National Security
SCIENCE AND TECHNOLOGY
Strategy

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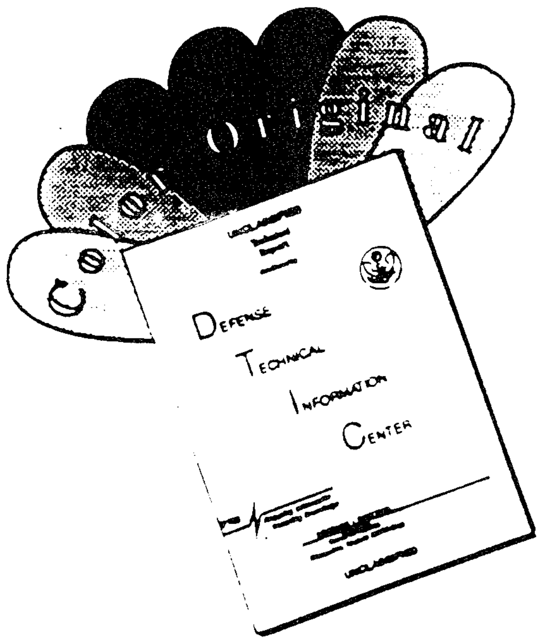

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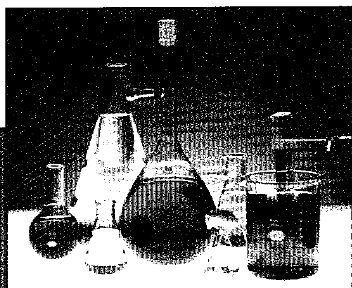
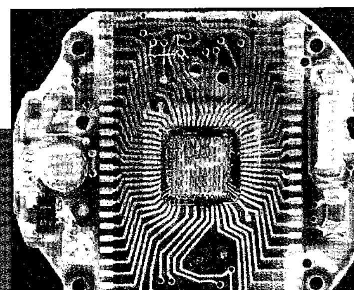
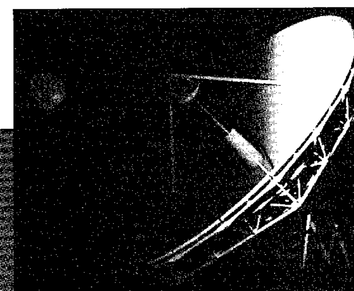
National Security SCIENCE AND TECHNOLOGY Strategy

THE WHITE HOUSE

WASHINGTON

The National Security Science and Technology Strategy

As we move into the next century, our nation's security will depend upon our continued commitment to leadership and engagement in global affairs. The challenges that we face will be increasingly complex and our ability to meet those challenges will be greatly influenced by the wisdom of our investments in science and technology.

This *National Security Science and Technology Strategy* presents a comprehensive approach to bringing science and technology to the service of our nation's security and global stability. This strategy supports the goals of my Administration's *National Security Strategy of Engagement and Enlargement*. It highlights the importance of U.S. investments in science and technology to preventing conflict and maintaining the strength and capabilities of our Armed Forces.

Our nation's security derives from a combination of diplomatic leadership, economic strength and military might. Advances in science and technology underlie this strength, giving rise to the discoveries that lead to new industries and to the improvements that make our industries more efficient and environmentally sound. By engaging economies abroad, cooperation in science and technology integrates states into a larger economic and political order that acts against division and conflict.

Improving global stability also demands that we put scientific insights and technology to work to promote sustainable development. No country is isolated from the consequences of newly emerging diseases, environmental degradation, or other global threats--even if the roots of these problems lie in distant parts of the world. The tragedy of AIDS has made this clear. Cooperation in science and technology to prevent and mitigate threats to society moves us forward, toward a world of free citizens, instead of victims and combatants.

