The US Army War College Quarterly: Parameters

Volume 30
Number 3 *Parameters Autumn 2000*

Article 10

8-16-2000

The Next Twist of the RMA

Steven Metz

The Next Twist of the RMA

STEVEN METZ

From *Parameters*, Autumn 2000, pp. 40-53.

Ten years ago, few Americans had heard of or thought about military revolutions. Soviet defense experts, who were intrinsically more comfortable with the notion that history's linear evolution is occasionally interrupted by rapid discontinuities known as "revolutions," had begun exploration of the idea. But even though the Soviets had an inkling of the changes in warfare that the late 20th century would bring, they did not have the technological base or the capability for creative organizational reform to actually undertake a revolution. They were the intellectual founding fathers of the current revolution in military affairs, but not its architects, playing the role of Marx rather than Lenin. But Americans were different. For a variety of reasons, they were both open to new ideas about warfare and able to capitalize on them.

Throughout history, militaries that have lost a war or have perceived themselves to be in a position of weakness have been most open to creativity. Often, though, the "new" ideas actually have been attempts to return to methods that brought success in the past. The creation of blitzkrieg in the 1930s, for instance, used new technology to return to the rapid operational tempo and quick decision that the German army attained in 1870-71. The American Army underwent a similar process of reform in the 1970s and 1980s. Failure in Vietnam had created an environment amenable to creativity. The result, however, was not a radically new perspective on warfare, but the marriage of new technology with operational concepts that Patton or Guderian would have been comfortable with--a rapid operational tempo, *Auftragstaktik*, seamless combined arms operations, and so forth. AirLand Battle was the first progeny of this period of innovation.[1]

Still, history may show that the true significance of this period for the US Army was not the crafting of AirLand Battle, but the inculcation of a tradition of creativity and introspection. Revolutions begin not when the first barricades are erected or even when people lose faith in the old ways of doing things, but rather when they realize that fundamental change is possible. This is what the process of designing AirLand Battle did: by institutionalizing creativity and conceptual thinking within the Army, it set the stage for even more extensive reform to come.

Like many revolutions, the current revolution in military affairs (RMA) began inadvertently. The Americans who first opted for armed resistance against the Crown in 1775 sought to restore lost rights but ended up driving a dagger into the heart of the old political order. Similarly, William DePuy, Donn Starry, Don Morelli, Huba Wass de Czege, William R. Richardson, Paul F. Gorman, Carl E. Vuono, and the other founding fathers of AirLand Battle sought to restore the morale and effectiveness the Army had lost in Vietnam, but instead set a revolution in motion.

Today, the US military is in the midst of the first phase of the current revolution in military affairs. Led by people like Andrew Marshall, the Pentagon's Director of Net Assessment, writers like Andrew Krepinevich and Eliot Cohen, and retired Admiral William Owens, former Vice Chairman of the Joint Chiefs of Staff, the concept of military revolutions has gone from a fringe idea to the foundation concept of futures-oriented thinking within the US military. Yet the vision of the RMA that drives the Pentagon and the services is a moderate one in which change is controlled or modulated. Key documents like *Joint Vision 2020* and service and joint programs designed to explore the long-term future all evince an essentially conservative view of the revolution in military affairs (to the extent that the concept of a "conservative revolution" makes any sense).

The Department of Defense's vision of the revolution in military affairs, in other words, seeks the application of new technology, particularly digital information technology, to operational and strategic concepts that are less than radical. War will still consist primarily of armed conflict between state militaries involving the maneuver of military forces and the use of fires to destroy the enemy and thus break his will. Militaries will still consist of professionals who have,

by virtue of training and experience, developed a set of skills and an ethos that sets them apart from civilian society. Information technology, new materials, new fuels, new guidance systems, and new means of propulsion will allow future militaries to do the things that they've always done, but to do them better than before.

This "conservative" perspective on the current revolution in military affairs is important and necessary, but may not be adequate. Increasingly, technological and, more important, social, political, economic, and psychological changes suggest that the RMA may be moving into a second, more radical, phase. In it, both the nature of war and the way in which war is fought may be transformed. If this proves true, the US Army and the other services must undertake changes that will make the reforms of the 1970s, 1980s, and 1990s pale by comparison.

