The US Army War College Quarterly: Parameters

Volume 28
Number 3 *Parameters Autumn 1998*

Article 1

8-13-1998

Radical Destabilizing Effects of New Technologies

Thomas K. Adams

Radical Destabilizing Effects of New Technologies

THOMAS K. ADAMS

From *Parameters*, Autumn 1998, pp. 99-111.

There is a tendency among strategic thinkers, especially in the military, to ignore or discount the potential effects of technology beyond its short-term applicability to military systems. This tendency complements a pervasive lack of interest within the services regarding the state of the defense technology and industrial base and the possible military consequences of any significant change in that industrial base.[1] The current information revolution is a case in point. The Army's Force XXI experiments and the Marine Corps' Hunter Warrior Exercise have taken great pains to upgrade the conventional industrial-age war machinery left over from the Cold War through application of automated information systems.[2]

But there is little apparent interest in the wider effects of these developments and their implications for national security. In fact, attempts to foresee even the near-term future are remarkable for their conservative approach and the general belief that the future will be very much like today with a few advances in technology. Not surprisingly, there have been even fewer attempts to anticipate basic change caused by technologies whose practical applications are only now being discussed by specialists.

This is a serious shortcoming because major changes in human affairs often have serious unexpected consequences. In the 18th and 19th centuries, the industrializing countries gained enduring advantages over non-industrial peoples. But urbanization, the demise of the extended family, and displacement of ruling elites (whose power depended chiefly on ownership of land) were among the casualties of industrialization. The industrial revolution also promoted democratic institutions by giving rise to a powerful middle class. It has taken hundreds of years to adapt to those changes, as spotty and uneven as that adaptation has been.

Even this painful process, however, has done little to prepare us for the rapid changes now under way. The examples described in this article suggest that new technology is evolving much more rapidly than anything in our collective experience or imagination. More important, they suggest that some of the results will be economic; traditional relationships between capital and labor will change profoundly. Social effects will follow quickly as modifications in agriculture, trade, and manufacturing lead to population shifts and new migration patterns. The technologies described here can create a climate of such uncertainty that individuals and states unable or unwilling to adapt may seek outlets for their rage and frustration in violence. The same outcome may be the only recourse to those in developed nations. Change this profound would surely create serious transnational tensions.

This article suggests that what we know as the information revolution is no more than the first stirring wavelet that precedes a tsunami. It further suggests that the most profound effects will stem from three of the many new technologies now being developed. They will profoundly alter our thinking about economics, manufacturing, social issues, and national security in ways we can as yet barely describe. The three fields discussed here are information systems, biotechnology (including genetic engineering), and nanotechnology. Known and potential advances in these fields can have radically destabilizing consequences in all walks of life. The opportunities and the dangers of rapid change will remain in equilibrium only if there is an unprecedented degree of economic, social, diplomatic, and military cooperation as we explore the limits of change.

Key Emerging Technologies

A number of emerging technologies are potentially destabilizing, but three are obvious, important, and already in progress: information systems, biotechnology, and nanotechnology. Furthermore, progress in these areas is accelerating rapidly. Because these three developments are mutually reinforcing, advances in any one of the three lend impetus to the others.

The most familiar area, information technology (infotech), includes the entire realm of automated information handling technology from computer programming to ancillary facilities such as the networks that connect the various nodes. The heart of infotech, however, is the microchip-based ability to process vast amounts of data with extraordinary speed and accuracy. Improvements in this basic capability drive development throughout the field.

The field of biological technology (biotech) is less familiar but is assuming great importance. Like infotech, the field includes a variety of applications ranging from traditional breeding of plants and animals to medical research. As with information technology, there is a central, driving development: new understanding of genetics and the ability to manipulate the genetic codes of plants and animals to produce wholly new results.

The third area, nanotechnology (nanotech), is even less familiar but holds almost boundless potential. The term is often misapplied to micro-machines; what it really means is the development of devices (including computers) orders of magnitude smaller than the human cell. Possible consequences of these developments, from medical applications to manufacturing, are staggering.

