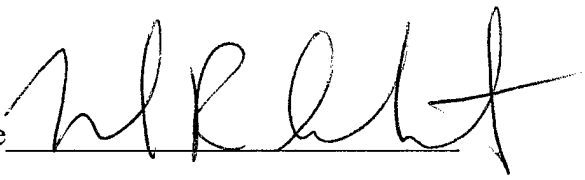
A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature 

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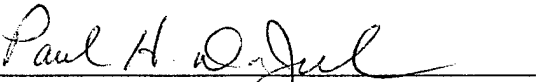

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15. Abstract: The rapid development of information processing technology portends a change in the ways and means U.S. forces will conduct future warfare. This potential revolution military affairs (RMA), termed Network-Centric Warfare (NCW), promises to increase freedom of action at the strategic, operational, and tactical levels of war by allowing greater control of the operational factors of space, time, and force than has been previously possible. The most significant benefit of conducting war in a network-centric environment is enhanced battlespace awareness. This enhanced awareness will allow the operational commander to work inside the enemy's decision cycle, better manage force disposition, and tailor forces to specific engagements using precision maneuver and precision guided, standoff munitions. Smaller, more effective and efficient forces will be able to accomplish a given objective and the pace of war will quicken, as combat in a network-centric environment becomes non-linear in conduct marked by simultaneous massing of effects.

Network-Centric Warfare will serve to compress the factor of time and expand the factor of space. While it applies to all levels of war, its greatest effect will be at the operational and tactical levels of war where NCW will become the way to match the right force to the best course of action. While the synergistic effects of Network-Centric Warfare are evident in nearly every aspect of armed conflict, the true determinant of success will be the individual capabilities of the operational commander.

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Abstract of

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"Know the enemy, know yourself; your victory will never be endangered.
Know the ground, know the weather; your victory will be total."--Sun Tzu[1]

Introduction

The U.S. Armed Forces are rapidly approaching a threshold in the conduct of armed conflict centered on information warfare. While the necessity of knowledge of the "battlespace" has been professed by the greatest of military theoreticians (beginning aptly with Sun Tzu[2]), superior battlespace awareness may well prove the deciding factor for victory in modern warfare. Secretary of Defense William Cohen provided the following insight regarding information warfare: "[The] information revolution is creating a Revolution in Military Affairs that will fundamentally change the way U.S. forces fight...[supported by a] "system of systems" that will give [United States forces] superior battlespace awareness."[3]

Termed the "American RMA"[4] and coined "Network-Centric Warfare"[5] this concept of information warfare is best defined by Admiral William A. Owens as a "system of systems"[6] designed to collect, process, evaluate and distribute information by linking sensor, processor/fusing and information distribution systems to form a network. This system promises to provide "a detailed understanding of battlespace and battle time...[via] sensor grids and transaction (engagement) grids hosted by a high quality information back plane. ...[This concept will enable a] shift from attrition style warfare to a much faster and more effective war fighting style characterized by new concepts of speed of command and "self-synchronization"...conducted by network-centric vice platform-centric "actors"...[via] a "bottom-up" command structure to meet the commander's intent."[7]

While well recognized as a fledging RMA by most observers, this concept of information warfare known as Network-Centric Warfare (NCW) has its share of detractors such as retired Marine Lieutenant General Paul Van Riper who contends, "the American RMA focuses on tasks

that were particularly relevant during Desert Storm but that are not nearly as relevant in the future [of warfare]".[8]

The purpose of this paper is to examine Network-Centric Warfare in the context of an RMA and apply its obvious merits to Operational Art; particularly the factors of space, time and forces across the strategic, operational and tactical levels of modern warfare. The focus will be on the operational level of war as it "links the tactical employment of forces to the strategic objectives".[9]

Network-Centric Warfare

> "Network-Centric Warfare derives its power from the strong networking of a well-informed but geographically dispersed force. The enabling elements are a high-performance information grid, access to all appropriate information sources, weapons reach and maneuver with precision and speed of response, value adding command-and-control (C2) processes--to include high speed automated assignment of resources to need--and integrated sensor grids closely coupled in time to shooters and C2 processes. Network-Centric Warfare is applicable to all levels of warfare and contributes to the coalescence of strategy, operations and tactics. It is transparent to mission, force size and composition, and geography."--Vice Admiral Arthur K. Cebrowski, USN[10]

The concepts providing the basis for information or Network-Centric Warfare may be found in the philosophies and practices of the civilian sector. Born on the crest of the "Third Wave", this quest for information initially took the form of telephone and television networks, and eventually included crude forms of computer networks.[11] The political, diplomatic, economic and military elements of individual nations suddenly developed connectivity via an "info-sphere". The concept of networking had begun.