Investments in science and technology are critical to military preparedness, enabling us to stay at the cutting edge of new developments so that our Armed Forces remain the best trained, best equipped, and best prepared in the world. Advancing the technologies of monitoring, verification, and dismantlement allow us to pursue a vigorous program to control the proliferation of weapons of mass destruction, including a Comprehensive Test Ban, the extension of the Nuclear Nonproliferation Treaty, and strengthened Biological Weapons and Chemical Weapons Conventions, as well as control of fissile materials. We have made great progress in dismantling the arsenals of mass destruction that are a legacy of the Cold War. This report describes collaborative U.S.-Russia efforts to protect, control, and account for nuclear weapons materials, the most pressing nonproliferation challenge of the post-Soviet era. Yet much remains to be done. Mobility has increased the availability of the technology and essential ingredients of weapons of mass destruction.

Assuring the security and well-being of this nation is my fundamental Constitutional responsibility. My Administration is committed to a comprehensive strategy for harnessing science and technology to accomplish these aims. Many of these investments are severely threatened by proposed Congressional budget cuts; such a retreat must be resisted. Our strategy of investment and international cooperation in science and technology will better assure our success today and in the future.

his document was prepared under the guidance of the National Science and Technology Council (NSTC). The NSTC, chaired by the President, is a Cabinet-level council charged with coordinating science, space, and technology policies throughout the Federal Government. An important objective of the NSTC is to establish clear national goals for federal science and technology investments. The NSTC includes the Vice President, the Assistant to the President for Science and Technology, the Cabinet Secretaries and agency heads with responsibility for significant science and technology programs, and other key White House officials.

The Committee for National Security of the National Science and Technology Council produced this document, with Chapter 4 prepared in cooperation with the NSTC Committee on International Science, Engineering, and Technology. While the members of these committees brought the perspectives of the Federal agencies in which they serve, they also accounted to a larger interagency review of Federal science and technology expenditures aimed at ensuring our nation's security with maximum efficiency and efficacy. In this undertaking, both committees relied upon a staff team from the White House Office of Science and Technology Policy. Significant and valued contributions were made by agency representatives who represented Committee principals and who also reflected the spirit of interagency collaboration.

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The Office of Science and Technology Policy staff team includes Dr. Gerald J. Hane, Lt. Col. Thomas A. Fuhrman, USAF, and Dr. Christopher F. Chyba.