Acceleration in information technology is obvious; technology improvements render systems "old" after one year and obsolete after two. Each level of improvement becomes the foundation for the next round of releases. Meanwhile the increasing utility of the systems creates a demand that fuels still more research and improvement as producers seek a competitive advantage, however fleeting they know it will be. This same dynamic seems to be emerging in genetic research. Nanotechnology, however, is still a theoretical field, but one with almost incalculable potential. While the effects of these trends are impossible to predict, it is worthwhile to consider potential shorter-term consequences for security issues and military organizations.

Information Systems

Infotech development has been the subject of considerable speculation. Military vision statements, including the JCS's current *Joint Vision 2010* and the accompanying Army product, *Army Vision 2010*, attempt to predict how these systems will affect warfighting.[3] Some of the immediate effects are already evident, and efforts are under way to incorporate this technology in military operations.

The straightforward, expected application of these technologies is "information dominance" of the battlefield. This means coupling them with reconnaissance and surveillance systems to provide decisionmakers with a near-real-time view of the battlespace and to link them with response systems, which are usually weapons. Early military applications of these technologies are in use, and a prototype of a combat information system was tested at the National Training Center in early 1997.[4] Meanwhile the Navy and Marine Corps are testing their own, very similar, versions.[5] Nor is the United States alone in this effort. According to the Defense Intelligence Agency, "Foreign states are increasingly cognizant of the link between automation and warfighting effectiveness and . . . information warfare" and are developing capabilities to wage it.[6]

A draft version of FM 100-5, *Operations*, the Army¢ s capstone warfighting manual, devotes 11 pages to information warfare, which it describes as a combination of "jamming, signal acquisition, PSYOPS, imitation and C2 [command and control] attack."[7] This description is certainly a credible one based on current developments. But the problem with this kind of straightforward extrapolation is that it is almost always wrong. The information revolution has already provided some unexpected developments, the most spectacular of which was probably the 1987 stock market crash created by computer-driven trading. In another instance, a group of fairly junior American military intelligence personnel, frustrated by an official system they consider sluggish and antiquated, have organized their own open-source information system called "G-2I" using the e-mail capabilities of the Internet.[8] When terrorists seized the Japanese embassy in Lima, Peru, the G-2I system was able to produce sketches and photos of the embassy from open sources within a matter of hours.

A darker side of information systems has also emerged. While the 1987 market crash was an inadvertent product of information processing, we now have threats from "computer hackers and crackers" who deliberately attack information systems as a hobby. Malicious computer viruses were unheard-of ten years ago; now they plague all manner of systems. During the Gulf War a Dutch hacker managed to pull a great deal of critical information on US forces, strengths, and dispositions from unclassified DOD computer systems. He offered to sell all this to the Iraqis, who fortunately didn¢ t believe him or trust his information. Police report a number of instances of innovative bomb-building by high school youngsters who learned how from Internet sites. Meanwhile, two private experts on nuclear weapons are publishing a guide to more than 500 nuclear-related websites called "The Internet and the Bomb."

These phenomena are interesting for several reasons. First, they were wholly unexpected; second, they are related less to the technology of the web and the Internet than to the uses people make of them. They are also interesting because none of these cases involved cutting-edge developments or even especially sophisticated users, which points to another and perhaps most important issue: all of these are examples of the diffusion of power brought about by the new information systems.

Biotechnology

The biotechnology revolution is already enhancing human health and nutrition well beyond earlier expectations. The field had been evolving quietly until the revelation of a cloned adult sheep named "Dolly" generated popular interest. The US government-funded "Human Genome" project to map human genetic structure is proceeding much faster than expected, due largely to new applications of information technology.[9] Serious money is being spent on projects, however seemingly fantastic, that appear feasible. Affymetrix Corporation, a leader in gene analysis, was able to raise $50 million in private capital in 1993. *Fortune* magazine and *Business Week*, two notably sober publications, each devoted multiple articles to biotech in their March 1997 issues, advising readers on which biotech stocks they should buy. According to Steven Fodor, research scientist and president of Affymetrix, "Ninety-nine percent [of the general population] have no idea how fast this revolution is coming."[10] Because the field of biotechnology is less well developed and generally less well publicized than information technology, the path and probable consequences of the biotech revolution are harder to discern. However, it has the potential to create greater social upheaval than the information revolution.