Strategic Context

The current revolution in military affairs emerged from a particular combination of post-Cold War strategic conditions and perceptions:

. The ongoing process of globalization and interconnectedness which increased the impact that conflict in one state or region has on others (the strategic "ripple effect"), and challenged the political utility of armed force by making war transparent to external audiences and providing nonmilitary means of pressuring warring parties.

. An overall increase in the pace of change which forced all large organizations to expand their planning horizons further into the future.

. A radical transformation of economics and business, with a stress on rapid adaptation, networked organizations, and strategic planning.

. A decision by American leaders to retain a strategy based on global leadership and engagement. The assumption is that such a role is natural and will continue for the foreseeable future.

. A perception on the part of American policymakers that public support for global engagement and leadership is fragile and thus can crumble in the face of failure or disaster.

. A willingness on the part of allies, coalition partners, and neutrals to accept American leadership and military strength.

. The lingering residue from the Cold War, specifically challenges to the American-led world order by aggressive, authoritarian states equipped with Soviet or Soviet-style military equipment.

. The perception that the world will remain a dangerous place so long as democracy and human rights are not universal. Under such conditions, those who stand pat, even if strong, will quickly weaken. American strength, in other words, is a fragile thing which must be carefully cultivated lest it wither.

. A strategic geography which demands long-range power projection.

. The proliferation of weapons of mass destruction and advanced delivery systems such as ballistic missiles.

. The availability of a wide range of new digital information technologies which give military commanders the ability to reach unprecedented levels of knowledge, speed, precision, and synchronization.

. The development of an institutional culture within the US military that stresses constant self-evaluation and improvement.

. Retention of a US military strategy based on decisive outcomes (gained quickly whenever possible) and qualitative advantage over enemies.

. The belief that qualitative advantage requires superior training, superior doctrine, and superior technology.

These strategic factors and perceptions laid the foundation for the first phase of the ongoing revolution in military affairs. But will they also characterize the security environment of the 21st century?

The movement toward a seamless global economy dependent on electronic linkages will continue and probably accelerate. Nations which resist will slide into deprivation. It is not clear at this point, though, what the transition from a world of global economies to a world economy would have on the use of economic power in security strategy. Economic interconnectedness might make economic power more effective because every state will be tied to the wider system. These ties could create vulnerabilities that could be threatened. On the other hand, the complex, networked nature of the global economy might make it more difficult to use the economic element of power against, say, a rogue state, since the greater number of connections to the world economy, the more difficult it would be to shut them down. If economic power were applied against a future rogue on one spot or in one way, it would simply shift resources and focus to another channel or linkage.

Interconnectedness also contributes to the rapid diffusion of ideas and technology. Many of the key technologies of the modern era, such as computer-assisted design and artificial intelligence, make it easier to reverse-engineer technology. In coming decades, advanced and backward states are likely to be distinguished less by the technological gap between their elites than by the extent to which technological advancements are dispersed through society. Eventually, this ability of the elites of backward countries or backward organizations to assimilate advanced technology will affect the military realm. Many militaries will become advanced in a few chosen realms by taking advantage of the global dispersion of information.

In particular, militaries that anticipate facing the United States in the future may focus on assimilating technologies that will have the greatest impact in countering the *Joint Vision 2010*/*2020* era US military. In all likelihood, these will be technologies that will fool or destroy American sensors, thus complicating target acquisition. One of the mottoes of the first phase of the RMA is, "If we can find it, we can kill it." The first "if" clause may be the most important of the two, particularly if commercially available technology to do things like camouflage targets and spoof sensors becomes available. In the old days, the perennial contest for ascendancy between the offensive and the defensive was played out in tactics and strategy. Now at least two more dimensions have been added: the struggle between those who want to defend information (through encryption and the like) and those who want to steal it; and the struggle between those who want to find physical targets and those who want to hide them.

Interconnectedness also opens the United States to infrastructure warfare. Information technology might provide a politically usable way to damage an enemy's national or commercial infrastructure badly enough to attain victory without having to first defeat fielded military forces. During World War II, the Germans and Japanese mitigated the effects of strategic bombing by dispersing their productive capacity. The only counter response of the Allies was massive, sustained bombing of every conceivable target. This was inefficient and caused extensive collateral damage (which would now be politically unacceptable). Modern economies are so tightly linked and interdependent that destroying a few key components, particularly communications and power grids, could lead to a cascading collapse of the whole system.