I

National Security Science and Technology Strategy

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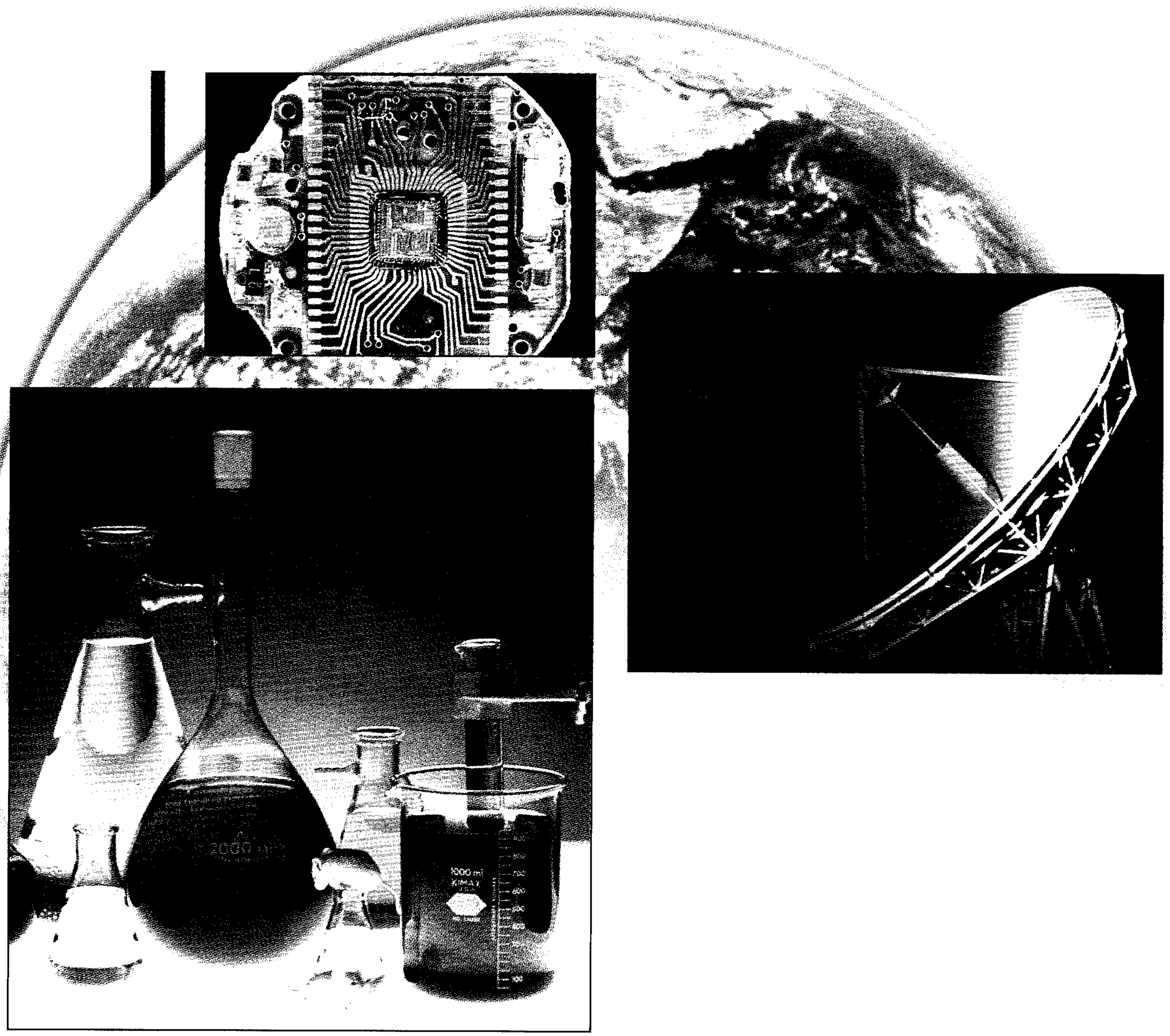


This national strategy builds on the ideas and recommendations offered in a forum on *The Role of Science and Technology in National Security and Global Stability* held March 29 and 30, 1995, as well as the following policy documents: *A National Security Strategy of Engagement and Enlargement* (February 1995); *Defense Science and Technology Strategy* (September 1994); *National Military Strategy of the United States of America* (February 1995); *Annual Report to the President and the Congress—William J. Perry, Secretary of Defense* (February 1995); *Second to None: Preserving America's Military Advantage Through Dual-Use Technology* (February 1995); *Dual-Use Technology: A Defense Strategy for Affordable, Leading-Edge Technology* (February 1995); *Science and Technology, A Report of the President* (1995); *Technology for America's Economic Growth* (February 1993); *Bridge to a Sustainable Future, National Environmental Technology Strategy* (April 1995); *Strategies for Sustainable Development* (March 1994); *Addressing Emerging Infectious Disease Threats* (1994); *Committee on National Security—Strategic Implementation Plan* (March 1995), and *Committee on International Science, Engineering, and Technology—Strategic Implementation Plan* (March 1995); *Committee on Education and Training—Strategic Implementation Plan* (March 1995).

