Nonlinearity and the Arc of Warfighting

Bending toward the tactical level of war?

by George M. Gross

The information environment (IE) has turned into a vast and expansive arena over the last decade, especially as a topic of study and intelligence analysis as well as of planning and operations. Disciplines that did not previously exist or were just beginning to evolve a decade ago are currently integral to understanding and operating in the IE. Understanding the IE involves a multi-disciplinary approach that lies at the intersection of sociology, politics, and technology.

The idea of nonlinearity is a good frame of reference for understanding and operating in the IE. United States Air Force (USAF) Col John Boyd carried out his major conceptual work on maneuver with an emphasis toward the previously emerging air domain of warfighting, but his contributions looked ahead to anticipate conditions of nonlinear warfare. For all intents and purposes, Boyd was the prophet of nonlinearity, envisioning the key traits of nonlinear warfare before the nonlinear domains of warfighting came on the scene. Because of the strategic aspects of nonlinear warfare, many people compare weapons in the nonlinear domains to nuclear weapons. While there is merit in the comparison, it is a limiting comparison because we do yet understand how the nonlinear domains will affect the three levels of war. The air domain has a prominent strategic aspect that, in some institutional contexts, overshadows air operations at the operational and tactical levels, but the MAGTF provides a correction by serving to institutionalize air operations at the tactical level. The strategic aspects of nonlinear warfare should not divert us from the challenge to assimilate warfighting in the nonlinear domains to combined arms formations. If the nonlinear domains follow an arc that is similar to that of the air domain, then—in time—that arc will bend toward the tactical level of war.

>Dr. Gross is a civilian employee of the Marine Corps at Quantico MCB, focusing on topics pertaining to integrated information warfare.

Boyd developed his concept of maneuver warfare by an intensive examination of the air domain of warfighting. *(Photo by LCpl Cody Rowe.)*

Principles of Nonlinearity

As an approach for understanding the IE, I propose the concept of nonlinearity. Think back to the high school or undergraduate course you likely had on the fundamentals of physics which usually included a short unit on relativity theory. In that unit, you learned the shortest distance between two points is not actually a straight line. Space is curved because mass bends space; light follows the arc of the curve, and hence, the path of light through space is nonlinear.

In the traditional warfighting domains of land, sea, and air, the shortest distance between two points is generally a straight line. But the nonlinearity of space is a frame of reference and a metaphor for understanding the challenge of the IE in our time. Information travels in the nontraditional warfighting domains of cyberspace and the electromagnetic spectrum through nodes and rarely in a straight line. Information travels in these domains at a rate that far exceeds the speed through which it moves through land, sea, or air. Because of these two traits of motion (nonlin-

earity and speed), the nontraditional domains differ from the traditional ones.

If you were planning to conduct a traditional information, then in the time it took for you to embark leaflets and loudspeakers—the tools of the trade in traditional psychological operations—and even prepare to set sail, the enemy already would have reshaped the IE by means of messaging in the nonlinear domains. The point is not that the nonlinear domains make the linear domains obsolete or traditional psychological operations a thing of the past. Rather, information warfare analysts, planners, and operators need to anticipate the threats and opportunities posed by the rise of the nonlinear domains.

The Prophet of Nonlinearity

Col John Boyd discovered the observe-orient-decide-act (OODA) loop and was the prophet of nonlinearity. Boyd sought to understand why it is crucial for a fighter pilot to exploit gravity by means of nonlinear thinking to infiltrate and dominate an enemy's decision cycle. In his insights about the role of nonlinearity and speed in exploiting gravity, Boyd anticipated both of the two key facets of nonlinear warfare.

Boyd built the foundation for his work on the OODA loop largely during the 1950s and 1960s when the air domain was still a relatively new domain of warfighting. Boyd conceived the energy-maneuverability (E-M) theory on the insight that a fighter cannot control gravity, but he can exploit it by means of the tight control of velocity and turn. Boyd showed how to view air maneuver on a spherical, nonlinear surface, such that mastering velocity and turn and exploiting gravity enables a fighter to rapidly increase and decrease motion along the surface of the sphere as he gains ascendancy over his enemy and penetrates their decision cycle.[1] Through successive cycles of maneuver in this fashion, a fighter dominates the tempo of engagement with the enemy. Boyd held that airplane design should generalize from these insights about pilots' experiences in order to enable U.S.-built fighter planes to exploit gravity systematically. Aside from conceiving the theory, Boyd assembled and analyzed data to enable airplane design to incorporate these insights and, thus, provide a systematic basis for pilots to master the enemy fighter's decision cycle.[2]

By the time of Boyd's work on the E-M theory, the air domain of warfighting was already about 50-years-old. Nonetheless, the air domain was still a new domain of warfighting in the sense basic issues about how to fight in it remained unresolved and in contention. Strategic bombing doctrine was the vehicle for the Air Force to assert its institutional independence from the Army. Despite achievements in tactical air support during World War II, the obstacles to maintaining institutional knowledge over the range of tactical air missions after the war meant that entropy—or the law of the dissipation of institutional knowledge in the absence of fresh experience—favored strategic bombing.[3] The controversy over strategic bombing lasted through most of the 20th and into the 21st century.[4] This story has been retold many times; however, for our purposes, it is worth a reminder because it highlights the challenges caused by a reluctant and—in some instances—resistant assimilation of the air domain to combined arms thinking. The Marine Corps developed close air support early and consistently in contrast to the other Services, and with the rise of this new domain of warfighting, Marines came to be more deeply imbued with combined arms thinking than members of the other Services.

