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Monitoring Emerging Military Technologies

The structure of today's military forces is largely predicated on the eruption of conflict between nations, particularly industrialized nations with large supporting infrastructures. But as the weapons of industrial age warfare have become more and more lethal, the likelihood of violent inter-state conflict between great nations seems to be declining.

Furthermore, a military designed for superpower conflict is ill equipped to deal with today's resurgence of sub-national warfare, ethnic violence and regional insurgencies, even if the will to intervene existed. The most sophisticated surveillance systems and the most advanced "brilliant" munitions have limited utility to resolve a Bosnia-type war.

A Case of Superpower Obsolescence?

According to historian Martin van Creveld, "The shift from conventional war to low-intensity conflict will cause many of today's weapons systems, including specifically those that are most powerful and most advanced, to be assigned to the scrap-heap. Very likely it also will put an end to large-scale military-technological research and development as we understand it today."

The end of the Cold War has already led to a loss of momentum in military innovation, especially among potential U.S. adversaries. "The pace and variety and intensity" of foreign military technology development "is not what it was at the height of the Cold War," says the Defense Intelligence Agency, "because so many countries just can't afford it."

Still, military research and development continues; though in the absence of a superpower adversary, it increasingly depends on and derives from advances in the commercial sector. According to the National Research Council, it is quite possible that the way that war is fought "will change much more between 1990 and 2020 than it did between 1915 and 1945 because the pace of technological change is faster now than it was then."

In fact, many now speak of a "revolution in military affairs," anticipating dramatic changes in military forces made possible by advanced technology. Despite the lack of a superpower threat to national security, such a revolution is needed, advocates say, to meet future, yet undefined threats or, alternatively, to sustain our qualitative margin of superiority in this period of uncertainty. Proponents of the status quo doubt this logic, particularly since it calls into question the massive and continuing investment in existing military forces. Other skeptics wonder if the proposed revolution is just another bid for new military spending at a time when other needs seem more compelling.

Certainly a revolution in information technology and in its exploitation for war is well underway. Ever greater quantities of data can be transmitted faster and more widely than ever before. Enthusiasts say that the military applications of information technology, embodied in microminiature weapons systems, will drastically alter the shape of future military forces. Large numbers of miniaturized, mass-produced, precision-guided weapons could in theory overwhelm and outperform today's conventional weapons at a fraction of their cost.

Although emerging technologies could hasten the obsolescence of the tanks, planes, submarines and aircraft carriers that have been the elements of twentieth century warfare, that will not happen anytime soon, because no nation appears to have both the will and the means to make it happen. Moreover, because Congressional hawks are wedded to the large, expensive weapons programs of the late Cold War era and their immediate follow-ons—such as the F-22 fighter and the Seawolf submarine—the emergence of the military of the 21st century may actually be delayed by further huge investments in weapons systems designed for conflicts of the past.

If a major new adversary were to arise, the advanced military technologies that are now on the horizon could

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This newsletter was prepared by FAS staffer Steven Aftergood with the support of a grant from the New-Land Foundation. It reviews the status of a number of emerging technology areas and provides a preliminary assessment of their prospects and implications.

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prove to be a double-edged sword that could be turned effectively against the United States, particularly considering our enormous investment in more conventional weapons systems. Furthermore, as the most technologically sophisticated of nations, the U.S. may paradoxically be the most vulnerable to certain emerging weapons technologies. This vulnerability is most clearly evident with respect to our profound dependence on information technologies for everyday transactions as well as for national security, and the corresponding threat posed by some varieties of "information warfare." Such considerations should motivate appropriate defensive measures as well as limits on the development and use of some new offensive systems.

There is a wide range of other emerging military technologies that will continue to require prudent oversight. Advances in genetic engineering in recent decades, for example, have revived concerns about the dangers of biological weaponry. Since the Biological and Toxin Weapons Convention was signed in 1972, it has become technologically easier to produce and deliver biological weapons. Overall, biotechnology has been advancing faster than its consequences have been evaluated, with enormous potential for good and ill.

For Good or Ill? No Certain Answers

So-called "non-lethal weapons" may bring the advantages of advanced technology to law enforcement and peacekeeping missions, or they may simply lower the threshold for the outbreak of violent conflict by offering the false promise of a benign battlefield. Or, of course, they may prove to be utterly insignificant.

Other issues of political and strategic impact may arise with respect to novel space technologies, nanotechnology, artificial intelligence and robotics, and numerous other technological frontiers.

As research and development in these technologies proceed, there will be opportunities and dangers that will require careful review and consideration. Does a particular new technology pose a unique threat to national or global security? Does it offer a significant new capability? Could it enable a dramatic reduction in military spending? Does it have corollary effects that would violate accepted humanitarian or other norms? Could its development otherwise disrupt the international order or threaten basic liberties?

Given the potential impacts of technological advancement, it is a matter of some urgency to begin to envision the advantages and drawbacks of emerging military technologies, and to consider whether their continued development should be selectively encouraged or opposed. With this in mind, FAS has initiated a project on emerging technologies and will continue to provide periodic updates on important developments.

—Steven Aftergood

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A REVOLUTION IN MILITARY AFFAIRS?

The emergence of new technologies heralds a "revolutionary" development in the conduct of warfare, according to the Department of Defense and many military analysts. This purported revolution is being offered by Pentagon planners as the organizing principle for the design of the military force structure of the near future.

Notion of "Revolution" Is Widespread

The notion of a "military technical revolution" or a "revolution in military affairs"—both of which are terms that originated in Soviet military thought—has become endemic in the literature of defense analysis. An astonishing number of professional journal articles have been devoted to asking what a military revolution is, whether one has already begun, and what if anything should be done about it. In late 1993, the Secretary of Defense established a Revolutionary in Military Affairs project "in order to better understand and exploit the potential for revolutionary changes in warfare."

There have been three such revolutions in the twentieth century, according to a Pentagon memorandum on the subject (borrowing directly from Soviet military literature), which have fundamentally altered military conflict:

In the period between 1917 and 1939, internal combustion engines, armored vehicles, improved aircraft designs, and radio and radar were harnessed in new operational concepts and organizational structures to produce the *blitzkrieg*, carrier warfare at sea, and strategic aerial bombardment.

A second revolution in the 1950s was brought about by the incorporation of nuclear weapons, development of jet aircraft, ballistic missiles, and advances in electronics.

The third revolution began in the 1970s and 80s with the application of cruise missiles to theater warfare, the use of satellites for reconnaissance, communications and global positioning information, stealthy aircraft and precision guided munitions. This revolution culminated in the Gulf War of 1991 "where the enormous potential of the integration of weapons systems with information networks began to be realized."

The current, or pending, revolution in military affairs is predicated largely on the exploitation of new information technologies that promise an unprecedented degree of detailed and near-instantaneous data on battlefield conditions along with the ability to coordinate and execute battle plans with extraordinary precision and lethality. And just over the horizon, according to the Army, is yet another revolution based on advances in biotechnology.

Military analysts emphasize that a military technical revolution is not simply a matter of introducing advanced technology, but that it also requires an appropriate revision of military institutions and practices. "In 1940," a recent Army doctrine manual notes, "tanks, improved aircraft designs, and radios were available to both the French and the Germans. However, it was the Germans who adapted their organizations, procedures, and tactics to transform the trench warfare of World War I into the *blitzkrieg*."

Accordingly, the new Pentagon Revolution in Military Affairs (RMA) project has begun to examine how the military services could be reformed to take advantage of new and emerging technologies. A series of wargames was conducted last summer under the auspices of the RMA to investigate organizational and operational changes that might be made to maximize the advantages of new technologies.