Today strategic information warfare remains simply a theory. The technology to wage it does not exist. Even if it did, however, strategists cannot be certain strategic information warfare would have the intended psychological effect. Would the destruction of a state's infrastructure truly cause psychological collapse? Would the failure of banking, commercial, and transportation systems crush the will of a people or steel it? After all, everyone who has attempted to use concerted strategic bombing, whether the Germans and the Allies in the World War II or the Americans in

Vietnam, underestimated the willpower of their enemies. But until infrastructure warfare is proven ineffective, states and nonstate actors which have the capacity to attempt it probably will, because it appears potentially effective and less risky than other forms of armed conflict.

Future infrastructure war could take two forms. In one version, strategic information attacks would be used to prepare for or support conventional military operations to weaken an enemy's ability to mobilize or deploy force. The second possible form would be "stand-alone" strategic information warfare. This might take the form of a sustained campaign designed for decisive victory or, more likely, as a series of raids designed to punish or coerce an enemy. Facing a future Iraq or Serbia, for instance, the United States could conceivably use strategic information attacks rather than aerial bombardment, in part because of the belief that such actions would provoke less political opposition. All of this, however, is speculation. Today the technological feasibility, psychological effect, and legal ramifications of strategic information warfare remain unclear.

Still, if cyberattacks, whether as part of strategic information warfare or as terrorism, become common, the traditional advantage large and rich states hold in armed conflict might erode. Cyberattacks require much-less-expensive equipment than traditional ones. The necessary skills can be directly extrapolated from the civilian world. One of the things that made nation-states the most effective organizations for waging industrial-age war was the expense of troops, equipment, and supplies. Conventional industrial-age war was expensive and wasteful. Only organizations that could mobilize large amounts of money, flesh, and material could succeed at it. But if it becomes possible to wage war using a handful of computers with internet connections, a vast array of organizations may choose to join the fray. Nonstate organizations could be as effective as states. Private entities might be able to match state armed forces. Private or commercial organizations might even wage information war on each other--cyber "gang wars" played out on servers and network backbones around the world rather than in ghetto alleys.

As one of the world's most "wired" nations, the United States could find strategic information warfare to be particularly problematic, forcing policymakers and military strategists to examine some of their most basic beliefs about warfighting and national security. For instance, the very existence of an infrastructure attack as well as its source could be hidden, at least for a while. An extensive series of problems and system failures induced by an infrastructure attack could occur before decisionmakers in the United States even understood that our country was under attack. It is easy to imagine how tempers would flare if some American defense official in the future had to tell the President that the United States was at war but it was impossible to identify the enemy.

Strategic information warfare would raise a plethora of ethical, political, and legal issues. If the United States was facing a high-tech insurgent, criminal, or terrorist movement, for instance, could the American military (or some other branch of government) strike at its information and financial assets even though they were spread out in computer networks in dozens of sovereign nations? Should cyberattacks be answered only in kind, or might traditional weapons be used to respond to them? And, how does the concept of collateral damage apply to cyberattacks? At an even broader level, who is responsible for the defense of a nation's information infrastructure? The government? The military? Private industry?

While substantial movement is under way on the defense of national information infrastructure, offensive information warfare is more controversial.[2] Following the 1999 air campaign against Serbia, there were reports that the United States had used offensive information warfare and thus "triggered a superweapon that catapulted the country into a military era that could forever alter the ways of war and the march of history."[3] According to this story, the US military targeted Serbia's command and control network and telephone system. Other press reports, though, suggested that whatever offensive information warfare capabilities the United States had were not used against Serbia due to ethical and practical problems.[4] Since the cascading effects of information attacks cannot be predicted or controlled given current technology, there were fears that their use would make American military commanders liable to war crimes charges. In January 2000, though, US Air Force General Richard Meyer, commander of US Space Command, announced that his organization had been given the mission of "computer attack."[5] The irony is that pressure exists to make the use of force both less lethal and more precise. At the end of the 20th century, information warfare is less lethal but also less precise than conventional force. If this changes, strategic information warfare could be catapulted to a central role in US military strategy.