Boyd was the prophet of nonlinearity. *(Photo by LCpl Brennan Priest.)*

Cyber and Nuclear Weapons Compared

Many people compare cyber and nuclear weapons because of their strategic role and, by implication, their presumed ability to circumvent and indeed supersede warfighting in the traditional, linear domains. We will review some of these comparisons in order to then push beyond them and arrive at a more balanced way of thinking about the nonlinear domains. Nuclear weapons require strategic-level decision making and achieve strategic-level effects. Even after recent efforts by Russia to rehabilitate tactical nuclear weapons, considerations pertaining to nuclear weapons are inseparable from the strategic level of war. Russia's attempt for a rehabilitation of tactical nuclear arms notwithstanding, for a while it was a central tenet of nuclear weapons strategy that the advent of nuclear weapons made conventional warfare obsolete. This was certainly a ruse to discourage investment in conventional arms and arms strategy, but it received a powerful lift by riding on the back of the myths about strategic air bombing.

Cyber warfare has prominent strategic aspects especially as it involves threats to industrial control systems and supervisory control and data ac-

Air and cyber operations are useful for pursuing limited objectives. *(Photo by LCpl Kenny Nunez Bigay.)*

quisition. Russia's use of cyber warfare illustrated the strategic aspect of the cyber domain during deployments against Georgia, Estonia, and Ukraine. For instance, cyber warfare was employed against Georgia and Estonia to disable Internet communications and sectors of the civilian economy, whereas it was used against Ukraine to disable that country's electric power grid.[5] In each instance, Russia deployed computer network operations to strategic effect. Aside from their uses in interstate war, cyber Internet monitoring and control are used domestically as strategic-level means for the state to repress its populations in China, Cuba, and other countries. Conversely, access to cyber communications is a barometer of openness in the world's open societies and is a means by which these societies declare, defend, and realize their strategic vision and mission as open societies.

Nuclear and cyber weapons achieve a special or exponential unity when considerations about nuclear command, control, and communications (NC3) are factored. Because of vulnerabilities in NC3, cyber or computer network operations threaten to disable an enemy's nuclear weapons systems. As strategic instrumentalities, nuclear and cyber warfare are complementary in cross-domain calculations. A nuclear or cyber threat can elicit either a cyber or nuclear counter-threat and so relieve pressure on each side in a contest to have both a tactical nuclear arsenal and a strategic cyber playbook. Yet, cyber and nuclear weapons are "dangerous complements" as stealth and the difficulty of attribution in the cyber domain, among other factors, can be destabilizing in calculations about nuclear deterrence.[6] But even apart from NC3 and cross-domain complementarity, concern about the use of nuclear and cyber weapons tend to rise rapidly to the strategic level of war.

The Cyber and Air Domains Compared

It is quite common to hear comparisons between nuclear and cyber weapons, but let's change course now and suggest comparisons between the cyber and air domains. It is less common and indeed more risky to make comparisons along these lines. The history of the cyber domain potentially follows that of the air domain across the three levels of war, even if difficult technological problems and authorization issues cause cyber to lag behind. The air and cyber domains are means for pursuing limited objectives and are both better suited than nuclear weapons to the three levels of war. The protracted affair with strategic air bombing, by virtue of which the air domain acquired its strategic face, is not likely to have an equivalent in the cyber domain. Strategic bombing and tactical air support represent only two-thirds of the picture as far as the air domain is concerned, reflecting only operations at the strategic and tactical levels. A discussion of cyber effects at the strategic and tactical levels will likely be similarly incomplete.[7] Cyber offers less resistance than air to assimilating in combined arms formations in any case. A recent training report highlights a finding that conducting cyber operations in conjunction with other branches of arms—in other words, using cyber operations in conjunction with maneuver forces including, by implication, tactical combined arms formations—is more effective than using cyber operations alone.[8]

Indeed the cyber and air domains are both relatively new domains of war. In certain respects, the air domain is not really a traditional domain at all. Rather, the air domain straddles the traditional and nontraditional domains; it is about halfway between them and serves as a bridge. The air domain has too many features in common with the nontraditional domains to be a traditional domain itself. The air domain was the arena for Boyd to develop E-M theory and the OODA loop; in both instances, Boyd anticipated key features of warfighting in the nonlinear domains. It is inconceivable that Boyd would have developed these concepts on land or on water. In discovering hitherto unexploited aspects of the air domain, Boyd anticipated key aspects of nonlinear warfare, most notably the OODA loop.