Executive Summary

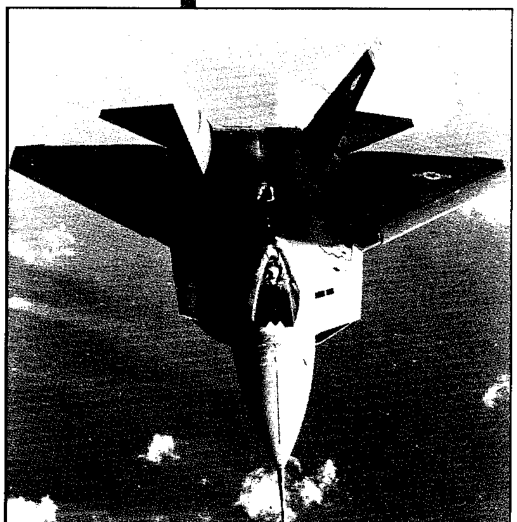
In March 1995, President Clinton ordered a sweeping reexamination of the United States Government's approach to putting science and technology to the service of national security and global stability in light of the changed security environment, increasing global economic competition, and growing budgetary pressures. This *National Security Science and Technology Strategy,* the product of that reexamination, is the country's first comprehensive Presidential statement of national security science and technology priorities. It augments the President's *National Security Strategy of Engagement and Enlargement* by articulating science and technology policies and initiatives that support the President's three primary national security objectives: enhancing our military readiness and capabilities, preventing conflict from occurring through engagement with other nations, and promoting prosperity at home. It advances that document's central approach of preventing conflict and maintaining the capability to respond should conflict occur. It is built on the recognition that our security depends on economic strength as well as military power. And it is grounded in the conviction that investment in science and technology is central to our ability to meet the challenges ahead. This *National Security Science and Technology Strategy* defines our new approaches to applying science and technology to the challenges that most directly affect our nation's security.

New Realities

The *National Security Science and Technology Strategy* recognizes that, with the end of the Cold War, our nation faces more diverse and complex challenges. The central security concern of the past half century—the threat of communist expansion—is gone, but civil conflict is spreading and rogue states pose a danger to regional stability. The rapid diffusion of information, people, capital, and technology raises the risk of proliferation of advanced weapons, including weapons of mass destruction. And demographic pressures contribute to large-scale environmental and resource degradation, which saps economic strength and can undermine political order. Meeting these modern-day threats to stability and security requires an enduring commitment to diplomatic engagement, military readiness, and economic performance. In each instance, science and technology cooperation and investments play a central role. For five decades, scientific discovery and technological innovation have advanced our military capabilities and economic prosperity, ensuring the United States' position as a world leader. Now, as the demands of international leadership are growing, so too are the demands on our financial resources. This document describes how investments and international cooperation in science and technology can contribute to our national security goals in a fiscally responsible manner.

Maintaining Military Strength

In the military arena, the challenge is to ready our forces to address a more varied set of threats while at the same time downsizing and restructuring our forces to respond to the defense needs of the 21st century. To achieve these objectives, the Administration has launched a series of initiatives designed to develop and apply the most advanced technologies, maintain critical defense-related industrial capabilities, and accomplish these goals in the most affordable manner.



The Administration is committed to a sustained investment in the technology base needed to ensure that our nation maintains the best-trained and best-equipped forces in the world. Our investment strategy involves long-term research as well as near-term applications as it is only in hindsight that we are able to discern the revolutionary military capabilities provided by breakthroughs such as radar, digital computers, semiconductor electronics, lasers, fiber optics, and navigation systems capable of great accuracy.

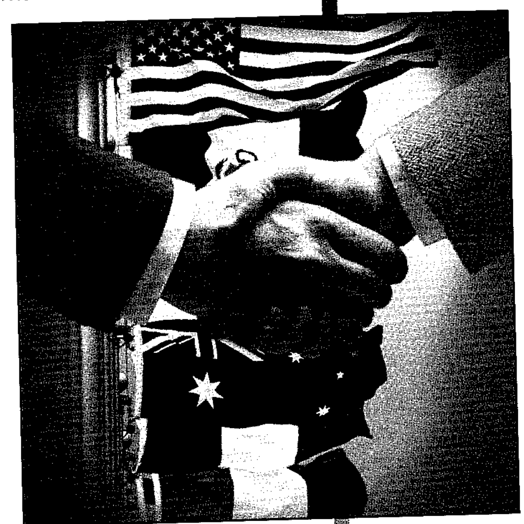
New technologies have dramatically enhanced our ability to both prepare for and execute military actions. By supporting advances in information technologies, sensors, and simulation, we strengthen our ability to plan and conduct military operations, quickly design and produce military systems, and train our forces in more realistic settings. These technologies are also central to greater battlefield awareness, enabling our forces to acquire large amounts of information, analyze it quickly, and communicate it to multiple users simultaneously for coordinated and precise action. As Defense Secretary William J. Perry has noted, these are the technological breakthroughs that are "changing the face of war and how we prepare for war."