Much of the recent attention has been directed at cloning and the ability to alter plants and animals to produce products useful to humans. Cows have been engineered that create insulin and other drugs as a byproduct of milk production.[11] Hemoglobin, a key ingredient in human blood, has been produced from genetically engineered tobacco plants. Plants that produce plastic have already been developed at the Carnegie Institute. Commercial development of these plants to produce enough plastic to reduce dependence on oil is also under way.[12] Other far-reaching projects are currently in research, and private corporations feel certain enough of success to invest heavily in them. Examples include:

- *Food*. Genetic engineering of plants to increase yields is an old story. New developments are enabling food plants to survive with less water and to resist threats such as insects, disease, and even fire. In principle there is no reason why inedible plants that are easy to grow cannot be made nutritious. Likewise, faster-growing forage will reduce pressure on grain supplies, while hardier grazing animals will make animal husbandry more efficient and perhaps practical in areas where it is not now profitable or even feasible. All of this will significantly affect farming patterns, especially in food exporting nations such as the United States. Some of the most destabilizing initial consequences may be felt by those nations that derive much of their national income from food exports.

- *Energy*. Work is in progress to develop microorganisms that can withstand high amounts of radiation and be used to clean up highly radioactive wastes. Similar organisms can be engineered to clean up other forms of waste and even make methane--natural gas--from inorganic material.[13] In the mid-1970s a world oil squeeze prompted attempts to use traditional plant-breeding methods to enhance so-called "energy crops." Slow progress and the return of cheap oil ended the attempts. Now, however, gene-tailored plants may produce cheap, locally available ethanol, methanol, and methane as supplements to and replacements for coal and oil as energy sources.[14] The potential effects of these developments on energy production are readily imaginable.

. *Materials Production*. In addition to the plastics mentioned above and new, more durable forms of wood, it now appears that certain strains of bacteria can be used to separate useful ores and other materials from deposits that are not currently exploitable. Not only is this potentially less expensive than current methods, but many developing countries depend on extractive industries and export of these materials for much of their income. Assuming that ores presently considered not economically practical as sources of raw materials would now become attractive, income for some of those countries could be seriously reduced. Such an outcome has consequences for trade and shipping as well as for employment patterns; mining and ore processing are still labor-intensive businesses.

The mutually reinforcing nature of these technologies is illustrated by genetic studies whose purpose is to learn the information-storing secrets of DNA, which compresses enormous amounts of data into microscopic spaces. Techniques from DNA studies are already being applied to computer microchips to create information systems much smaller, faster, and more capable than existing ones.

Other relatively short-term developments from biotech will certainly include "predictive medicine," some forms of which are already in use through genetic screening.[15] The ability to identify and treat potential problems before they occur holds out the prospect of even longer and healthier lives for individuals who can afford such treatment. A more immediate consequence is fear that discovery of "bad" genes will make the carriers uninsurable, subject them to penalizing premiums for health and life insurance, or even affect their employability. Of course, within every country there are those more fortunate than others, so the new genetics raises the possibility of serious social schisms within nations. During the Black Death of the 14th century, the plague took rich and poor, royalty and commoner alike. Consider the consequences if the rich and powerful sectors of society had the means to immunize themselves while the masses of ordinary people around them were dying.