It is too early to assess the impact of the Pentagon's Revolution in Military Affairs initiative, although it is clear from the volume of discussion it has generated that the idea itself has captured the imaginations of many analysts inside and outside the military. But a few preliminary observations can already be made and some questions posed for future clarification.

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The RMA begs the question: *What is the threat?* What kind of wars will the United States be fighting in the next few decades? Obviously, a military force must be configured differently to fight a technological peer than to suppress civil unrest in a technologically primitive nation. Subnational or metanational threats (religious movements or international criminal organizations) may engender altogether new "styles" of warfare.

"Every war that the United States has fought has been different from the last," the U.S. Army Science and Technology Master Plan notes, "and different from what defense planners had envisioned." Moreover, "History suggests that we most often deter the conflicts that we plan for and actually fight the ones we do not anticipate." Long-term planning is accordingly a difficult and even paradoxical task, and creates a temptation to support all imaginable contingencies at all costs.

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Is the Pentagon's Revolution in Military Affairs a scam? Could it be just another, more seductive way of packaging military programs to help sustain defense budgets at a time when the longstanding military justification for existing structures and programs has diminished sharply? Certainly, the fervor with which "revolution" has recently been embraced in military circles is peculiar.

"No other cadre of professionals flings about concepts like change and revolution with greater abandon than American soldiers," writes A.J. Bacevich in the conservative journal *The National Interest* (Fall 1994). It appears that "no gadget or gizmo is without revolutionary implications," he writes. "High-tech rations revolutionize the way soldiers are fed. High-tech nozzles revolutionize the way

trucks are fueled. High-tech dog tags revolutionize the first sergeant's approach to counting noses." In short, much of the talk of revolution is self-serving and not quite credible. "The military's recent discovery that war itself is being revolutionized is only another example of [the] compulsion to convey an image of techno-chic. . . . As an overarching framework for change, the Military Revolution purports to integrate reform undertaken at many levels and on many fronts. It endows military thought with a sheen of coherence. It implies depth and spaciousness. And it makes for great looking charts and slogans."

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Could the Revolution in Military Affairs enable deep cuts in the military budget? Could the adoption of "revolutionary" new technologies facilitate significant reductions in military spending by maintaining or even increasing the efficiency and effectiveness of the U.S. military at a sharply reduced cost? Already, the development of stand-off weapons like cruise missiles launched far from the battlefield has eroded the justification for large, expensive, new penetrating platform systems. (Many of these stand-off weapons, however, still tend to be quite expensive and, in any case, we keep building the large platforms.)

"Bringing innovations to fruition will often be expensive," writes Stephen Peter Rosen in *Winning the Next War*. But historically, "initiating an innovation and bringing it to the point where it provides a strategically useful option has been accomplished when money was tight."

Savings could also accrue from the fact that many advanced technologies are being independently pursued in the commercial sector, drastically reducing development and acquisition costs. And according to a report of a roundtable discussion sponsored by the Office of the Secretary of Defense, "New organizational structures could also potentially have concealed cost savings— e.g. 'virtual brigades' would be less expensive to maintain than traditional military units. Entirely new types of organizations (e.g. information warfare brigades) could replace multiple, redundant functions in the current force structure, potentially reducing troop requirements. Information technology developments (e.g. downlinking command information directly to the soldier on the battlefield) could also potentially enable layers of staff to be eliminated, thus flattening organizational structures."

Whether the Revolution in Military Affairs turns out to be a major turning point in the history of the U.S. military, or merely a widespread rhetorical fantasy, the underlying technological trends are real enough. And while advances in key technologies such as information processing are led by the private sector, the Defense Department maintains a research and development budget of around $30 billion per year.

The following sections of this report present snapshots of some of the key technology areas that are now under development or that are expected to emerge within the near future. □

THE INFORMATION EXPLOSION

Rapid advances in information technology are driving an information revolution within the U.S. military. The Persian Gulf War, which has been termed the first information war, indicated the potential of new information technologies, as well as some of their limitations, and has generated increased emphasis and investment in their application to warfighting.

Of course, information has always been a central component of warfare. In general terms, information about an enemy's intentions and actions will define one's response. Precise information about enemy forces and capabilities is essential for targeting and damage assessment. And detailed knowledge concerning one's own forces is necessary for effective employment of those forces. Wars can be lost due to insufficient or incorrect information, or due to too much information delivered too late or unintelligibly.

Given their essential and often decisive role, information systems are an obvious target for attack. In modern times, the Soviet Union developed what was probably the first full-fledged doctrine of information warfare, known as Radio Electronic Combat, which aimed to disable an enemy's command and control infrastructure through bombing, electronic warfare and deception. Echoes of this approach were evident in the beginning of Desert Storm, when the first Iraqi targets to be destroyed were radar stations near the Saudi border.

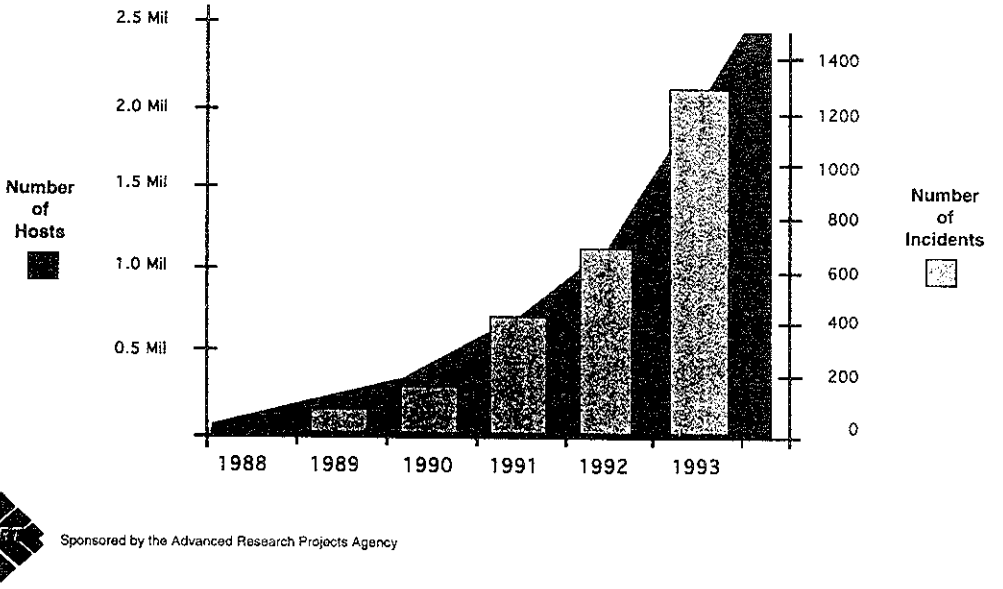
Info Technology Expands Exponentially

What is new is the remarkable and continuing acceleration in the development of information technologies. The information systems of the near future promise to reduce if not eliminate the proverbial "fog of war" by collecting, processing and disseminating vast quantities of information throughout the "battlespace" and beyond.

"By 2020 there will be so much information to collect, analyze, assess, synthesize, and disseminate that the quantity will present a challenge of such magnitude as to be almost incomprehensible," states a recent Air Force study entitled *Spacecast 2020*. "Constructing an information architecture to selectively capture, process, and use information is a critical priority."

Information processing capacity is now doubling every one and a half to three years, notes Martin C. Libicki of the National Defense University, and each successive generation is not only faster, but cheaper, smaller and less power-consumptive as well. In a fascinating study entitled *The Mesh and the Net: Speculations on Armed Conflict in a Time of Free Silicon*, Libicki extrapolates from current trends to declare that "Free silicon is inevitable; more precisely, unlimited amounts of information acquisition, processing, storage, and transmission capability will be available from indefinitely small and inexpensive packages."