Today, business, economic and information technologies are linked by three themes: a shift from the individual entity or actor to one who is a member of a system or a franchisee of a parent organization, a focus on network vice individual information nodes and the significance of successfully adapting to rapidly changing situations. Information is exchanged via a series of "information grids"-- the most obvious of which is the World Wide Web.

Joint Vision 2010 provides the template on how U.S. Armed Forces will achieve effectiveness in joint war fighting. The cornerstone of this futuristic concept is "dominant battlespace awareness"[12] which will provide an interactive picture and accurate assessment of friendly and enemy operations within an area of interest. This concept is further described in "the Army's "Force XXI", the Navy's "Forward... From the Sea," the Air Force's "Global Engagement", and the Marine Corps' "Operational Maneuver... From the Sea." Each [pronouncement cites a doctrine to employ a] force with greater precision and less risk with increased effectiveness...[with each service relying on improved] command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR), and precision guided munitions (PGMs) in carrying out their mission".[13]

The centerpiece of the NCW concept is the "grid". Individual components of the grid include a sensor grid that provides real time knowledge of the battlespace; an engagement grid to manage the battle and enhance the speed and lethality of forces; an information grid to speed data to all levels of command; and an offensive information warfare system to blind the enemy and defensive mechanisms to prevent net intrusion by the enemy.[14] The power of NCW lies in robust networking between the war fighter, sensors and weapon platforms producing superior battlespace awareness characterized by a common operational picture shared by all entities from the strategic through the operational to the tactical level of war. This battlespace awareness will produce an informed force composed of individual entities able to "self-synchronize"[15] their individual efforts by communicating and coordinating their individual intent among each other vice receiving top-down synchronization instructions from a higher level of command. This "bottom-up" command organization is facilitated by using rule sets, detailed knowledge of their own situation, information gathered from the local environment and interactions with other network and battlespace entities.

This concept of top-down guidance and bottom-up feedback relies on unity of effort, unity of command, carefully crafted rules of engagement, and a well articulated commander's intent while promising a synergistic war fighting effect with the pledge to reduce the fog and friction of war. A simple mathematical model best illustrates the synergistic effect. "Assuming an individual node has a five percent chance of possessing a given piece of information a formula may be derived where the probability of possessing the desired info increases with the number of nodes in a network: [p (probability) = $1-.95^n$]. As n increases the probability increases. Given the capabilities of a modern network, by linking nodes, a low probability, single node event can be turned into a high probability, multi-node event".[16]

Estimates have a grid capable of supporting sustained Network-Centric Warfare developed and fully functional by 2015.[17] The grid of the future will incorporate many features that may include the ability to support Military Operations Other Than War (MOOTW) (to include guerilla and urban warfare), as well as Non-Combatant Evacuation Operations (NEO). It will also include security features that will prevent the enemy from conducting cyber attacks on the system and will be sufficiently robust in breadth to prevent the enemy from exploiting a warfare area in which the system cannot cope.[18] The system may also be expanded to incorporate ancillary functions such as tracking logistics, coordinating repair cycles, conducting "what if" exercises, modeling the battlespace, simulating alternative operational concepts and gathering operational experience (e.g. after-action reports) to build a knowledge base for consumption by all levels of command.[19]

The information warfare "grid" of the future holds significant promise to reshape the conduct of armed conflict and its support of the concept of NCW may truly represent an RMA as proposed by Cebrowski, Owens, Gompert and Libicki.[20] Only historical study in the future will reveal the certainties of an RMA. In the meantime, it is worthwhile to examine the effect NCW will

have on the operational factors of space, time and force and relate postulated positive effects to the strategic, operational and tactical level of war.

Operational Factors of War

The art of warfare at all levels of war is to obtain and maintain freedom of action: the ability to carry out critically important, multiple and diverse decisions to reach assigned military objectives.[21] Freedom of action can be defined as controlling the enemy's ability act at the strategic, operational and tactical levels of war while maintaining one's own ability to accomplish actions relating to the achievement of the military objective by properly "balancing the operational factors of space, time and forces".[22]

Operational factors are best applied to the actions of an operational commander. It is difficult to isolate any single factor as actions impacting one factor invariably impact the influence of the other two factors in the accomplishment of a military objective. Space and time are related as are time and force and space and force. The task of the operational commander is to manage these mutual relationships so they collectively enhance his ability to act freely within the battlespace.