This can also contribute to greater differences between the advanced countries and the developing world. Development has been uneven, as the "green revolution" of the 1960s has demonstrated. Although aggregate world food production has continued to rise faster than population since 1967, this has done little to eliminate chronic malnutrition and occasional famine in Africa and South Asia.[16]

Unfortunately, this technology may offer as many, if not more, opportunities for abuse than have emerged from the information revolution. With a complete catalog of the human genome it should be possible to create chemical and biological weapons that will target only specific genotypes. This would make it possible to kill or incapacitate persons with specific characteristics in a given area without affecting other persons. Even combinations of physical characteristics could be targeted, such as all left-handed redheads.

Nanotechnology

Dr. Ralph Merkel, a researcher in the field, states: "Nanotechnology should let us economically build a broad range of complex molecular machines (including, not incidentally, molecular computers). It will let us build fleets of computer-controlled molecular tools much smaller than a human cell."[17] Just as information science helped in genotechnology, biotech and infotech come together to assist the development of nanotechnology. Computer modeling makes much of this research possible, while analogies from DNA formation become the basis for building nano-devices.

"Nano" means one billionth; it suggests the size of nano devices when compared to current machinery. Nanotech is the business of creating ("building" is the wrong word for this process) very small machines, not just micro machines, but devices smaller than bacteria. To give an idea of the size of these machines, a volume only slightly larger than 0.001 cubic microns could hold a small computer (a typical cell is thousands of times larger).[18] The first commercial nanomachine, a biosensor with components measured in billionths of a meter, was announced in June 1997.[19] Because such devices operate on the molecular level and may be self-replicating, they could replace some or all of current manufacturing, not with various kinds of new factories but with a sort of general purpose facility that could make almost anything. Since these devices can be programmed, and because they operate at the level of individual molecules, a single facility could simply be given the basic materials and instructed how to make anything from ashtrays to auto parts.

The mutually reinforcing nature of these developments is again illustrated by the fact that bacteriological processing of ores and other materials could do away with the need to import many of the materials for these facilities. Even if such nanofacilities turn out to be very expensive, in some instances they would still be cheap compared to the cost of developing and sustaining a traditional industrial base. At this point in its evolution, nanotech seems to offer the prospect of something close to independence from the need for conventional manufacturing. It also could mean truly massive displacement of all those skills used in manufacturing, from tool and die making to industrial management.

Once more, this is not science fiction. The principles of molecular nanotechnology were first demonstrated in 1990 when industry researchers at IBM were able to arrange 35 individual xenon atoms to spell out "IBM."[20] In 1991, the Japanese government reportedly began budgeting an annual $185 million for nanotech research.[21] Since that time three-dimensional structures have been experimentally produced from DNA,[22] and researchers have demonstrated the engineering of branched, non-biological protein with enzymatic activity,[23] a basic methodology for nano devices. Computer software to aid in the development of molecular nanotechnology is also being produced with computer-aided design and modeling software.

If the trends associated with nanotech do no more than live up to their initial promise, the changes in the worldwide manufacturing base would be dramatic and likely irreversible. Sophisticated manufacturing would consist entirely of advanced programming and the transport of raw materials. Even the distribution of finished products could be substantially reduced since, in principle, any nanofacility could produce any product. It would not be long before weapons of all kinds could be manufactured, not from purpose-built factories as they are now, but from any nanofacility anywhere in the world. And nanofacilities would become so common that it would be much more difficult, perhaps impossible, to prevent weapons proliferation. Weapon-producing processes derived from nanotechnologies could certainly become a major part of worldwide illegal trafficking.

Beyond the Blue Event Horizon

"Event horizon" is a term borrowed from astrophysics and refers to the area around a singularity or "black hole." The important feature of this phenomenon is that it marks the point at which nothing can escape from the singularity, not even information. It is impossible to know what is on the other side of such an event horizon.

We are rapidly approaching an event horizon in human development, a point at which the mutually reinforcing trends described here will combine to produce an aggregate result so different from what we now know that it is impossible to guess what it will be. Some short-term consequences, however, can be predicted with a degree of confidence.