Technological Breakthroughs

Today technology is an enabler of the revolution in military affairs, allowing changes that political and military leaders would like to make as they respond to political, economic, and social changes. But it can also be an independent variable, forcing uncomfortable changes and, sometimes, eroding stability and order. New technologies or new combinations of technology have the potential to alter not only tactics and operational methods, but military strategy itself.

One of the most important trends in military strategy between the 18th and 20th centuries was the broadening of its focus. In the 18th century, one needed only to destroy the enemy's field army or, in some cases, seize control of key forts or territory. With the emergence of "total war" in the 20th century, an enemy's entire society and infrastructure became the targets of military operations. Modern technology allowed war to move toward a "total" form described by Clausewitz, reaching ever greater levels of destruction. One conundrum faced by political leaders today is that there is still a need to use armed force, but interconnectedness and other factors have made it difficult to mobilize and sustain the level of passion and hate necessary for total war. Strategists thus need some way to coerce or punish an enemy elite, or at least to disrupt their plans, without the wholesale destruction of infrastructure or killing of noncombatants. This is the reason that precision is such an integral element of the current revolution in military affairs.

Soon technology may provide solutions to this strategic conundrum. After the Gulf War, American military leaders bragged that technology allowed them to not only select which building a bomb would hit, but to select which window of the building the bomb entered. Soon technology, particularly mini- or micro-robots, may allow military planners to select which individual or physical object in a building is to be destroyed. For the first time, it might be possible to target only the aggressor's leaders, leaving noncombatants untouched. Killer robots the size of a grain of sand might search for and kill the future Saddam Husseins of the world.

Like all new military technology, such fine-tuned precision will bring new risks, costs, dilemmas, and unintended side effects. Americans have long struggled with the ethics of deliberate assassination of enemy leaders. Such acts were rare even in the midst of declared war. During World War II, the only known instances were the American downing of the plane carrying Admiral Yamamoto, a British attempt to kill Erwin Rommel, and a German plot to kill Dwight Eisenhower. Today, assassination of enemy leaders outside of declared war is proscribed by presidential directive. But as the technology to target enemy elites becomes available, Americans (and any others who develop a postmodern military) may be forced to rethink the ethics of using it. Future armed conflict may no longer pit one society against another, but one leadership cadre against another.[6] While much speculation on future war focuses on the proliferation of weapons of mass destruction and the spread of terrorism and thus contends that noncombatants will be prime victims of future wars, the opposite is at least feasible. With brilliants robots, future armed conflict, like much of medieval war and 18th century European war, may be a sport for elites that leaves the mass of producers relatively untouched.

This is only the tip of the technological iceberg. Coming decades are likely to see the proliferation of robots around the world and in many walks of life. Hans Moravec, for instance, contends that mass-produced robots will appear in the next decade and slowly evolve into general-purpose machines.[7] Ray Kurzweil takes the argument even further and holds that by the end of the 21st century, human beings will no longer be the most intelligent entities on the planet.[8] However fast the evolution of robotics proceeds, it will invariably affect armed conflict. As one of the most avid customers of new technology, this will certainly affect the American military.

Initially, the prime function of military robots will be to replace humans in particularly dangerous or tedious functions. Examples of the latter might include evacuation of casualties under fire; operating in environments where nuclear, biological, or chemical weapons have been used; mine clearing; fire fighting; and reconnaissance, surveillance, and target acquisition.[9] The real breakthrough and decision point will come when robots advance to the point that they have the potential for combat use. This will take some time, particularly for land warfare which takes place in a much more challenging operating environment for autonomous systems than does air, space, or sea warfare. Robots intended for battlefield use will have to be orders of magnitude "smarter" than those used for less stressful functions such as loading and moving material.[10]