"The factor of time is more dynamic and changeable than the factor of space. Space and time can be determined and delineated. In contrast, the factor of force is difficult to quantify because the real strength of the armed forces or individual services lies not only in the number of personnel or weapons and equipment but, among other things, in the quality of leadership, morale and discipline, and combat spirit of the troops".[23] Over the years, the factor of time has been gradually compressed and the factor of space has steadily expanded.[24]

As we examine recent advances in information management technology, it is apparent that "information" expanding options within the battlespace are readily available to the operational commander via the concept of Network-Centric Warfare, increasing his freedom of action and allowing him the ability to more adroitly balance the operational factors of space, time and forces.

As the operational level of war serves as a link between the strategic and tactical levels, the positive impact of Network Centric Warfare at the operational level may be translated up and down the chain of command.

Space. Space, in a traditional sense, has many factors associated with it. Space has size and dynamics such as urban areas and rural areas. Space also has topographical and natural features, a climate, geostrategic position and a location in relation to the belligerents and their associated lines of operations (LOOs) and lines of communications (LOCs). Space is an element in which operations and combat of the enemy's forces are conducted. Finally, space can be lost and gained quickly. Generally, gaining control of space is favorable; losing control of space is not. "The higher the level of war, the more important space becomes".[25]

When the concept of Network-Centric Warfare is applied to the factor of space three additional elements become apparent. First, the concept of a battlefield or an engagement zone associated with a sea or air battle is no longer applicable. The term "battlespace" is now more appropriate as the battle, conducted under the concept of Network-Centric Warfare, may expand beyond the area of the actual battlefield or engagement zone to other enemy entities such as information nodes or information networks residing well outside the physical area of combat. Second, while the battlespace may expand, Network-Centric Warfare, (via its sensor, engagement and information grids), will allow the operational commander greater freedom of action within the battlespace. This marked information advantage and superior battlespace awareness will allow the operational commander to draw an enemy order of battle and force disposition from the information grid, shaping the battlespace and allowing him to tailor his own forces to best combat the enemy. The result will be exceptional economy of force in the context of Bernard Brodie's definition of "shrewd husbandry or usage"[26] and quicker defeat of the enemy. Third, where the battlefield focused on three historical common dimensions of height (air), width (ground) and depth (water),

within the battlespace, "the fourth the dimension of time"[27] gains increased significance. Thus, when we consider the element of space in the context of NCW we must also consider the effect of time on the battlespace.

Time. Time in the context of the conduct of armed conflict has many definitions. There is the time required to prepare for anticipated scenarios and react to specific scenarios. There is time required to plan, mobilize, deploy and re-deploy forces and time required to conduct operations to achieve a specific military objective. Finally, time, as the fourth dimension, plays an increasing role in NCW as new technologies in weapons and information systems tighten the decision loop until the asymmetry in time proves decisive.[28]

Time offers advantages and disadvantages in the conduct of war. Clausewitz stated, "[t]he decision can never be reached too soon to suit the winner or delayed long enough to suit the loser. A victory is greater for having been gained quickly; defeat is compensated for by having been so long postponed".[29] In this context the success lies in the swiftness of action by not allowing the opposition time to organize his forces. The success of the opposition lies in delaying action--allowing time for the preparation of the defense. "Every gain of time is of advantage to the defender".[30]

In the scheme of operational art, time is needed to overcome the factor of space.[31] Unlike space and forces however, time lost can never be recovered.[32] "Applying the concepts of Network-Centric Warfare to time management in operational art will result in optimizing Boyd's observe, orient, decide, act (OODA) cycle[33] by allowing response to local and transient battlefield elements. "Instead of one big OODA loop, NCW will allow an array of individual OODA loops, each tailored to individual events".[34] This concept supports self-synchronization and a bottom-up command structure. The time required to obtain required information has been reduced and further reductions

will be possible as technology advances suggesting that time will play an increasing significant role in the conduct of modern warfare.

The leveraged advantage of Network-Centric Warfare related to time is the ability to work within the enemy's decision cycle--that is, the information-decision-action (IDA) cycle starts and finishes before the enemy's IDA cycle is complete.[35] Working inside the enemy's decision cycle provides tremendous temporal advantage via the ability to "generate very high rates of change"[36] in that operating at a faster tempo than the enemy can react to, allows additional flexibility in the battlespace as the enemy is simply not able to keep up with the action.

Network-Centric Warfare impacts other "temporal characteristics of war--duration, frequency, sequence and opportunity".[37] Using the advantages provided by Network-Centric Warfare, it may be surmised that the duration of a conflict may be reduced via the ability to accomplish military objectives in less time by denying the enemy an advantage in time. Working inside the enemy's decision cycle will allow the event frequency to be increased, again denying the enemy an advantage by denying him the occasional operational pause to reconstitute while increasing the "shock and awe effect".[38] "Sequenc[ing] may be used to confuse the enemy as achieving temporal advantage in war allows additional flexibility in that operations may become non-linear in time--that is, operations need not be sequential, instead they may be simultaneous and parallel without operational pauses".[39] Opportunity increases via control of the battlespace. Controlling the battlespace allows the generation of events on one's own terms vice reacting to events generated by the opponent.