The foremost consequence--the bottom line--will be a tremendous diffusion of power. The examples above illustrate the likelihood of a greater diffusion of power both within and among societies, the consequences of which could be to make the world a more dangerous place. Although the radical diffusion of power in the form of infotech, biotech, and nanotech will certainly have unanticipated consequences, some can be foreseen. Despite the claims of some commentators, the nation-state will probably remain the dominant form of large-scale social organization--at least in the short run. Nation-states are still the locus of power and legitimacy. Furthermore, the nation remains the center of loyalty for most persons. No one is likely to fight and die for Chrysler or Mitsubushi or even the International Union of Machinists and Sheet Metal Fabricators.

Nevertheless, there is a wide variety of violence-prone groups that could take advantage of power diffusion and, in so doing, disrupt nations at all levels of development. A list suggested by Steven Metz includes organized crime, private armies, urban gangs, insurgents, regional separatists, conspiracy theory terrorists, radical cults, neo-Luddites, and violent environmentalists.[24] To this list, one might add anti-government militias and the "hobbyists" who disrupt information systems as a form of recreation.

Some territorial-based entities (states and sub-states) may become economically more independent while others will become less so. The combination of increased power through technology and greater economic independence will likely make it both attractive and feasible for various sub-regions and even cities to break way from larger states. A city like Vancouver, for example, will be in a much better position to go it alone than a country like Somalia. It can be argued that a material-producing province like British Colombia will need metropolitan Vancouver more than Vancouver needs British Colombia--or Canada, for that matter. Comparable conditions could apply to Seattle and the state of Washington, to Los Angeles or San Francisco and the state of California. As smaller political entities acquire power from the new technologies, they will increase their ability to advance an agenda that may have little in common with either rural regions or urban centers in their states. And as they become capable of prospering on their own, some of them will want independence, while others will want a greater share of political power. One outcome of such a trend could be much smaller nation-states but more of them.

The breakup of the USSR, aided and abetted by the new information technologies, may be an early model of this process. China likewise is a composite state, made up of parts such as Tibet and the western provinces that have historically been independent. They would like to be independent again, especially if the means could be found to support that desire. Other areas such as the advanced economic zone between Shanghai and Hong Kong might choose to alter their relationship with the remainder of China. City-states, now mere oddities existing under the wing of nation-states, could become successful, independent structures for the first time since the 17th century. An increase in the number of states will also increase the number of probable friction points, resulting in a net increase in conflict, with violence a likely outcome in some instances.

The developments described above are inherently destabilizing to the current political and social order; one likely consequence would be a great deal of competition and a number of failed states, old and new. Migration pressures in the form of illegal aliens will certainly increase as workers are displaced and the economic differences between political entities, whether traditional states or new city-states, become even more marked. Some forms of nontraditional military missions, especially those that fall under the broad heading of stability and support operations, will be increasingly common as the international community (including the United States) tries to stabilize conditions within and among both new and existing parastates.

These prospects suggest that there could be many new opportunities for nontraditional military operations in many parts of the world, including within the United States itself. It has become common to predict that the next 20 years will see an increase in such activities, especially in failed states. Less frequently noted, however, is the likelihood that the expected diffusion of power will make these missions increasingly dangerous. If the expected dissolution of the composite states and others turns ugly, there may also be requirements for forceful intervention in the form of peace enforcement or large-scale rescues. Unfortunately these tasks could emerge while the ability to resist such interventions is also on the rise.

The Military Future

It would be wonderful if new developments in technology promised only peace and plenty, but no one should count on it. Some disputes are intractable, and organized, targeted violence will still be seen by some as a legitimate way to achieve political and economic ends. Conventional war probably will remain a very powerful instrument. Even the most advanced countries may initially find themselves vulnerable to old-fashioned brute force.