Current thinking about the technological characteristics of future military robots moves along two parallel tracks, each synthesizing robotics and other emerging technologies. The first envisions autonomous systems that employ sensors, computing, and propulsion very different from that used by people. One of the goals in this arena is miniaturization. These could be particularly valuable because they could be easily carried, yet perform a range of difficult or dangerous military missions.[11] The Pentagon already has a $35 million program under way to develop a bird-like, flapping-wing, micro-air vehicle for battlefield reconnaissance and target acquisition.[12] That is just the beginning. The true revolution could come from the maturation of microelectromechanical systems or "MEMS." This technology entails the construction of very tiny mechanical devices coupled to electrical sensors and actuators.[13] According to the Defense Advanced Research Projects Agency (DARPA), MEMS "will merge the functions of compute, communicate, and power together with sense, actuate, and control to change completely the way people and machines interact with the physical world."[14]

Eventually MEMS could open the way for an even more profound revolution in nanotechnology, which is based on "bio-mimicry" manufacturing. In the military realm, MEMS and nanotechnology could allow things like a "robotic tick" the size of a large insect, which could attach itself to an enemy system such as a tank, then gather and transmit information or perform sabotage at a designated time.[15] In a fanciful but technologically feasible description of the future battlefield, James Adams writes:

> MEMS opens a window on a new generation of technology that will literally transform the battlefield. Tomorrow's soldier will go to war with tiny aircraft in his backpack that he will be able to fly ahead of him to smell, see, and hear what lies over the hill or inside the next building. Additional intelligence will be supplied by sensors disguised as blades of grass, pockets of sand, or even clouds of dust.[16]

However radical such a notion might seem, it is, like the official vision of the future, essentially the use of new technology in old ways. By contrast, futurists like Martin Libicki of the RAND Corporation have speculated on modes of warfare to make maximum use of MEMS-based technology. In fact, Libicki's alternative vision of future war is one of the most profound and creative seen to date. Its essence is that information technology, among other things, is shifting the advantage in warfare to "the small and the many" over "the large, the complex, and the few." This is in stark contrast to orthodox American strategic thinking that seeks ever more capable systems that are, by definition, more expensive, and thus acquired in smaller numbers, but it is a logical development of the concept of distributed robotics under exploration by DARPA.

Based on the superiority of "the small and the many," Libicki describes three stages. He calls the first "popup warfare." This is based on extant technology in a security environment characterized by the proliferation of precision guided munitions (PGMs). While *Joint Vision 2010* and other official documents expect many states to have precision guided munitions, they assume that the American military can overcome enemy PGMs by stealth, operational dispersion, and speed. Libicki is more skeptical. "The contest between stealth and anti-stealth will be long and drawn-out," he writes, "but . . . the betting has to be against stealth for any platform large enough to encompass a human . . . [and] even with stealth, everything ultimately can be found."[17] The result will be "popup warfare" where both sides stay hidden most of the time, pop up just briefly to move or shoot, and then "scurry into the background."[18]

Libicki's second stage of future warfare, which he calls "the mesh," uses technologies available over the next 20 years against an enemy with developed industry but underdeveloped informational capabilities. To a large extent, this is coterminous with the official vision that calls for an interlinked mesh of sensors and information technology to give American commanders a clear and perfect view of the battlefield while their opponents remain in the dark. Reinforcing the assumptions found in *Joint Vision 2010, Joint Vision 2020*, and other official documents, Libicki writes, "Tomorrow's meshes will allow their possessor to find anything worth hitting."[19]

Libicki's third stage represents the ultimate ascendance of "the small and the many." He contends that eventually enemies will develop their capabilities to the point that the platforms composing the American military's "mesh" will be vulnerable to attack. The solution is to weave a mesh composed of small, moderately priced objects rather than a handful of very large and very expensive ones. "Battlefield meshes, as such, can be built from millions of sensors, emitters, and sub-nodes dedicated to the task of collecting every interesting signature and assessing its value and location for targeting purposes."[20] This is where MEMS-based robotics becomes significant. Libicki speculates on

the value of ant-like robots with each one having a fairly limited capability, but which can be woven together to collectively generate extensive capabilities. The inherent redundancy of the mesh in what Libicki calls "fire ant warfare," in which small, relatively simple weapons and sensors swarm onto a large complex one as a means of attack, would make it much more robust than the one envisioned in official documents.