Internet Dynamics



The number of reported computer security "incidents" on the Internet has increased at the about the same rate as the growth of Internet host computers.

Put another way, a current military computer performs more than 300 million computations per second. "In terms of biological systems, that places it about geometrically intermediate between a worm and a bee," notes physicist Gregory H. Canavan of Los Alamos. "Over approximately the next forty years," Canavan projects, "information processing will improve about a factor of [two to the 20th power]" or about a million times, corresponding to a trillion connections. "That will make machines that are 'brilliant squared' by today's standards, but in absolute terms, they will be about as smart as chickens." By way of comparison, human computational capacity corresponds to about 1,000 trillion connections. (Of course, computers are already "smarter" than humans by some important criteria, including some forms of information acquisition, processing, and memory.)

In any case, the growing availability of cheap, compact and powerful information systems is likely to change the conduct of warfare in ways that cannot be fully anticipated. Some of the changes that can be anticipated, and that indeed have already begun, are discussed below.

The Digitized Battlefield

The use of digital information technology, according to the U.S. Army, represents the foundation for land warfare in the 21st century.

Advanced digital technology will enable forces at all levels to quickly receive orders, to exchange intelligence, to maintain electronic fixes on enemy and friendly forces, and to synchronize targeting. The efficient dissemination of information across the battlefield will maximize "situational awareness."

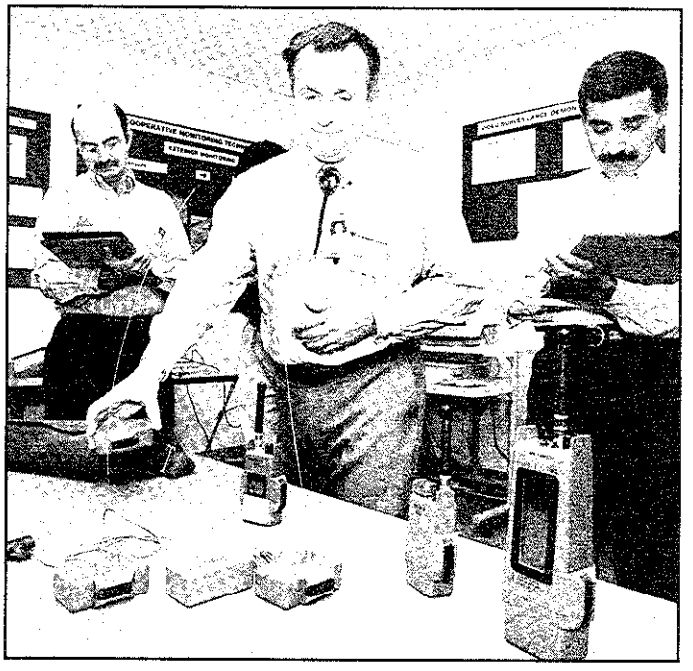
For example, one of the first systems to be adopted in the Army's digital battlefield approach is called the Inter-Vehicular Information System (IVIS), which is installed in the M1A2 Abrams Tank. This system is used to enhance communications with other tanks on the battlefield. Among its other features, IVIS automatically notifies other friendly tanks of its position every 15 minutes, or after every 100 meters of movement. Thus, tankers can remain constantly aware of the location of other friendly vehicles far beyond visual contact. Other new digital technologies are being applied to targeting and navigation systems. Due to resource limitations, most of these near-term developments are being adopted in the form of selective upgrades to existing systems. (It may be noted that this approach hardly signifies a revolution, and may actually generate new inefficiencies due to incompatibilities among diverse systems.)

On the intelligence front, new information technologies will continue to play a transformative role. To cite a single example, the Defense Intelligence Agency has recently begun to assemble a digital database, code named Argus, that will catalog all available data on all known weapons systems, foreign and domestic. Weapon "signatures," including radar, seismic, magnetic, visible, and infrared data, will be consolidated from a number of far-flung sources and will ultimately become available on-line on demand and in useful formats. (*Washington Technology*, 9/12/94)

Digitization will "bring everyone into the fight simultaneously" and in a coordinated fashion, the Army says. "Every shooter is shooting, every decider is deciding and every supporter is supporting. Full unity of effort and the enhanced battle command capability allow the commander to control the battlespace, the operational tempo and the environment."

That's the theory, at least. The reality is rather more ambiguous. As Army General Paul E. Funk has observed, "With the increased speed, range, lethality and real-time communication capabilities of the modern battlefield comes a directly proportional increase in the chaos on that battlefield." In other words, as ever more information becomes accessible (or unavoidable), the task of processing and managing that information becomes ever more challenging.

The first large-scale test of new digital technology, the April 1994 Advanced Warfighting Experiment called Desert Hammer VI, was less than satisfactory. In this exercise



Foreign visitors to the Cooperative Monitoring Center at Sandia National Lab inspect ground sensors that are available for verification and confidence building applications.

held at Fort Irwin, California, a digitally equipped battalion-sized task force was defeated by its conventionally equipped counterpart. The undigitized, but tactically adept Opposing Force (OPFOR) out-thought and outfought its futuristic foe, spoofing digital infrared sensors by creating false heat source targets, and minimizing electromagnetic emissions that could be detected by the digitized force. (In fairness it should be noted that the OPFOR, which is resident at Fort Irwin, almost always defeats the units which are brought in for battle training there.)

Furthermore, the digital battlefield technologies adopted turned out to be immature and to require more soldier training than had been provided. Even tanks equipped with the IVIS digital locators were not immune to fratricidal attacks on one another. In short, "The goal of creating a battalion task force, seamlessly linked across battlefield operating systems, proved elusive," according to an official assessment obtained by the newsletter *Inside the Army*.

Nevertheless, the Army remains enthusiastic about the concept of digitizing its weapons systems and support infrastructure. The wargame Desert Hammer VI, they say, served its purpose by highlighting the areas where improvement is still needed. Given sufficient resources, the Army hopes to have a digitized brigade by 1997, a digitized division by 1998, and a fully digitized force by 2010.

Simulations

New technologies are creating a capability to conduct warfighting simulations with unprecedented verisimilitude. The important new capability promises to improve military training, to enhance battle preparedness, and to streamline the weapon acquisition process. It should also help save some money.

"We cannot afford the time nor the dollars to place large formations of soldiers and expensive prototypes in the field simply to test hypotheses," says Army Chief of Staff General Gordon R. Sullivan. "Instead we are investigating the future through the use of simulations."

Simulated warfighting, of course, has always been an important part of military planning. The ancient Jewish historian Josephus Flavius wrote "The Romans are sure of victory, for their exercises are battles without bloodshed, and their battles are bloody exercises."

As recently as the 1970s, the U.S. Army trained its soldiers against an ad hoc group of opponents, fighting a low-tech, pre-scripted battle that had no particular doctrinal relevance to any real conflict that might ever be fought. These ante-information age exercises "smacked a lot of cowboys and Indians," according to an Army historian, "with very stupid, indolent Indians."

More recently, however, Army combat brigades have been training "in the most realistic conditions short of actual war," according to Army Major John F. Antal. Military units rotate through the National Training Center for fourteen day battles against an "enemy" force armed with Soviet weapons and employing tactics derived from Soviet military doctrine. Emulating the Roman 'battles without bloodshed,' soldiers are equipped with lasers and laser-sensors that are attached to each vehicle, soldier and weapon. These eye-safe lasers, known as the Multiple Integrated Laser Engagement System (MILES), simulate the range and effects of a real weapon without producing casualties, allowing for unscripted, force-on-force engagements and high quality training.