Arguably, the factor of time is the most critical and precious factor in the conduct of warfare.[40] While space and forces are dynamic in the conduct of war, time lost cannot be recovered. The concept of NCW has a significant impact on the concept of time as the time required, and consequently the time available, to collect information, make a decision, and act on

that decision has been reduced and will likely be further reduced as technology advances information warfare.

Force. Force defined in the terms of the conduct of warfare is a broad term. The first image that comes to mind is that of armed forces conducting operations in the three dimensions of land, air and sea across the fourth dimension of time. Force in the NCW environment encompasses much more. Using knowledge of the enemy's intent facilitated by the information back plane, enables force to take the shape of diplomatic and economic sanctions and information management campaigns designed to affect the outcome of a situation. While all the elements of force benefit positively from the concept of NCW, this discussion will focus on an armed force controlled by the operational commander.

"The factor force is difficult to quantify because the real strength of the armed forces or individual services lies not in the number of personnel or weapons and equipment but, among other things, in the quality of leadership, morale, discipline and combat spirit of the troops".[41] The concept of NCW applied to a specific armed force will not make it instantly "better" as NCW is not aimed at the intangibles of an armed force but rather, allows a given force to act quicker, with great efficiency and effectiveness. The first benefit that comes to mind is that a smaller force will be required to accomplish a given military objective. This benefit is formulated in the environment of austere defense budgets and downsizing. Without budget and force level constraints, this concept may be modified toward accomplishing larger objectives with a given size force.

The true benefit of NCW's effect on forces is probably best described by Vice Admiral Cebrowski who theorizes that Network-Centric Warfare will enable forces to organize from the bottom-up and self-synchronize to meet the commander's intent.[42] This will be facilitated by the operational commander's high situational awareness of the battlespace via the network and consequently his ability to tailor his own force distribution to combat the specific enemy order of

battle, allowing forces to achieve speed of command, precision and reach and massing effects rather than force. Precision and reach mark the force of the future. Using the concept of top-down guidance via an effective commander's intent, very high levels of shared battlespace awareness and self-synchronization, the force of the future will likely employ precision maneuver and precision-guided munitions (PGMs) to conduct stand-off attacks of enemy forces from remote locations within the battlespace. "[I]n a more revolutionary version tomorrow's battlefield could consist of enemy troops absorbing friendly fires with friendly forces beyond the range of enemy fires".[43]

This transition from platform-centric to network-centric conduct by individual combat entities within the battlespace is the bottom line in Network Centric Warfare. The actor-sensor-decider relationship is refined within the network and all entities act in concert with one another. Less force structure is required to accomplish the mission. This reduced structure translates into easier force deployment/redeployment, easier logistical support, reduced casualty potential as less forces are within the battlespace, and reduced susceptibility to the effect of weapons of mass destruction (WMDs) due to reduced troop density and dispersal of forces. "Geography and positioning become less relevant and the network allows much of the war fighting effort (C2, planning support, etc.) to be conducted outside the theater. Combat actions may become non-linear; small actions may have disproportionate effect".[44]

Time-Space and Space-Force Relationships

The effect of time on space can present a dilemma for the operational commander. With the advent of modern means of conveyance and information transfer; space has shrunk in terms of time. Lines of communication and lines of operation take less time to travel. Information may be transferred more quickly and in greater volume. Accordingly, NCW "reduces the importance of space"[45] to the operational commander. Conversely it may be argued that NCW has expanded space and thus its role in modern warfare as the concept of battlespace now encompasses an area well

beyond the actual battlefield or engagement zone and may include remotely located information nodes and processing facilities serving the enemy. It becomes evident that battlespace may expand very quickly during Network-Centric Warfare-based combat. The concept of battlespace may cause operations within to become non-linear in nature in the respect that there may be no defined forward edge of the battle area (FEBA), no forward line of troops (FLOT) and no fire coordination line (FCL).[46]

Expanding the concept of shaping the battlespace and tailoring forces introduces the relationship between space and force. Smaller, more effective and better-distributed forces define the space-force relationship in Network-Centric Warfare. This is made possible by determining the enemy's order of battle and his force disposition via the grid thereby reducing combating the enemy to a series of precision engagements. This concept is also supported by the theory that the force of the future will doctrinally conduct combat operations using superior C4ISR, standoff weapons and precision engagement techniques. While the benefit is that "effects can be massed without the need to mass forces, rendering geography and the positioning of forces less relevant than in the past",[47] the space-force relationship, as optimized by the operational commander, is still to achieve positional advantage over the enemy.