While initial thinking about robotics concentrates on miniaturization and the integration of networks of small robots with relatively limited functions, partially organic robots may prove nearly as useful. According to a recent report from the US Commission on National Security/21st Century: "Notions of `androids,' `cyborgs,' and `bionic' men and women have dwelled exclusively in the realm of science fiction. But at least the beginnings of such capabilities could literally exist within the lifetime of today's elementary school children."[21] Soon it might be possible to mount cameras or other sensors on dogs, rats, insects, or birds and to steer them using some sort of implant. Research scientists are already experimenting with placing very small mechanical components into cockroaches, thus proving the viability of the idea.[22]

Simple cyborgs like this may be only the beginning of an even more fundamental revolution or, more precisely, the marriage of several ongoing technological revolutions. Lonnie D. Henley, for instance, argues that a melding of developments in molecular biology, nanotechnology, and information technology will stoke a second-generation revolution in military affairs.[23] Nanotechnology is a manufacturing process that builds at the atomic level.[24] It is in very early stages, but holds the real possibility of machines that are extremely small, perhaps even microscopic. Eric Drexler, the most fervent advocate of nanotechnology, predicts that it will unleash a transformation of society as self-replicating nanorobots manufacture any materials permitted by the laws of nature and thus help cure illness, eliminate poverty, and end pollution.[25] As Henley points out, combining nanotechnology with molecular biology and advances in information technology could, conceivably, lead to things like biological warfare weapons that are selective in targets and are triggered only by specific signals or circumstances. It could also lead to radically decentralized sensor nets, perhaps composed of millions of microscopic airborne sensors or, at least, a mesh of very small robots as envisioned by Libicki. And, Henley contends, it might eventually be possible to incorporate living neuron networks into silicone-based computers, thus greatly augmenting their "intelligence." In such a world, the *Joint Vision 2010* future, or even that of advanced programs like the Army After Next project, will fade into obsolescence.

Beyond technological obstacles, the potential for effective battlefield robots raises a whole series of strategic, operational, and ethical issues, particularly when or if robots change from being lifters to killers. The idea of a killing system without direct human control is frightening. Because of this, developing the "rules of engagement" for robotic warfare is likely to be extraordinarily contentious. How much autonomy should robots have to engage targets? As a robot discovers a target and makes the "decision" to engage it, what should the role of humans be? Would prior programming be adequate, or would a human have to give the killer robot final approval to shoot? How would the deployment of battlefield robots affect the ability of the US military to operate in coalitions with allies who do not have them (given that a roboticized force is likely to take much lower casualties than a non-roboticized one)? Should the United States attempt to control the proliferation of military robotic technology? Is that even feasible since most of the evolution of robotic technology, like information technology in general, will take place in the private sector? Should a fully roboticized force be the ultimate objective?

Other emerging technologies could prove equally revolutionary. One example is what can be called "psychotechnology." Future military commanders might have the technology to alter the beliefs, perceptions, and feelings of enemies. This could range from things like "morphing" an enemy leader and creating a television broadcast in which he surrenders, to much more frightening ideas like perception-altering implants, chemicals, or beams of some sort. Such technologies would be particularly ominous from an ethical perspective. Today, effective and controllable "psychotechnology" is science fiction, but so too was space flight not so long ago. Any developments in this realm warrant very close scrutiny. Barring some sort of truly fundamental change in the global security environment, they should be eschewed.

The Twisting RMA

Since the second phase of the current revolution in military affairs is, at best, only beginning, we have but hints of what it might mean for the United States and the US Army. At the operational level, the essence of the first phase of

the RMA has been the quest for speed and knowledge through application of digital information technology--an essentially conservative process in the spirit of Guderian and Patton. The next phase may bring more radical change to the operational art. For the US Army, rediscovery of the operational art was an important part of the "pre-revolutionary" period of the 1970s and 1980s. The operational level of war was that which linked tactics and strategy. Primarily the responsibility of the commanders of unified commands, it translated political objectives into military ones, and organized military operations into phased campaigns. The next phase of the revolution in military affairs, however, may make the operational level of warfighting, at least in its old manifestation, irrelevant. Any future armed conflict is likely to be a "world war" in that it will be played out, both militarily and politically, across the globe. Eventually, the idea of regional commanders with prime responsibility for a war will give way to some sort of "CINC World." Digital communications and the emergence of virtual staffs will allow "CINC World" to understand regional conditions and effectively control local military activities without powerful intermediary commanders such as the current regional CINCs. Since prime responsibility for the operational level of war resides with the regional CINCs, the operational level itself may be an anachronism when their function is downgraded or removed altogether.