Today, virtual reality simulations can enable soldiers to train in high fidelity mockups, at substantial reductions in spending. Currently, according to the Pentagon's Defense Technology Plan, the U.S. spends over $19 billion per year on individual training costs, not including unit and joint training exercises. But while it costs an estimated $55 per mile to drive a real tank, for example, "driving" a high-tech simulator only costs about $2.50 per mile. However, the development of effective simulations requires sizable initial investments that are proving to be an obstacle to widespread use in the present budget environment.

Computer simulations, of course, play a tremendously important role in research and development, military and otherwise. Simulations permit the designer to optimize a new design and to reduce, if not eliminate resource-intensive testing. Soldiers can begin to train on weapons that may not even exist yet. Battle scenarios of ever greater complexity can be played out, studied, and revised. Ideally, mistakes can be made in the laboratory or the training center that will save lives in the field. And for better or worse, simulations already play a more important role in the development of military technology than does intelligence about foreign threats.

As simulation technology advances, however, its limitations are becoming apparent. One problem is that many trainees suffer nausea from the more sophisticated simula-

tors. The better the simulators become, according to an Army study, the more people suffer from "simulator sickness." This is defined as "a feeling of discomfort that arises from performing tasks in the simulator, where such discomfort is not elicited when the same tasks are performed operationally."

A more profound limitation has to do with the intrinsic difficulty of simulating nonlinear systems, which may be inherently indeterminate. Further, the type of learning that is accomplished by a trainee in a simulator, no matter how sophisticated, may only be partially relevant at best to what will be required under actual battlefield conditions.

In any case, simulator technology continues to advance and to gain acceptance. Whatever its limitations, it appears to be an increasingly important and cost-effective tool for the military of the future.

New Vulnerabilities

As the development of information technologies accelerates and the military exploits them more fully, new vulnerabilities are created.

This is due in part simply to the complexity of the technologies involved. A mundane example of this familiar problem is the case of the Denver International Airport. Billed as the most sophisticated, state-of-the-art airport, its high-tech baggage handling system proved to be a disaster and led to significant cost overruns and schedule delays.

But military information systems will also face active threats, not just costly glitches. The information technologies that serve as force multipliers under favorable conditions can become principal targets for enemies, terrorists, or others who would wreak havoc.

In its 1991 study entitled *Computers At Risk*, the National Research Council observed that "The modern thief can steal more with a computer than with a gun. Tomorrow's terrorist may be able to do more damage with a keyboard than with a bomb."

In the civilian sector, the increase in computer crime is keeping pace with the explosive growth of the Internet. In recent years, the Internet has grown by several thousand percent to encompass more than 2.2 million computer hosts and an estimated 20 million users. The number of *reported* security incidents, including attacks on military networks, has grown proportionally, to as many as three hundred successful or attempted breaches of security reported each month. Security professionals say that the number of actual computer security violations may exceed the number reported by perhaps a factor of fifty. The Pentagon currently spends about $50 million per year specifically on computer security. That amount may soon rise to as much as $1 billion per year.

The overwhelming dependence on advanced information technologies in key sectors of the U.S. economy, and in the military of today and tomorrow, all but guarantees that information systems will become an increasingly important target in times of conflict. As the most technologically dependent and sophisticated of nations, the U.S. may paradoxically be the most vulnerable to information warfare.

"The ability of potential adversaries to target and disrupt critical U.S. assets will grow even as our reliance on these assets does," according to a Defense Department report on the Revolution in Military Affairs obtained by *Inside the Navy*. "Even without significant advances in adversary offensive capabilities, U.S. vulnerability will increase. Even a 'dumb' bomb can have crippling effects if it is well-placed on vital information nodes."

Social Implications of the Information Revolution

Whether or not advanced information technologies "revolutionize" warfare, these technologies will continue to have a profound impact on social and political structures and practices.

Beginning from the shared premise that information is power, optimists and pessimists alike foresee radical consequences flowing from the explosion of information technology. The creation of multiple new mechanisms of accessing information tends to flatten existing hierarchies and, perhaps, to "empower" small social units and individuals.

"The information revolution sets in motion forces that challenge the design of many institutions," write RAND analysts J. Arquilla and D. Ronfeldt. "It disrupts and erodes the hierarchies around which institutions are normally designed. It diffuses and redistributes power, often to the benefit of what may be considered weaker, smaller actors. It crosses borders, and redraws the boundaries of offices and responsibilities . . . . It generally compels closed systems to open up." (*Comparative Strategy*, vol. 12, no. 2, 1993).

Cassettes, FAX and E-Mail Aided Uprisings

It has been widely noted in recent years that information can be a most powerful tool against repressive governments. Islamic fundamentalists fomented revolution against the Shah in part through distribution of cassette tapes and players. Fax machines were first introduced into Poland by the U.S. government in an effort to aid Solidarity. The student uprising at Tiananmen Square likewise received international support through use of fax machines. E-mail and other information technologies have increasingly been used to disseminate information about atrocities in the Balkans. And so on.

But the hierarchy-leveling effects of the information explosion do not apply only to dictatorships. As public access to high quality, interactive information nodes has spread, new forms of personal interrelationship have begun to emerge within our own society. Ultimately, it is imaginable that "virtual" communities could come to replace actual physical communities in political importance. Already, it is not unusual to find individuals who have established closer relationships with strangers on-line than they have with their next-door neighbor. While this can be a source of personal enrichment, it can also represent a form of alien-

ation from the public sphere. Extrapolating from this emerging trend, some analysts envision an end to the nation-state as a unit of political significance. In any case, many foresee dramatic and not entirely positive social changes driven by new technologies.

"The technology of the computer age does not necessarily make the world permanently safe for democracy and traditional American values," says the National Research Council in a report on future technologies called *STAR 21*. Whereas the military technologies of the modern industrial era relied upon citizen-soldiers, the technologies of the information age will tend to rely on elites defined by their superior technical skills, the NRC pessimistically concludes. "Current international trends toward democracy may reverse, as computational technologies shift economic and military power from the masses to technical elites."

Revolutionary Television

Although television cannot be considered a new or emerging technology, it too is being hailed as pregnant with revolutionary implications for the future of war.

"TV and video are poised to change warfare as extensively and dramatically in the 21st century as radio changed conflict in this century, for policymakers as well as combatants," writes Frank J. Stech of the MITRE Corporation, formerly of Army psychological operations.

Television constitutes "a new threat to the nation's war fighting capability," Army Lt. Col. Michael D. O'Brien writes even more breathlessly. "Through the U.S. television news media, the enemy has the ability to transmit from their capital directly into the living rooms of American citizens. They can utilize this media tool to present their perspective. Enemy leaders will attempt to use this new weapon to influence the will of the people and quite possibly the nation's ability to fight. . . . The United States must solve this problem before the next conflict."

There are two issues raised here. One is the pervasiveness of television and the other is its potency in shaping perceptions.

The global reach of television, particularly since the advent of Cable News Network, has fundamentally altered the flow of information throughout world political systems. "TV news carries information directly and immediately to top leaders, bypassing the entire apparatus of intelligence, diplomacy, and national security," observes Stech. Large bureaucracies that have a long time constant are overwhelmed by instantaneous reporting of crises in progress and the demand for instantaneous responses.

The challenge is intensified by the fact that video imagery is a uniquely powerful and seductive form of communication. This fact is best understood by those who would resist the charms and idiocies of television. Last year, for example, Iran's highest ranking cleric issued an injunction against the widespread installation of satellite dishes in Iran intended to intercept Western television (*Wall Street Journal*, 8/8/94, A10). Television, according to the ayatollah, infects the country with "cheap alien culture" and spreads "the family-devastating diseases of the West." Another Iranian official asserted remarkably that "The enemy's cultural blitz is more dangerous than guns, tanks, and missiles."