The Levels of War

"The levels of war are doctrinal perspectives that clarify links between strategic objectives and tactical actions. Although there are no finite limits or boundaries between them, the three levels in general are strategic, operational and tactical".[48] "The highest level of war is the strategic level where military strategy is applied to accomplish national strategy via establishing goals, assigning forces, providing assets and imposing conditions on the use of force. The lowest level is the tactical level where combat power is applied to defeat an enemy force at a particular time and place".[49] Between the two, the operational level of war links the strategic and tactical levels.[50] Here the

decision is made by the operational commander as to when, where and under what conditions the enemy will be engaged across the operational factors of time, space and by which forces.

Network-Centric Warfare is applicable to all levels of warfare and contributes to the coalescence, or high-speed compression, of the strategic, operational and tactical levels of war.[51] "This means we will increasingly match the right force to the most promising course of action at both the tactical and operational levels of warfare. Further, we will have an increasing capacity to apply tailored forces faster with more precise weapons over greater distances".[52] In this context it can be argued that the greatest benefit of NCW will be experienced at the operational and tactical levels of war.

Tactical. At the tactical level of war, the most significant benefit is the transition from platform-centric to network-centric conduct by the unit level actor. This allows the sharing of sensor data by all units participating in the network, enhancing individual unit situational awareness and allowing the concept of top-down direction via the commander's intent and bottom-up feedback regarding the execution of tasking. The network allows the individual actor to provide own-unit sensor data to, and at the same time draw fused data from, the network. This provides a common picture for all actors and enhances the efficiency and effectiveness of the tactical action.

Operational. At the operational level, the operational commander's greatest benefit is enhanced situational awareness via bottom-up feedback from the tactical level actor. This enhanced situational awareness will assist the operational commander in quickly and effectively employing certain elements of the Principles of War[53] in accomplishing the military objective. In terms of mass, economy of force, and maneuver, the operational commander's networked forces allow the massing of effects vice the massing of force. Economy of force is enhanced because greater battlespace awareness allows the commander greater knowledge of the enemy's order of battle, allowing him to tailor troop disposition and refine taskings. Maneuver is enhanced by the

preposition that smaller, networked forces are required to accomplish a given objective and that smaller forces are easier to deploy, logistically support, and more difficult to detect. Unity of command is enhanced via the ability of the commander to control larger forces including those of an alliance or coalition, as long as those forces demonstrate compatibility with the network and possibly accomplish larger objectives with a given force that would be otherwise impossible without the benefits of networking.

Strategic. The strategic level achieves its benefits from the output of the tactical and operational levels of command via a greater situational awareness of the battlespace. The network also provides the means for the strategic level of command (national or theater) to provide appropriate and timely feedback to the operational level of command.

Network Centric Warfare may serve to alter the scope and focus of the levels of war in the future. Professor Milan Vego of the Naval War College argues, "the tactical level will be larger in scope than it is today, while the operational level will probably encompass a part of what today is considered the theater-strategic level."[54] Vice Admiral Cebrowski cautions that the strategic offense must not be discounted: "At the tactical and operational levels offensive operations must be undertaken, even within the context of a strategic defense. If the strategic objective is to terminate hostilities on favorable terms, then the formidable task for decision makers will be shifting from strategically defensive thinking to a mindset that is offensive across all levels of warfare. This difficulty should not be underestimated."[55] Further emphasizing the growth and influence of the tactical level of war and the tactical actor's ability to self-synchronize, Vice Admiral Cebrowski proposes, "actions at the tactical level can have powerful operational and even strategic effects".[56]

Network-Centric Warfare's proviso of enhanced battlespace awareness at all levels of command, and the changing scope and focus of the levels of war, portends other considerations. Dr. David S. Alberts cautions of the blurring of the levels of warfare.[57] Vego counters this argument

by proposing that "new technologies would not lead to the collapse of the levels of war...as history has shown that strategy and tactics cannot be bridged by bypassing the operational level of war".[58] Leonhard offers that "flattening the hierarchy" enhances command and control in the military as well as the business world.[59] Finally, there is the concern of micromanagement by the highest echelons of the strategic level aimed directly at the lowest entity of the tactical level of command.