Air is both a branch of arms and a domain of warfare. The other new branches of arms in American history—cavalry (1863) and armor (1940)—belong to the land domain and are not domains themselves. Air is the first new branch of arms (1926) to be a domain, but it is perhaps not the last.

What does it mean for a new branch of arms to come of age? Does it mean the branch can defeat its opposite number in a duel, as implied by Eric J. Wittenberg's study of the Union cavalry in the American Civil War?[9] Or, does it

The air domain is halfway between linear and nonlinear warfighting domains. *(Photo by LCpl Kevan Dunlop.)*

mean that the new branch of arms can go it alone at the strategic level of war, as implied in the history of the strategic air bombing movement?[10] Perhaps what it should mean is that the new branch of arms is ready for assimilation to combined arms formations at the tactical level of war. If this is true—and I argue it is sounder and more accurate historically than the duelist or go-it-alone perspectives—then as nonlinearity comes of age, we would look to see the increasing use of nonlinear means at the tactical level of war.

Conclusion

Nonlinearity is a key attribute for understanding the challenge of the IE in our time. Boyd identified unexploited aspects of the emerging air domain of warfighting: nonlinearity and speed. In doing so, he became the prophet of warfighting in the nonlinear domains. Strategic considerations tend to bring the common features of cyber and nuclear weapons into relief, but it is worthwhile to keep these common features in perspective to give thought to similarities between the air and cyber and electromagnetic domains in their careers as new and emerging domains of warfighting. The air domain is not really a traditional domain, although we make the mistake of thinking it is one by counting it among the traditional domains. The air domain is really a halfway point between the linear and the nonlinear domains. Persistent contention about the role of the air domain likely reflects, in part, its intermediate or ambiguous status. The MAGTF has absorbed and enabled tactical air operations, and recent concept development shows the way forward for the MAGTF to enable tactical cyber and electromagnetic spectrum operations as well. An aspect of the competition between the United States and its rivals surely concerns the ability to assimilate warfighting in the IE to combined arms formations. As the arc of warfighting bends to accommodate the nonlinear domains, it may well assimilate them to combined arms thinking—for which Marines retain a unique and historic affinity.

Notes

1. Ian T. Brown, *A New Conception of War: John Boyd, the U.S Marines, and Maneuver Warfare,* (Quantico, VA: Marine Corps University Press, 2018).

2. Robert Coram, *Boyd: The Fighter Pilot Who Changed the Art of War,* (New York, NY: Back Bay Books/Little, Brown and Company, 2002).

3. I.B. Holley, Jr., "A Retrospect on Close Air Support," in Benjamin Franklin Cooling, ed., *Case Studies in the Development of Close Air Support,* (Washington, DC: Office of Air Force History/United States Air Force, 1990).

4. Robert H. Gregory, Jr., *Clean Bombs and Dirty Wars: Air Power in Kosovo and Libya,* (Lincoln, NE: Potomac Books/University of Nebraska Press, 2015).

5. Alison Lawlor Russell, *Cyber Blockades,* (Washington, DC: Georgetown University Press, 2014); and Andy Greenberg, "How an Entire Nation Became Russia's Test Lab for Cyberwar," *Wired*, (Online: June 2017), available at https://www.wired.com.

6. Eric Gartzke and Jon R. Lindsay, "The Cyber Commitment Problem and the Destabilization of Nuclear Deterrence," in Herbert Lin and Amy Zegart, eds., *Bytes, Bombs, and Spies: The Strategic Dimensions of Offensive Cyber Operations,* (Washington, DC: Brookings Institute Press, 2018).

7. Maren Leed, "Offensive Cyber Capabilities at the Operational Level: The Way Ahead," Center for Strategic & International Studies (CSIS)/ Georgia Tech Research Institute, (Online: September 2013), available at https://www.csis.org.

8. James Lacey, "How Does the Next Great Power Conflict Play Out: Lessons from a Wargame," *War on the Rocks*, (Online: April 2019), available at https://warontherocks.com.

9. Eric J. Wittenberg, *The Union Cavalry Comes of Age: Hartwood Church to Brandy Station, 1863,* (Washington, DC: Brassey's, 2003).

10. John W. Huston, ed., *American Airpower Comes of Age: General Henry H. "Hap" Arnold's World War II Diaries,* (Maxwell AFB, AL: Air University Press, 2002).

>Author's Note: The author would like to thank Joshua A. Keyfauver, James E. McGinley, and Maj Andrew C. Roberts for their comments on a draft version. This article expresses the author's views and not those of the Marine Corps or any government agency.