The idea that television is a medium or an instrument of warfare is gaining prominence and poses a growing temptation to the military to deliberately exploit it for purposes of perception management. "Our next enemy is developing its skills at this very moment to exploit our freedom of speech," says O'Brien. Consequently, "the real time news broadcasts from the enemy's capital should be the focus of a national counterpropaganda or counter-psyops [psychological operations] program."

The proposed solution to the supposed TV threat is at least as unsettling as the alleged threat. Drawing on the literature of semiotics—the theory of signs and symbols—as well as established advertising techniques, the TV warriors would take television's power to sell lite beer and breath mints and use it to mold the public's attitudes towards the *conflict du jour*. While this may be nothing new, the techniques and strategies proposed to accomplish "visual persuasion" are remarkable in their sophistication. They will also inevitably compromise the integrity of public discourse.

Significantly, video warriors offer the broadcast of Patriot interceptors launched against Scud missiles and the (false) interpretation of Patriot performance as the paradigm for television warfare. Citing the dramatic video footage and President Bush's wildly exaggerated assertion that 41 out of 42 Patriots hit their targets, analyst Frank Stech hails it as "a classic example of presidential semiotics and operational art in CNN war."

Whatever its effectiveness in the Persian Gulf War, the entire strategy of TV warfare seems predicated on the idea that television speaks with a single authoritative voice. But in the unfolding era of the information explosion with its multiple and multifarious information nodes, that is exactly what it will not do. □

Chechnya: Russia's First TV War

"Much more than the impassioned denunciations of political figures, the images of Russia's first major televised conflict appear to be stirring bitter opposition to what was already an extremely unpopular war."

"The government has threatened to revoke NTV's [Independent Television Network's] license to broadcast, but the station's coverage has been unrelenting. The pictures and reports apparently have taken their toll in public opinion about the war: Polls show that Russians oppose it by more than 2 to 1."

"Another effect of the NTV coverage has been to puncture the official government line on the war's progress." —*The Washington Post*, 4 Jan 95

OTHER TECHNOLOGIES FOR FUTURE WAR

While there is a general consensus that "information technology will be the greatest contributing factor in the emerging Revolution in Military Affairs," as the Pentagon put it, there is intensive activity in a wide variety of other technologies that will have implications for the future of warfare. A few of these technology areas are briefly noted below.

The Biotech Revolution

The most prominent near-term military concern with biotechnology is its potential role in biological warfare. According to the National Research Council, "Biotechnology will change nearly every aspect of our lives; and it will change the way war is waged."

While biological weapons are nothing new, major advances in biotechnology are certain to test the Biological Warfare Convention of 1972, which prohibits the development, production or use of biological organisms for the purposes of warfare.

Without a strong verification regime that itself utilizes advanced technology, such as remote sensors, concealed production of the so-called "poor man's nuclear bomb" in a dual-use facility remains a possibility. For as little as $40 one can "depopulate" a square mile using anthrax spores, which are easily producible, viable in air for hours, and over 95 percent fatal. Chemical weapons cost about $100,000 for the same effect, according to Conrad V. Chester of Oak Ridge National Laboratory.

Consequently, an important near-term priority is to improve defensive capabilities against military or terrorist use of biological weapons. These include enhanced detector systems for field deployment and vaccines, none of which currently exist for many important BW agents.

But biotechnology has implications that go far beyond biological weapons and that, unlike many other technological endeavors, can fairly be termed revolutionary. Biotech methods will enable the creation of entirely new materials. It will become possible to cost-effectively "grow" materials of specified strength and mass, for example, and with new "biocamouflage" and "bioantifreeze" properties.

Mastery of bioproduction mechanisms will enable soldiers to generate food, fuel, and materiel from raw materials in the field, allowing for extended operation in remote areas. Advanced anti-materiel substances will be developed to damage or disable targeted enemy weapons systems and infrastructure.

Bionic techniques will be used to establish sophisticated man-machine interfaces using neural connections. In preliminary Air Force experiments, subjects are already controlling flight simulators using "brain actuated control," in which sensors similar to those in an electroencephalogram are used to detect willed modifications of brainwave activity. (*Defense News*, 8/15/94, p.12).

And, of course, in contrast to their potential for improving health and staving off hunger, gene technologies and biomolecular engineering could be used to develop a variety of means to inhibit, modify or damage human performance, as well as crop and livestock production.

The biotechnology revolution is unfolding more quickly than its consequences can be understood and assimilated. Compared to other technologies with military application, the NRC notes, biotech is "the most rapidly expanding in terms of discoveries, inventions, and applications."

The U.S. military has not yet come to terms with this development. "If you go to any place in the Department of Defense, you can have a conversation about microelectronic technologies," said one official quoted in *Aerospace Daily* (10/5/94), but "you're going to have a tough time finding many places where you can talk about biotechnologies."

Unmanned Military Vehicles

One important technology trend that is already manifest is an increasing reliance on unmanned vehicles for certain military missions.

The fact that unmanned systems should be cheaper, mass-producible, and more dispensable than manned systems will bring about increased reliance on unmanned aerial vehicles (UAVs) for reconnaissance, intelligence, surveillance, and target acquisition. Last year, the Central Intelligence Agency deployed a fleet of UAVs known as Gnat 750s to conduct surveillance over Bosnia, notes aviation writer Bill Sweetman. The Gnats weigh less than 1000 pounds each and can stay aloft for 24 hours, while relaying reconnaissance photos via satellite. (In their initial deployment to Bosnia, the performance of the UAVs was degraded by bad weather and data transmission problems, but is said to have subsequently improved.)

In the future, the role of UAVs in military operations will only expand and diversify. With the microminiaturization of sensors and computers, and new developments in materials and weapons technologies, we will even see swarms of UAVs that are each "the size of a songbird," says the National Research Council.

The future military will also emphasize the use of unmanned ground vehicles (UGVs) for land warfare. "The core weapon of twentieth-century land war has been the tank, but the core weapons of the twenty-first century may be unmanned systems, operating mostly under computer control," reports the NRC in its *STAR 21* study.

Unmanned ground vehicles (UGVs) will exploit advances in robotics and artificial intelligence, microelectromechanical systems and lethality and, either through autonomous programming or tele-operation, could increasingly replace human soldiers in the field.

"Because they can be much smaller, lighter, and cheaper than a soldier or manned platform, [unmanned systems]

can be deployed in large numbers," says the NRC. "They can be produced secretly and much more rapidly than soldiers can be trained. They can employ sensors that humans lack and weapons that no human could accurately aim or safely fire. They do not tire or grow afraid, and they can be deployed in places and for tasks where soldiers cannot or should not be sent. The technology to build them exists now."

The growing capability of, and reliance upon, unmanned systems could lead to new limitations on human decision-making in future warfare. As the pace of conflict accelerates in the information age, the question of whether there will be a "man in the loop" to exercise authority over automated systems becomes more urgent. The answer, in some cases, may be no.

Some of the experts who were asked to forecast the future of military technology for the National Research Council noted that they "have frequently been told that the automated decision-making systems [that they envisioned] will not be developed because national leaders will not tolerate fire/no-fire decisions being made without a human in the loop. The [NRC] Group believes this is wishful thinking. National leaders have tolerated land and sea mines (which make fire/no-fire decisions), harassment and interdiction fires, chemical warfare, and the nuclear bombing of civilian populations. If there is a military advantage in having some decisions made by machines, and the Group believes that there is, then that advantage will be exploited."

And More

A host of other technology areas, not addressed here, could also have a significant impact on the shape of wars to come.