Some of the military consequences of the information revolution are becoming evident. One may be a structural change, leading to "two-tier" militaries in developed countries. Current attempts to apply new information systems to existing military formations are proving to be far more expensive than their advocates admitted or even understood. Military information systems for combat may be efficient and effective, but they also tend to be expensive and difficult to use and maintain. It is hard to believe that average recruits with a high-school education will be able to learn to use these systems as easily as they can learn to fire a rifle or machine gun.[25] Video games don¢ t teach the players anything about system maintenance. These qualifying circumstances make it unlikely that entire armies will be so equipped. Instead we may soon witness the creation of an upper tier, consisting of a small number of technically advanced military units, while the bulk of the armed forces remains more-or-less conventional, industrial-age formations. Although militaries will remain committed to their conventional weapons for at least a few more decades, the proliferation of targeting information and "smart weapons" suggests a brief future for large warfighting machinery such as tanks, airplanes, and warships.

This trend can be expected to accelerate as threats based on information warfare and genetic engineering methods become feasible. *Jane¢ s Defense Weekly* commented in 1997, "It is possible to produce new organisms, exploit variations on organisms, or induce organisms to respond in new ways, such as producing synthetic bioregulators or chemical toxins."[26] Some insects, ants for example, might be programmed to attack specific types of economic targets such as communications facilities. A conventional armed force will not be very useful against threats that, for most purposes, are not even military in the usual sense. In order to protect themselves, states and other entities will need very sophisticated security forces, not necessarily armies as we understand the term. These security forces may be composed chiefly of technical specialists, educated at the graduate-school level and paid professional-level wages. They will carry out what we consider today to be preemptive functions and capability-against-capability missions rather than reactive missions using force-against-force methods. Much of what they do would not be considered war by current definitions.[27] Conventional forces, especially of the advanced states, will be the residual elements of the industrial-age force structures of the late 20th and early 21st centuries. At the same time, the size of advanced military establishments may shrink significantly. Reduction in size would be accompanied by less capacity to perform large-scale or manpower-intensive missions, such as humanitarian assistance, at exactly the time that such operations may be most in demand.[28]

Even this residual conventional capacity may erode. As advanced countries move into new information- and genetics-based economies, it is reasonable to expect that much basic heavy industry such as steel, shipbuilding, and chemical production will be almost entirely relocated to the developing nations of the so-called "second and third worlds" such as Argentina, Brazil, Hungary, or Pakistan. Even a cursory reading of the daily newspapers shows that some of this is already happening. This is not to argue that America will lose its production capacity; rather, it will be devoted increasingly to processes and products fundamentally different from our 19th- and 20th-century experiences. It may no longer be "industrial" in the usual sense of smokestacks and factories. Should a trend of this sort occur, it could mean that advanced nations like the United States might lose the heavy industrial base needed to mobilize and sustain forces to fight large-scale conventional wars.

Violence will not disappear in this version of our brave new world; it is too useful for that to happen. Instead, the conventional component of warfare may be conducted by relatively small, highly trained organizations like the US Army's "Delta Force." Operations appropriate for these groups would include precision missions designed to conduct surveillance, destroy critical nodes, recover vital equipment, or rescue personnel. Other elements of the special operations community, especially psychological operations units, may also find their future roles different from their past ones. And changes of this sort may be so expensive that the size of such military establishments could be severely constrained.

While it might seem that covert operations would play an important role in future conflict, that may not be true. One of the effects of the information revolution is the loss of privacy, an early example of which is the capability to trace individuals through their various commercial transactions. Right now, anyone who uses a credit or cash card for purchases at a scanner-equipped store is identifying himself and his personal preferences right down to hard or soft bristles on his toothbrush.[29] Increasing use of electronic media, such as computer banking, will only increase the "resolution" of such systems. Genetic identification may make it possible to further trace or track individuals with considerable precision.