The Future

"Something occurred in the night skies and desert sands of the Middle East in 1991 that the world had not seen for three hundred years--the arrival of a new form of warfare...".[60] In view of this comment, arguably Network-Centric Warfare was first demonstrated during Operation Desert Storm. Desert Storm was different because "combat forces largely were deployed, sustained commanded, and controlled through satellite communications."[61] Coalition forces, led by U.S. forces, employed a "system of systems" in the form of C4I such as the Global Command and Control System (GCCS), sensor nodes such as Airborne Warning and Control System (AWACS) and Joint Surveillance and Attack Radar System (JSTARS), and precision, stand-off weapons such as Tomahawk Land Attack Cruise Missile (TLAM), Stand-off Land Attack Missile (SLAM), Conventional Air Launched Cruise Missile (CALCM), and High Speed Anti-Radiation Missile (HARM) to prevail in combat. Elements of technology, weaponry, force disposition, non-linearity of operations, techniques of destruction, command and control and scale were redefined in terms of "information warfare".[62] Gompert offers a further thought on war in the information age: "Information technology has made traditional assets of power-territory, huge armies, heavy industry-less strategically relevant".[63] Examining Desert Storm in the context of NCW reveals the synergistic effect of the concept in terms as simple as the Coalition's defeat of Iraq's million-man Army with total theater strength approximately one-half that level while incurring minimum casualties.

Based on the demonstrated successes of information warfare or conducting war in the information age, NCW is the way of the future. This concept of networking promises to revolutionize the way war is fought. Despite the numerous and often obvious advantages of conducting warfare in a Network-centric environment discussed above, as with any developing concept, several concerns warrant discussion.

First is the concern that as the span of control of the operational commander is increased via the superior battlespace awareness associated with Network-Centric Warfare, exceeding the point of culmination within the theater of operations could become an issue. This can be caused by the success inherent in the NCW concept related to force size; a force of a given size is possibly able to accomplish a larger objective. This may lead to the operational commander's attempt to "do it all" within the battlespace and exceed his stated military objective. A second concern associated with superior battlespace awareness, is the potential for the well-informed strategic level commander (or above) to reach directly through to the tactical level, bypassing the operational level commander and creating a situation of micromanagement. The counter to both these concerns is utilization of proper command and control discipline that is inherent in the NCW concept. As long as the command and control protocols and military objectives are defined in the initial tasking order and followed by all levels of command, the issues of exceeding a specified culminating point and micromanagement may be avoided.

Another concern is that as the U.S. Armed Forces continue to develop the concept of Network-Centric Warfare, technology associated with the concept will rapidly exceed the capability of current allies and potential future coalition partners thereby affecting their ability to integrate their forces at the operational level of war and restricting the addition of "friendly space" via territory accompanying allies and coalition partners. While this is a valid concern and possibly represents the most significant liability associated with NCW in the combined environment, several

solutions are possible. In the case of allies such as NATO, Gompert proposes a system "to develop weapons, forces and doctrine need to carry out operations alongside U.S. forces."[64] Regarding potential future coalition partners who do not warrant baseline integration into the network, an exportable plug-and-play capability to tailor their integration is appropriate.

Finally, since a portion of the systems to form the Network-Centric systems are available commercially, it may be argued that the enemy will remain only steps behind the friendly level of battlespace awareness and may develop the means to exploit the friendly network, negating the benefits of Network-Centric Warfare. The means to counter this possibility, are to continue to develop the capability to work inside the enemy's decision cycle—staying one-step ahead while preventing his ability to access the friendly network by hardening the net against intrusion and by using encryption technologies to prevent signal exploitation.

Conclusion

The application of Network-Centric Warfare to modern warfare clearly provides the potential to increase freedom of action at all levels of war by allowing greater control of the operational factors of space, time and force than has been previously possible. In terms of space, the traditional battlefield will be expanded and will become "battlespace". The most significant benefit of conducting war in a network-centric environment is enhanced battlespace awareness. Within the battlespace, the operational commander will be better able to manage force disposition and tailor his forces to specific precision engagements based on knowledge of the enemy's order of battle and intent. Because of superior battlespace awareness, he will be able to maintain temporal advantage over the enemy via the ability to work within the enemy's decision cycle--to simply out pace the enemy in the battlespace by generating very high rates of change. By quickening the pace of war, OODA loops are shortened and the enemy is denied an operational pause making it impossible to reconstitute or regroup. In terms of force, greater knowledge of the battlespace will

allow the use of smaller forces to accomplish a given objective. Forces will be tailored to the task and will conduct operations from remote locations; employing precision maneuver and precision guided, standoff munitions in a self-synchronizing mode achieving massing of effect vice massing of force. Overall, combat in the network-centric environment will become non-linear in conduct marked by simultaneous massing of effects.