The nanotechnology revolution promises new types of electronic devices measured on the scale of atoms and unprecedented control of material processes and designs.

The role of space-based systems, and the possibility of space-based war, will continue to grow. Directed energy weapons, including lasers, radio frequency and particle beam weapons, remain a technology area of military interest and expectation.

Even highly speculative topics such as weather modification are receiving renewed attention. "The difficulty, costs, and risks of developing a weather control system for military applications are extremely high," notes the Air Force *Spacecast 2020* report. "However, the potential benefits for national security could be even higher."

In all of these areas and others, steady and sometimes spectacular advances in technology are taking place. Generally speaking, the NRC concludes, "If the new technologies are applied vigorously, war will change much more between 1990 and 2020 than it did between 1915 and 1945, because the pace of technological change is faster now than it was then."

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TECHNOLOGIES FOR PEACE

Can technology create new opportunities for averting war and promoting peace? The answer is clearly yes, although no one presumes to speak of a "revolution in peace technology" and the research and development budget for advanced peacemaking is rather hard to locate in government documents.

Just as technology is used to magnify, extend and focus human abilities in other domains, it can also be applied to reduce the likelihood that violent conflict will erupt and to ameliorate the consequences of warfare.

Technology for Confidence Building

For example, one response to the threat of proliferation of weapons of mass destruction is the "proliferation" of technologies for monitoring sensitive facilities and for increasing international transparency. This approach is particularly important in areas of regional conflict or instability, where the perception of a threat, even when unfounded, can lead to a regional arms race.

The Department of Energy has established a new Cooperative Monitoring Center (CMC) at Sandia National Laboratories which is intended to introduce foreign visitors to a variety of new and current technologies that can be used to verify compliance with regional arms control and environmental agreements.

The purpose of the CMC, according to a Sandia brochure, is "to provide a forum where international and regional participants can meet to share the extensive U.S. monitoring and verification experience base, and explore ways that technology can facilitate implementation of regional confidence building in areas such as arms control, resource management, and environmental restoration."

With a tiny budget of just over $2 million, the new Center is already working to give visitors hands-on experience with a range of monitoring hardware, software, and data processing and integration capabilities. These include cameras and acoustic and seismic sensors, as well as access to unclassified satellite imagery and data from airborne sensors. Computer simulations are used to train participants in the use of sensors to monitor potential agreements and to help devise applications that are suited to their particular needs.

"The objective of this project is to establish a prototype of a regional cooperative monitoring center," says CMC program manager Arian Pregenzer. "Center personnel will help international and regional participants in the design, evaluation, and testing of sharable monitoring systems for regional confidence building."

"Participants may be skeptical when they arrive or they may be overly optimistic," Pregenzer says. "Ideally, while at the center they will achieve a more realistic view of the capabilities and limitations of technology and acquire new ways of thinking about the role of technology in regional confidence building."

In its efforts to promote regional and global security based on enhanced monitoring and verification regimes, the new Center has recently participated in several multilateral workshops dealing with the Middle East peace process, and has hosted representatives from India and China.

"By promoting communication and cooperative approaches to resolving regional tensions," Sandia says, "the CMC will help achieve important nonproliferation objectives." More broadly, wherever miscommunication or skewed information generate conflict, new technologies offer sophisticated new opportunities to address them before they erupt into war.

Remedial Technology

New technologies are also urgently needed to repair the profound damage that has been done in recent decades through the prosecution and preparation for war.

Aside from the continuing hazard posed by environmental contamination, the need for new remedial technologies is perhaps most evident with respect to threat posed by the use of land mines.

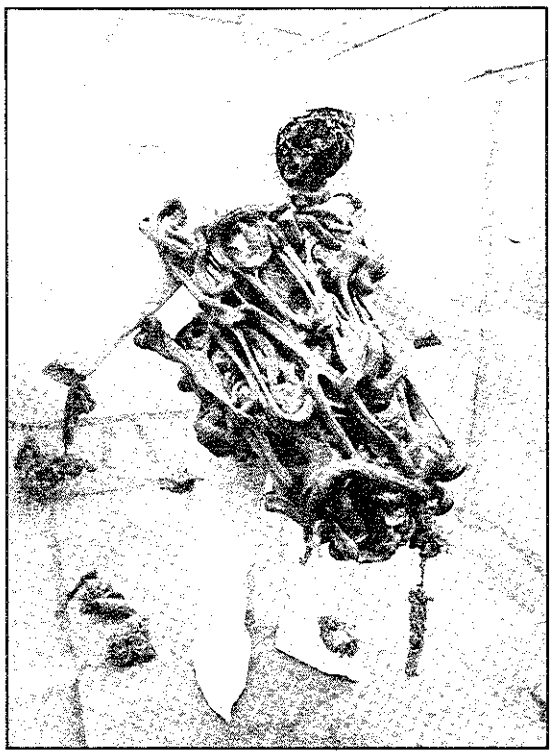
"There is today a global land mine crisis," writes UN Secretary General Boutros Boutros-Ghali in *Foreign Affairs* (September/October 1994). "While it began as a military problem, it is now an ongoing humanitarian disaster."

At least 85 million land mines, and perhaps twice that many, are scattered in past and present battle zones, as well as civilian locales, in 62 countries, according to the State Department. The number of deployed mines is estimated to increase each year by up to 5 million. There are as many as 360 distinct types of anti-personnel landmines produced in 55 different countries, according to a report in *Jane's Intelligence Review* (September 1994).

Long after the conflicts in which the mines were deployed have ended, scores of people around the world are killed or maimed every day. These minefields constitute "a legacy of death that will continue to affect noncombatants for years," according to the U.S. Foreign Science and Technology Center. Thousands of unexploded munitions even remain in place in Berlin left over from World War II.

Advanced mine technology development continues apace to produce more lethal, mobile, and "intelligent" landmines. But as Boutros-Ghali observes, "mine clearance technology, in contrast, has advanced little since the 1940s. New techniques are badly needed." Currently, while most mines cost less than $25, the cost of mine disposal runs between $300 and $1000 per mine.

While many problems of human conflict are as resistant to technological solutions as they are to military ones, it is no less clear that some such problems, like the enduring horror of buried mines and munitions, can only have technological solutions. And given a modicum of resources, new technologies for preventing and recovering from conflict can achieve a world of good. □



In one non-lethal weapons concept, sticky foam is used to immobilize—or at least to really annoy—an adversary.

NON-LETHAL WEAPONS

So-called non-lethal weapons, which are slowly emerging from the secret "black budget," are among the military technologies of the near future.

According to a March 1991 memorandum from Under Secretary of Defense Paul Wolfowitz, "Non-lethal weapons disable or destroy without causing significant injury or damage." As discussed below, this is a significant misconception. In any case, Wolfowitz wrote, "A U.S. lead in non-lethal technologies will increase our options and reinforce our position in the post-cold war world."

Dozens of non-lethal weapons have been proposed or developed, mostly in laboratory scale models. They encompass a broad range of technologies, including chemical, biological, kinetic, electromagnetic, and acoustic weapons.

Of course, the arsenal of conventional warfare already includes systems like electronic jamming devices and anti-radar missiles that are "non-lethal" in the sense that they are designed to disable enemy weapons, but only within the context of armed and deadly conflict. In contrast, the proponents of non-lethal weapons appear to hold out a vision of a relatively benign battlefield.

Sticky foams and "calmatives" would immobilize or sedate adversaries. Specially cultured bacteria would corrode and degrade components of weapons systems. Optical munitions would cripple sensors and dazzle, if not blind, soldiers. Acoustic beam weapons would knock them

out. Netting and shrouds would thwart the movement of aircraft, tank, and armored vehicles. These and many other related technologies have already been demonstrated to at least a proof of concept level. Still others have been described that appear to defy a conventional understanding of physics or biomedical science. In some cases, the proposed technologies raise questions about compliance with international agreements.