Given the progress in micro-miniature systems and information processing, it may soon be possible to monitor virtually all electronic transmissions, from radio and e-mail to cellular telephones. The only thing presently lacking is the information processing capability to usefully collect and analyze the resulting oceans of data. Very quickly the same progress could make it possible to conduct full-time, remote surveillance of any area, large or small. Sub-miniature video "cameras on a chip" for such systems are cheap and available right now.[30] Later, thousands of tiny, inexpensive nanotech imaging devices monitored by automated systems would make it possible and feasible to monitor the entire public area of a city or, given the motivation and the capital, an entire country. Although such systems will be created as crime prevention measures, they will also have the effect of stripping the concealment and anonymity of covert operators, who after all are criminals to the target state.

Despite the assurances of some commentators, there is no guarantee that the United States will dominate the environment of information, biotechnology, and nanotechnology. At the close of World War II the US military had the atom bomb, millions of battle-hardened fighters, unprecedented mobility, systematic training, global logistics, the best battlefield communications anywhere, and a host of other capabilities from sophisticated artillery coordination to medical evacuation helicopters. In the words of historian Geoffery Perret, it was "at least a decade ahead" of any other force in the world.[31] Yet, slightly less than five years later in Korea, that same military was fought to a standstill by a fourth-rate power backed by a third-rate one. The consequences of that stalemate remain with us.

Unsurprisingly, the most likely outcome of rapid, destabilizing changes inherent in the new technologies will be a mix of advantages and disadvantages. While the millennium is not at hand, neither is anarchy inevitable. Some destabilization and consequent violence and suffering is probably unavoidable. Cooperation in development may help mitigate the causes of instability, while security cooperation may help deal with its consequences. International cooperation, especially in the parallel development of these technologies, may help assure that no states or peoples become desperate at being left behind, leading to war. But that will not prevent other forms of difficulty.

Most people will eventually adjust and come to accept the future as routine and ordinary. It is sometimes easy to forget how far we have come already. In the fifth century, the Bishop of Milan was praised as an advanced intellectual on the grounds that he could actually read without moving his lips. The idea that someday reading would be the most basic skill required of virtually everyone would have been incomprehensible to the good bishop.

All of this adds up to what the ancient Chinese might have called "interesting times." But remember, they intended that phrase as a curse.

NOTES

1. See Gordon Boezar, Ivars Gutmanis, and Joseph E. Muckerman III, "The Defense Technology and Industrial Base," *Parameters*, 27 (Summer 1997), 26-51.

2. Chris Lawson, "Test-driving New Tactics, Technology: Navy, Marines Explore High-tech Possibilities During Field Exercises," *Navy Times*, 31 March 1997, p. 1. See also *Summary Report Fleet Battle Experiment ALFA 3-13 March 1997*, Naval War College, Newport, R.I., April 1997.

3. John Shalikashvili, *Joint Vision 2010* (Washington: US Joint Chiefs of Staff, 1997); Dennis J. Reimer, *Army Vision 2010* (Washington: US Army, 1997).

4. Steven Komarow, "Cybersoldiers Test Weapons of High-Tech War," *USA Today*, 6 March 1997, pp. 1, 6; George C. Wilson, "Army's Battle Technology Gets Key Nod," *Navy Times*, 14 April 1997, p. 2. Also Marcus H. Sachs, e-mail traffic posted to the Internet, March 1997. Major Sachs is an Army automator assigned to the 4th Infantry Division and is Chief, Division Automation Management Office. He provided daily updates from the National Training Center via Internet.

5. Lawson.

6. Defense Intelligence Agency (DIA), "Global Threats and Challenges," statement for the Senate Select Committee on Intelligence, 5 February 1997, p. 13.

7. Department of the Army, FM 100-5, *Operations*, 1997, Coordinating Draft, p. II-5-3.

8. David Wood, "Private E-mail Setup Big Hit with Spy Community," *The Patriot News* (Harrisburg, Pa.), 1 April 1997, p. A5.

9. A. P. Butler, "Data Flow Within the Chromosome 20 Project at the Sanger Center," conference paper, Single Chromosome Workshop, Cambridge, UK, 26 February 1997.