Network-Centric Warfare applies to all levels of war but its greatest benefit is noted at the operational and tactical levels. At the tactical level the greatest benefit is the transition from platform-centric to network-centric conduct by actors allowing them to function as members of a networked force with common knowledge of the battlespace. At the operational level, the operational commander achieves superior battlespace awareness and is able to quickly and effectively employ certain elements of the Principles of War; particularly mass, economy of force, maneuver and unity of command to produce a synergistic effect. At the strategic level, the greatest benefit is increased situation awareness and the ability to provide appropriate and timely input to the operational level of command. Overall, it may be postulated that the concept of Network-Centric Warfare will expand the influence of the tactical level of war as tactical action may have strategic effect due to the fluidity and rapidity of information flow within the network.

The concept of Network-Centric Warfare promises to change the conduct of warfare by making combat forces more effective and efficient by enhancing freedom of action for the operational commander. While we can postulate the positive effects of this concept in nearly every aspect of armed conflict, the true determinant of success will be the individual capabilities of the operational commander.

Notes

[1] Sun Tzu, *The Art of War*, Samuel B. Griffith, trans. (New York: Oxford University Press, 1963) 129.
[2] Ibid.
[3] William Cohen, *Quadrennial Defense Review*, (Washington, DC: Department of Defense, May 1997), ii, iv.
[4] William A. Owens, "The American Revolution in Military Affairs," *Joint Forces Quarterly*, Winter 1995-96, 37.
[5] Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future," *U.S. Naval Institute Proceedings,* January 1998, 32.
[6] William A. Owens, "The Emerging System of Systems," *U.S. Naval Institute Proceedings*, May 1995, 36.
[7] Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future," *U.S. Naval Institute Proceedings*, January 1998, 32.
[8] P. K. Van Riper and F. G. Hoffman, "Pursuing the Real Revolution in Military Affairs: Exploiting Knowledge-Based Warfare," *National Security Strategy Quarterly*, Summer 1998, 2.
[9] Joint Chiefs of Staff, *Doctrine for Joint Operations*, Joint Pub 3-0 (Washington DC: 1 February 1995), I-2.
[10] Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future." *U.S. Naval Institute Proceedings,* January 1998, 35.
[11] Alvin Toeffler, *The Third Wave* (New York: William Morrow and Company 1980), 51.
[12] Joint Chiefs of Staff, *Joint Vision 2010* (Washington DC: 1995), 13.
[13] William A. Owens, "The Emerging System of Systems," *U.S. Naval Institute Proceedings*, May 1995, 36.
[14] David C.Gompert and others, *Mind the Gap* (Washington DC: National Defense University Press, 1999), 34.
[15] Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future," *U.S. Naval Institute Proceedings*, January 1998, 33. Self-Synchronization is the ability of a well-informed force to organize and synchronize complex warfare activities from the bottom-up. The organization principles are unity of effort, clearly articulated commander's intent, and carefully crafted rules of engagement. Self-synchronization is enabled by a high level of knowledge of one's own forces, enemy forces and all appropriate elements of the operating environment. It overcomes the loss of combat power inherent in a top-down command directed synchronization characteristic of more conventional doctrine and converts combat from a step function to a high-speed continuum.
[16] David S. Alberts and others, *Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington DC: DOD C4ISR Cooperative Research Program (CCRP), 1999), 104.

[17] Martin C. Libicki, *Illuminating Tomorrow's War* (Washington DC: National Defense University Press, 1999), 57.
[18] Ibid., 65, 85.
[19] David C.Gompert and others, *Mind the Gap* (Washington DC: National Defense University Press, 1999), 49.
[20] Vice Admiral Arthur K. Cebrowski, USN, Admiral William A. Owens, USN, David C. Gompert and Martin C. Libicki have all discussed Network-Centric Warfare in the context of an RMA in the following citations:
Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future." *U.S. Naval Institute Proceedings,* January 1998, 29.
William A. Owens, "The American Revolution in Military Affairs," *Joint Forces Quarterly*, Winter 1995-96, 36.
David C.Gompert and others, *Mind the Gap* (Washington DC: National Defense University Press, 1999), 29.
Martin C. Libicki, *Illuminating Tomorrow's War* (Washington DC: National Defense University Press, 1999), 1.
[21] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 53.
[22] Ibid.
[23] Ibid., 54.
[24] Ajay Singh, "Time, The New Dimension in War," *Joint Force Quarterly*, Winter 1995-96, 56.
[25] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 57.
[26] Bernard Brodie, "The Worth of Principles of War," Lecture Transcript, U.S. Army Command and General Staff College, Fort Leavenworth, KS: 7 March 1957.
[27] Ajay Singh, "Time, The New Dimension in War," *Joint Force Quarterly*, Winter 1995-96, 57.
[28] Ajay Singh, "Time, The New Dimension in War," *Joint Force Quarterly*, Winter 1995-96, 57.
[29] Carl Von Clausewitz, *On War*, Michael Howard and Peter Paret, trans. (Princeton, New Jersey: Princeton University Press, 1976), 238.
[30] Chet Helms, "Operational Factors," (Unpublished Joint Military Operations Department Paper, U.S. Naval War College, Newport, RI: September 1997), 10.