In the aftermath of the Gulf War, the Pentagon created an initiative to coordinate these diverse research programs and to plan the acquisition of non-lethal weapons and their incorporation into military training and doctrine. Current funding, which is on the order of several tens of millions of dollars per year, could grow to more than $1 billion over the next several years. In 1994, the Pentagon received more than 150 proposals for funding the development of non-lethal technologies. Additional efforts are separately underway on a highly classified, special access basis.

The "futuristic" aura of many non-lethal weapons has proved seductive to many, and their advent has been heralded by almost entirely uncritical media reports of kinder, gentler weapons. Basic questions about the meaning and utility of the new non-lethal technology thrust remain unanswered and even unasked.

"Non-lethal": A Misnomer

The first step in trying to understand the non-lethal weapons program is to get past the name. Even proponents concede that non-lethal weapons are not necessarily non-lethal. So why are they called that? Because the term is deemed politically attractive.

"It is postulated that major political benefit can be accrued by being the first nation to announce a policy advocating projection of force in a manner that does not result in killing people," writes Dr. John B. Alexander, the director of non-lethal weapons programs at Los Alamos National Laboratory and a leading figure in the field.

Various program names were considered and are still sometimes used: soft kill, mission kill, less-than-lethal weapons, noninjurious incapacitation, disabling measures, strategic immobility, and others.

"Having been through a number of names, I can say that *nothing* has had the impact of "non-lethal," avers Alexander. The growing prominence of the non-lethal program tends to validate this perception management strategy.

Fantasy or Comprehensive Solution?

Rebelling against the marketing spin placed on the program, analysts across the political spectrum have rejected the assertion that non-lethal weapons represent a qualitatively new development in warfighting or even a fruitful avenue for investment.

Defense analyst William M. Arkin notes that the resurgence of interest in non-lethal weapons was spawned in part by "the use of special weapons (the Kit 2 carbon-fiber warheads on Tomahawk sea-launched cruise missiles) against electrical installations" in Desert Storm. However, he said, this "non-lethal" application paradoxically "had devastating effects on a civilian population that was otherwise largely spared the direct effects of bombing. "Non-lethal" weaponry, Arkin concludes, is a "fantasy program."

Likewise, Eliot A. Cohen, writing in *Foreign Affairs*, declared that "the most dangerous legacy of the Persian Gulf War [is] the fantasy of near-bloodless use of force."

Cohen pointed out that "in the end, a disabling weapon works only if it leaves an opponent vulnerable to full-scale, deadly force." (The disabled Iraqi electrical generating stations were subsequently bombed for good measure.) Official spokesmen concede the point. Frank Kendall, until recently the director of tactical warfare programs at the Pentagon, says "We're not looking at this as a new warfighting strategy per se, but rather as another effective tool for the users."

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CONCLUSION

Although the notion of a "Revolution in Military Affairs" has been accepted by many military analysts inside and outside the Defense Department, the one place it has not been endorsed so far is among Pentagon budget planners.

Shrinking defense budgets, including reductions in research and development, will limit the options for military investment in advanced technologies. Last year the Clinton Administration ordered the cancellation or delay of several new major weapons acquisition programs in favor of increased funding for troop salaries, equipment maintenance, military housing and other "readiness" needs. "Money is tight and we are choosing people over systems," said Deputy Secretary of Defense John Deutch. (*The Washington Post*, 8/24/94, p. A4).

In any case, military research and development in many important technologies has been overtaken by the commercial sector. It has reached the point where much military R&D has become redundant, or worse. "Major savings could be achieved by abolishing virtually all the Defense Department and military service laboratories," writes Lt. Gen. William E. Odom. "Few of them have invented anything of note in several decades, and many of the things they are striving to develop are already available in the commercial sector. . . . Because they are generally so far behind the leading edges in some areas, they cause more than duplication; they also induce retardation and sustain obsolescence," says Odom.

While some advanced technologies promise considerable savings over the long term, they often require significant investment up-front which tends to discourage budget planners. Even when new technologies are adopted, they tend to be integrated as enhancements to existing weapons systems, not as "revolutionary" departures from the status quo.

(continued on page 14)

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(continued from page 12)

Nevertheless, technology marches on, for better or worse, and the emergence of new technologies will continue to pose important challenges for policymakers and citizens.

Military planners must be concerned about the implications of advanced technologies in the hands of potential U.S. enemies. It is not possible to guarantee or to assume that all future conflicts will be lopsided affairs in which the U.S. wields advanced weapons to gain swift victory against a befuddled foe. Indeed, many of the key technologies that constitute the "technical" part of the "military-technical revolution" are being developed independently by many other nations.

"The U.S. leads or shares the lead in most areas of research and technology applied to advanced weapons systems," according to the U.S. Army Science and Technology Master Plan. "However, other nations, notably Japan, France, Germany, and the United Kingdom, are superior in some areas. The Russian Republic has strong capabilities in many military aspects of technologies. Other countries offer niches of excellence. . . . "

The growing internationalization of advanced technologies, including military systems, raises the question of whether and how to control certain applications of such technologies.

Already, amendments to the laws and conventions of war are being urged to prohibit the use of anti-personnel landmines and blinding weapons. Other candidates for preemptive arms control or other limitations will emerge as new technologies mature. National and international institutions will be challenged to define appropriate standards for the development and use of these technologies and to overcome the perceived competitive advantage in their early acquisition.

In some technology areas, new measures will be required to assure the transparency of the development process. In other areas, a degree of secrecy will be appropriate.

Predictions about future technologies, like those about other topics, are naturally unreliable, except perhaps as an indication of what will *not* happen. The following observations of the National Research Council, however, seem well-founded in experience and have the ambiguous ring of truth.

The NRC concludes that future weapons systems, "like any revolutionary technical development, will disrupt existing military structures and industrial competencies. Especially when adopted too soon, they will be expensive and often will not work. When they do work, they will remain vulnerable to enemy countermeasures. They cannot be trusted blindly or simply substituted for humans; they require understanding on their own terms. They are surrounded by cycles of exaggerated expectation and disillusionment. In general, they will not be welcomed."

—*Steven Aftergood*

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FAS ENDORSES RESEARCH ON MEDICAL MARIJUANA

On November 15, FAS released a petition, and background paper, describing the need for expediting and facilitating medical research to determine if so many patients and doctors are right in arguing that smoking marijuana could alleviate the symptoms of a significant number of patients suffering from a number of medical conditions, in ways that could not otherwise be done.

The background paper was prepared by the Chairman of the FAS Drug Policy Committee, Harvard Professor Mark A.R. Kleiman.

The FAS petition read:

TITLE: EXPEDITE RESEARCH ON MEDICAL MARIJUANA FOR THE SERIOUSLY ILL

Based on much evidence, from patients and doctors alike, on the superior effectiveness and safety of whole cannabis (marijuana) compared to other medicines for many patients—suffering from the nausea associated with chemotherapy, the wasting syndrome of AIDS, and the symptoms of other illnesses—-and based on the lack of incentives for profit-seeking corporations to validate the effectiveness of a medicine that cannot be patented, we hereby petition the Executive Branch and the Congress to facilitate and expedite the research necessary to determine whether this substance should be licensed for medical use by seriously ill persons.