In addition, the rapid tempo of future wars may also erode the importance of the operational level of warfighting as currently defined. While it may take an extended period of time to bring 21st-century wars to ultimate closure, they are likely to be decided in days, hours, or even minutes. Under such conditions, the idea of phased campaigns may have little meaning. At a minimum, the concept of the operational level of warfighting will give way to "national security operations" which will entail the full integration of the military, political, economic, and, perhaps most important, psychological elements of national power even at the sub-strategic level.

In fact, fundamental alterations in the nature of the operational art may occur even more rapidly than expected. History suggests that technology may not provide the Army the degree of operational freedom necessary to fulfill its vision of rapid maneuver and decisive victory. At various times in the history of warfare, technology and tactics have made the defense ascendant over the offense. In World War I, operational maneuver was paralyzed both by technology--especially the heavy machine gun, barbed wire, and accurate heavy artillery--and by the ability of European states to mobilize, train, and equip armies that they could not supply in rapid campaigns over long distances. The idea of rapid operational movement was there. In many ways, blitzkrieg was not fundamentally different from the operational concepts that European generals began the war with, which called for punching a hole in enemy lines and unleashing cavalry to exploit the opening and to sever communications between the enemy's front and rear. But it eventually took motorization, wireless radios, and effective close air support to turn these ideas into reality.

If large-scale state-on-state war occurs in the first decade or so of the 21st century, there may be an operational paralysis similar to that of 1915 to 1918 as the defensive again takes ascendance over the offensive. The main cause may be the proliferation of weapons of mass destruction and the means to deliver them. This would both prevent the concentration of forces in decisive numbers and make it difficult to sustain them in a rapid, far-reaching offensive. Eventually, technology may again provide a breakout from operational paralysis. A combination of technologies could allow widely dispersed forces to briefly swarm on an objective and then re-disperse, thus minimizing the effectiveness of weapons of mass destruction. And the invention of new fuels, new materials, and innovations such as directed energy weapons might allow military forces to reduce the importance of or even cut the umbilical cord that links them to vulnerable fixed supply bases. Until then, the first battles of the next major war may look more like the Somme or Verdun than the great encircling sweeps that the world witnessed in the summer of 1941 or the winter of 1991. The generals of 2020 may be like those of 1915 who truly understood the essence of rapid maneuver warfare, but who did not have the technology or doctrine to bring it to fruition.

The potential effects of emerging technology are even greater. War has always been integrally psychological. It is a contest of wills, with antagonists struggling to dominate each other. But industrial-age warfare has been one of a psychological hammer. Decisive results usually came through the pummeling of an opponent, often through the destruction of productive capacity and attrition of human resources. Technology may allow future war to be one of psychological scalpels, with fine-tuned mental effects. It may no longer be necessary to grind down an enemy's infrastructure, productive capacity, and human resources, but instead to target key elites and decisionmakers directly. Under such conditions, the mass armed forces of the 20th and early 21st centuries may become anachronisms.

The heart of military success has always been the skill of soldiers or sailors, the talent of their leaders, and the

relationship between the two. For the mid-term, this will continue to hold. But the glimmerings of a *true* revolution can been seen in the midst of the current evolutionary change. Soon emerging technology will allow those who master it to radically alter the nature of armed conflict. No people are better at mastering technology than Americans. Hopefully this talent will allow us to follow the next twist of the RMA rather than being left behind by it.

NOTES

1. See Paul H. Herbert, *Deciding What Has to Be Done: General William E. DePuy and the 1976 Edition of FM 100-5, Operations*, Leavenworth Papers Number 16 (Ft. Leavenworth, Kans.: US Army Command and General Staff College, Combat Studies Institute, 1988).

2. See Winn Schwartau, "Ethical Conundra of Information Warfare," in *Cyberwar: Security, Strategy, and Conflict in the Information Age*, ed. Alan D. Campen, Douglas H. Dearth, and R. Thomas Goodden (Fairfax, Va.: AFCEA International Press, 1996). On the legal arguments surrounding information warfare, see Walter Gary Sharp, Sr., *Cyberspace and the Use of Force* (Falls Church, Va.: Aegis Research Corporation, 1999).