[31] Hermann Foertsch, *The Art of Modern Warfare*, Theodore W. Knauth, trans. (New York: Veritas Press, 1940), 40.
[32] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 75.
[33] David S. Alberts and others, *Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington DC: DOD C4ISR Cooperative Research Program (CCRP), 1999), 74.
[34] Mark Tempestilli, "The Network Force," *U.S. Naval Institute Proceedings,* June 1996, 43.
[35] Ajay Singh, "Time, The New Dimension in War," *Joint Force Quarterly*, Winter 1995-96, 61.
[36] Arthur K. Cebrowski, "Sea Change," *Surface Warfare Magazine*, November/December 1997, 4.
[37] Robert R. Leonhard, *Fighting By Minutes: Time and Art of War*, (Westport, CT: Praeger Publishers, 1994), 10-12.
[38] Bryan Bender, "Buying into Networked Warfare," *Jane's Defense Weekly,* May 13, 1998, 27.
[39] Arthur K. Cebrowski, "Network-Centric Warfare: An Emerging Military Response to the Information Age," Lecture Transcript, Command and Control Research and Technology Symposium, Newport, RI: 29 June 1999, 3.
[40] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 83.
[41] Ibid., 54.
[42] Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origins and Future." *U.S. Naval Institute Proceedings,* January 1998, 32.
[43] David C.Gompert, "National Security in the Information Age," *Naval War College Review*, Autumn 1998, 7.
[44] Arthur K. Cebrowski, "Network-Centric Warfare: An Emerging Military Response to the Information Age," Lecture Transcript, Command and Control Research and Technology Symposium, Newport, RI: 29 June 1999, 3.
[45] David C. Gompert and others, *Mind the Gap* (Washington DC: National Defense University Press, 1999), 33.
[46] Arthur K. Cebrowski, "Network-Centric Warfare: An Emerging Military Response to the Information Age," Lecture Transcript, Command and Control Research and Technology Symposium, Newport, RI: 29 June 1999, 3.
[47] Ibid.
[48] Joint Chiefs of Staff, *Doctrine for Joint Operations*, Joint Pub 3-0 (Washington DC: 1 February 1995), II-1, 2.
[49] Marine Corps Doctrine Publication 1,Warfighting, (Washington DC: 20 June 1997), 28, 29.
[50] Joint Chiefs of Staff, *Doctrine for Joint Operations*, Joint Pub 3-0 (Washington DC: 1 February 1995), II-2.
[51] Arthur K. Cebrowski, "Statement," U.S. Congress, House, Committee on Armed Services, *Network Centric Warfare*, Hearings before the Subcommittee on Military Procurement and Subcommittee on Military Research and Development, 106th Cong, 1st sess, 23 February 1999, 1.
[52] William A. Owens, "The Emerging U.S. System-of-Systems," Lecture Transcript, National Defense University, Institute for National Strategic Studies Strategic Forum 63, Washington DC: February 1996.
[53] Joint Chiefs of Staff, *Doctrine for Joint Operations*, Joint Pub 3-0 (Washington DC: 1 February 1995), Appendix A.
[54] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 148.
[55] Arthur K. Cebrowski, "Network-Centric Warfare: An Emerging Military Response to the Information Age," Lecture Transcript, Command and Control Research and Technology Symposium, Newport, RI: 29 June 1999, 2.
[56] Ibid., 4.
[57] David S. Alberts and others, *Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington DC: DOD C4ISR Cooperative Research Program (CCRP), 1999), 84.
[58] Milan N. Vego, "On Operational Art," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: September 1998), 148.
[59] Robert R. Leonhard, *The Principles of War for the Information Age* (Novato, CA: Presidio Press, 1998), 198.
[60] Alvin Toeffler and Heidi Toeffler, *War and Anti-War: Survival at the Dawn Of the 21st Century*, (Boston: Little, Brown and Company, 1993), 64.
[61] Ibid., 98.
[62] Ibid., 64-80.
[63] David C. Gompert, "National Security in the Information Age," *Naval War College Review*, Autumn 1998, 6.
[64] David C. Gompert and others, *Mind the Gap* (Washington DC: National Defense University Press, 1999), 37.

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