10. David Stipp, "Gene Chip Breakthrough," *Fortune*, 31 March 1997, pp. 56-73.

11. John Carey, et al., "The Biotech Century," *Business Week*, 10 March 1997, p. 90.

12. Ibid., p. 81.

13. Ibid., p. 88.

14. *Useful Facts on the Impacts of Deploying Energy Efficiency and Renewable Energy Technologies and Practices*, Office of Technical and Financial Assistance, US Department of Energy, January 1994.

15. Stipp, p. 84.

16. Leif R. Rosenberger, "The Strategic Importance of the World Food Supply," *Parameters*, 27 (Spring 1997), 89.

17. Ralph C. Merkle, "Nanotechnology and Medicine," *Advances in Anti-Aging Medicine*, ed. Ronald M. Klatz (Larchmont, N.Y.: Liebert Press, 1996), I, 277-86. The material was first presented at the 2d annual conference on anti-aging medicine and biological technology for the year 2010, 4-6 December 1994, Las Vegas, pp. 1, 14.

18. Ibid., p. 4.

19. Reuters, 8 June 1997, via Internet. The producer is given as The Cooperative Research Center for Molecular Engineering and Technology in Australia.

20. D. M. Eigler and E. K. Schweizer, "Positioning Single Atoms with a Scanning Tunneling Microscope," *Nature* (No. 344, 1990), pp. 524-26.

21. John L. Petersen, *The Road to 2015* (Corte Madera, Calif.: Waite Group Press, 1994), p. 297.

22. N. Seeman, "Construction of Three-dimensional Stick Figures from Branched DNA," *DNA Cell Bio* (No. 10, 1991), pp. 475-86.

23. K. W. Hahn, W. A. Kliss, and J. M. Stewart, "Design and Synthesis of a Peptide Having Chymotrypsin-Like Esterase Activity," *Science*, No. 248 (22 June 1990), pp. 1544-47.

24. Steven Metz, "Which Army After Next? The Strategic Implications of Alternative Futures," *Parameters*, 27 (Autumn 1997), 23.

25. This is suggested by recent tests at the National Training Center. See George C. Wilson, "Rating the Experimental Force at the NTC," *Army Times*, 26 May 1997, p. 3.

26. *Jane's Defense Weekly*, 25 June 1997, p. 6.

27. For example, "spoofing," or the art of electronically convincing sensors to produce a complete, consistent, and utterly false picture that furthers the interests of the "spoofer."

28. A similar notion, that advanced armies will lack large-scale manpower, is advanced by Ralph Peters in "The Future of Armored Warfare," *Parameters*, 27 (Autumn 1997), 50-59. See also Charles J. Dunlap, Jr., "21st-Century Land Warfare: Four Dangerous Myths," *Parameters*, 27 (Autumn 1997), 27-37.

29. For examples see Edward Mendel, "What Others Know Can Hurt You--The Pirating of Privacy," *Union Tribune* (Sacramento, Calif.), 15 May 1997, p. 4. Also Winn Schwartau, "A Call for Leadership and an Electronic Bill of Rights," *Federal Computer Week*, 19 May 1997, p. 2.

30. Andrew Pollack, "New Technology Promises 'Camera on a Chip,'" *The New York Times*, 27 May 1997, "CyberSection," p. 1.

31. Geoffery Perret, *There's a War to Be Won: The United States Army in WWII* (New York: Random House, 1991), p. 543.

Thomas K. Adams is a political-military strategist with more than 30 years of experience in all forms of military

operations other than war, including counterguerrilla operations in Vietnam, humanitarian assistance in Haiti, counterdrug missions in South America, and peace operations in Bosnia. His recent publications include *Special Operations and the Challenge of Unconventional Warfare* (Cass, 1998). His last operational military assignment was with the NATO stability force in Bosnia. A retired Army lieutenant colonel, Adams holds a Ph.D. in political science from Syracuse University, an M.A. in international relations, an M.S.Sc. in social psychology, and a B.A. in liberal arts.

Reviewed 13 August 1998. Please send comments or corrections to carl_Parameters@conus.army.mil