Reviewed and Approved by the FAS Executive Committee

The petition was released at a press conference called by NORML in support of "Medical Marijuana Day." FAS President Stone authorized any and all organizations and groups to circulate the petition for signatures in the interest of expediting the results. He observed that FAS has no position on non-medical issues of marijuana but only wants to be sure the research is done promptly. He added:

"There is ample evidence that political fears, legal restrictions on research, and the absence of a prospect for profits, are combining, in an unconscionable way, to prevent both doctors and patients from knowing whether they should, or should not, use marijuana in a variety of medical circumstances.

"This includes not only those familiar with marijuana but, also, those many millions of persons, like myself, who have never smoked anything, including tobacco, but who would certainly want to know, if they came to have one of these relevant medical conditions, whether smoking marijuana is medically more indicated than some other medicine. Who is going to give them credible advice if the research is not done? And how are they going to get the substance legally if the research does not exist on which to base the right of physicians to prescribe it?"

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FAS Award to Stone for Public Service; Higinbotham Memorialized

On December 16, FAS President Jeremy J. Stone was awarded the FAS Public Service Award for 1994 in an elegant dinner ceremony for 50 guests in the Lyndon Johnson Room of the U.S. Capitol. The award followed a memorial service for William A. Higinbotham who died on November 10 and for whom the FAS headquarters is now named. (See FAS PIR of November/December 1994 and adjoining box). Stone was praised by a number of officials and colleagues for his diverse achievements.

FAS Chairman Robert Solow lauded Stone for "acts of foreign policy entrepreneurship in Cambodia, in Peru and in Kosovo"; for inducing FAS to branch out "to public interest issues that grow naturally out of the organization's past: space, the trade in weapons, and secrecy in government"; and for finding, funding and encouraging young experts and designing "a neat outlet for their talents" through independent newsletters.

Stone, said Solow, has understood that most scientists, economists and political scientists are "fundamentally passive", tending to be satisfied when "they think they understand something"—leaving it to others to "make the right thing happen". But, he said, "making things happen is exactly what turns Jeremy on. He is God's own activist".

Solow continued:

"I was going to say that he has learned how to turn the knowledge and interest of the scientific community into purposive action in the policy arena. But he did not learn that art; it is truer to say that he invented it. The last thing that needs saying is that Jeremy's activism is never for its own sake. He desperately wants action to be based on knowledge and understanding, and to be directed toward just and virtuous goals. Sticking to that has turned Jeremy into one of the moral leaders and key intellectual spark plugs of the peace movement for over two decades."

FAS Fund Chairman Richard Garwin said Stone has been "forceful, imaginative, and successful" in his stewardship of FAS but that it was for "personal contributions" that he was being given the FAS Public Service Award. Garwin cited Stone's 1963 paper "Should the Soviet Union Build an Anti-Ballistic Missile System?" and reminded the audience how Stone had spent "the next decade in the style so familiar to us, urging American and Soviet scientists and their governments to adopt an ABM Treaty"—efforts that included two books and five self-financed trips to the Soviet Union (with his wife, B.J. Stone, who learned Russian for the purpose) to lobby Moscow.

"One of Jeremy's strengths is to combine personal diplomacy with prodigious energy in acquiring information, analyzing it, and providing inspired . . . output," Garwin said. He gave as an example the first scientific delegation to China—organized by Stone who, after meeting with Chou En Lai, pushed effectively for a reciprocal trip. Upon arrival in the U.S., the Chinese scientists promptly announced that they were in the U.S. at "the joint invitation of FAS and the National Academy of Sciences".

FAS Fund Chairman Garwin presents a plaque to Stone and commends B.J. Stone for her linguistic abilities that supported Stone's work in Russia and China.

As another example, Garwin described the FAS campaign to shame legislators into visiting the Soviet Union by having a delegation call on them to ask "If you've never been there, how can you be sure that your policies on U.S.-Soviet questions are appropriate?" Garwin also recalled Stone's three years of work to save Cambodia, his hosting of Cambodia Prime Minister Hun Sen's visit to Washington, and his effort to ensure the arrest of the Peruvian "Shining Path" leader Guzman.

First in a procession of colleagues honoring Stone was Frank von Hippel, former FAS Fund Chairman. He talked about Stone's conception of a tacit agreement by U.S. and Soviet leaders not to be the first to deploy an ABM, and the ABM Treaty; how Stone became Andrei Sakharov's "most effective defender in the West . . . laying the foundations for the important collaborative effort between U.S. and Russian scientists on nuclear arms control during the early Gorbachev era"; how Stone persuaded Senator Ted Kennedy to back the nuclear-weapons freeze movement at a crucial juncture; and how he had assisted other persons' careers, including his own (von Hippel's) in U.S.-Russian activities and that of David Albright in Latin American non-proliferation activities.

With regard to non-FAS activities, Council on Foreign Relations Vice President Alton Frye commented on Stone's "incredible versatility" and noted that Stone had been responsible for ensuring—"with a campaign of insidious effectiveness"—that the Board of the Council on Foreign Relations became a "truly elective body". And Charles Price, former Chairman of the Board of Swarthmore College, commented on Stone's "insight and determination" when in 1982 Stone, as President of the Class of 1957, persuaded Swarthmore College to name its presi-

dent's house after Courtney C. Smith, a former president who died of a heart attack during a sit-in by black protesters in his office in 1969.

Ann Druyan, the elected Secretary of FAS and Chairperson of the Awards Committee, said Stone's work "symbolized providing truth to power and giving science the good name it deserved" and that his career was "a masterpiece of human conscientiousness".

On behalf of the Federation, she presented Stone with an original copy—one actually autographed by Albert Einstein—of the 1933 edition of "The Fight Against War," statements collected by Alfred Lief and published with a foreword by Einstein who declared: "I consider it my duty to confess my pacifist conviction publicly."

Memorial Service for Higinbotham

On December 16, the plaque naming the FAS Headquarters for Willy Higinbotham, mounted on the outside of 307 Massachusetts Avenue, N.E., was unveiled and a memorial ceremony held in the Lyndon Johnson room of the U.S. Capitol.

In a benediction, FAS expressed the hope that "the spirit of this man, who walked among us in such a way as to excite our admiration, respect and love, would be infused into the walls of our building and would characterize our work and guide our hand forever more."

Letters praising Higinbotham were read by Ann Druyan. One written by Freeman Dyson, FAS Chairman in 1962, recounted his early experiences with FAS:

"One of the things that attracted me most strongly to FAS was the spontaneous and unhierarchical way in which it functioned. Coming fresh from England, I found it amazing that the leader of FAS was not Sir Somebody Something but this young fellow Willy Higinbotham who had grabbed the initiative in 1945 and organized the crucial dialogue between scientists and congressmen. In 1947, Willy was already a legendary figure, a symbol of the "ordinary guy" who changes history by doing the right thing at the right time. To me Willy was also a symbol of the good side of America, the open society where everyone is free to make a contribution. Willy just happened to make one of the biggest contributions."

Attending the ceremonies were Willy's sister, Dorothy Higinbotham Osgood—for 12 years herself a key administrative official of the Federation; Willy's son William B. Higinbotham and Willy's daughter Julie Schletter, her husband and two sons. After colleagues remembered Willy as a scientist, Mrs. Schletter spoke movingly of him as a father and grandfather. It was announced that the Federation had agreed that the plaque would be reinstalled if the headquarters were moved and that, if FAS were ever to close its doors, the plaque would be offered to the Higinbotham family.

Von Hippel Rejoins FAS

Frank von Hippel, longtime FAS official, is in residence with the FAS Fund after serving 18 months in the Office of Science and Technology Policy as Assistant Director for National Security, a position he resigned December 31. He will return to Princeton University at the end of the summer. While at FAS, von Hippel may be reached by telephone directly at (202) 675-1021, and by e-mail at "cees@igc.apc.org". ■

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