3. Lisa Hoffman, "U.S. Opened Cyber-War During Kosovo Fight," *Washington Times*, 24 October 1999, p. C1.

4. Bradley Graham, "Military Grappling With Guidelines for Cyber Warfare," *The Washington Post*, 8 November 1999, p. A1.

5. Bill Gertz, "U.S. Set to Take Warfare On-Line," *Washington Times*, 6 January 2000, p. 3.

6. Although thinking in terms of low-intensity conflict rather than high technology, Martin van Creveld made this same argument in *The Transformation of War* (New York: Free Press, 1991), pp. 198-201.

7. Hans Moravec, *Robot: Mere Machine to Transcendent Mind* (New York: Oxford Univ. Press, 1999), p. 25.

8. Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (New York: Viking, 1999).

9. Report from the Robotics Workshop 2020, sponsored by the US Army Research Laboratory, 25-27 February 1997, Jet Propulsion Laboratory, Pasadena, Calif. Workshop report developed by the Strategic Assessment Center of Science Applications International Corporation, McLean, Va., pp. B-2 to B-3.

10. Technology Forecast Assessments, *STAR 21: Strategic Technologies for the Army of the Twenty-First Century* (Washington: National Academy Press, 1993), p. 148.

11. Defense Advanced Research Projects Agency (DARPA) Distributed Robotics Program, overview on the Internet at http://www.darpa.mil/MTO/DRobotics/index.html, accessed 23 May 2000.

12. Lee Gomes, "It's a Bird! It's a Spy Plane!--Pentagon Funds Research into Robin-Sized Robots," *The Wall Street Journal*, 6 April 1999, p. B1.

13. H. Lee Buchanan, Deputy Director, Defense Advanced Research Projects Agency, testimony before the Subcommittee on Military Research and Development, Committee on National Security, US House of Representatives, 27 February 1997.

14. Defense Advanced Research Projects Agency, "MEMS Project Vision Statement," Internet, http://www.darpa.mil/MTO/MEMS/frameset.html?Overview.html. See also Albert P. Pisano, "MEMS 2003 and Beyond A DARPA Vision of the Future of MEMS," Internet, http://www.darpa.mil/MTO/MEMS/2003/index.html. Both accessed 23 May 2000.

15. Report from Robotics Workshop 2020, p. B-26.

16. James Adams, *The Next World War: Computers Are the Weapons and the Front Line Is Everywhere* (New York: Simon and Schuster, 1998), p. 125.

17. Martin C. Libicki, *The Mesh and the Net: Speculations on Armed Conflict in a Time of Free Silicon* (Washington: National Defense University, Institute for National Strategic Studies, 1994), p. 23.

18. Ibid., p. 21.

19. Ibid., p. 24.

20. Ibid., p. 29.

21. The United States Commission on National Security/21st Century, *New World Coming: American Security in the 21st Century, Major Themes and Implications* (Washington: The Commission, 15 September 1999), p. 20.

22. Report from Robotics Workshop 2020, p. A-8.

23. Lonnie D. Henley, "The RMA After Next," *Parameters*, 29 (Winter 1999-2000), 46-57.

24. See Eric Drexler and Chris Peterson, *Unbounding the Future: The Nanotechnology Revolution* (New York: William Morrow, 1991), Internet, http://www.foresight.org/UTF/Unbound_LBW/index.html. See also the nanotechnology web page of the Foresight Institute at http://www.foresight.org/NanoRev/index.html. Both accessed 23 May 2000.

25. David Voss, "Moses of the Nanoworld," *Technology Review*, March-April 1999, pp. 60-62.

Dr. Steven Metz is a research professor of national security at the US Army War College and an analyst at the Strategic Studies Institute. He has also served on the faculty of the Air War College, the US Army Command and General Staff College, and several universities. He is a graduate of the University of South Carolina and holds a Ph.D. in political science from Johns Hopkins University. Dr. Metz is the author of more than 70 articles and monographs on world politics and national security affairs.

Reviewed 15 August 2000. Please send comments or corrections to carl_Parameters@conus.army.mil