Steady investment in science and technology also underlies our ability to succeed in high-priority missions, to minimize casualties, to mobilize all of our military services swiftly in coordinated action, and to act in concert with other nations to achieve shared security objectives. New technologies are being developed to strengthen our efforts in peacekeeping, counterproliferation, counterterrorism, and the stewardship of a safe and reliable nuclear weapons stockpile. Technological advances are also being pursued to fortify the joint fighting capabilities of our services. And advanced technologies support multilateral efforts to enhance mutual defense capabilities through standardization and interoperability with the forces of friendly and allied countries.

To increase the performance and reduce the costs of new defense technologies, the Administration has launched initiatives that reflect new ways of doing business. *Acquisition reform* removes barriers that separate the defense industry from the commercial industry and thus ensures that the military acquires the highest quality equipment at the lowest cost. Our *dual-use technology policy* recognizes that our nation can no longer afford to maintain two distinct industrial bases and allows our armed forces to exploit the rapid rate of innovation of commercial industry to meet defense needs. The *Technology Reinvestment Project* supports that policy by leveraging commercial technology advances to create military advantage. In addition, to continue the development of advanced, operationally-relevant technologies without making expensive commitments to product procurement, the Administration has developed the *Advanced Concept Technology Demonstration* initiative.

Controlling Arms and Stemming the Proliferation of Weapons of Mass Destruction

Stemming the proliferation of weapons of mass destruction is a priority that requires both science and technology investments and cooperation. The United States is expanding its cooperation with the states of the former Soviet Union to dismantle the massive arsenals left from the Cold War at an accelerated pace, to ensure that weapons and weapons materials are secure and accounted for, to assure the scientifically sound disposition of these materials, and to employ former weapons scientists in needed civilian research.



The Administration is pursuing a broad range of efforts to reduce existing military threats and stem the spread of weapons of mass destruction and their missile delivery systems, including new agreements, improved safeguards, and new technologies for monitoring and verification. We have secured agreements with Ukraine, Belarus, and Kazakstan to send all the nuclear weapons on their soil to Russia. We have also achieved an indefinite extension of the *Nuclear Nonproliferation Treaty*, and we are working toward a *Comprehensive Test Ban Treaty* and *Ban on Fissile Materials*; for the ratification of the *Chemical Weapons Convention*; and the strengthening of the *Convention on Biological Weapons*.

Science and technology are fundamental to arms control treaty verification and nonproliferation. The Administration's strategy for investing in science and technology to support our nonproliferation and arms control policies focuses on three critical elements: strengthening the technical know-how to build effective arms restraint; continually improving detection, monitoring, and verification capabilities; and promoting science and technology cooperation to advance arms reduction and nonproliferation goals.

Meeting the Challenge of Global Threats

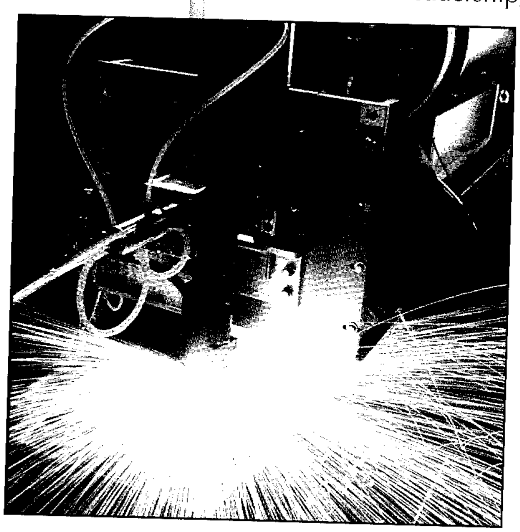
The Administration recognizes that there is a broad class of global threats that endangers the security and well being of Americans and others around the world. The United States is not isolated from the effects of disease, disasters, or human suffering abroad. In the modern world, diseases readily cross borders; chronic hunger can set off a cycle of instability and migration that can lead to war; and environmental degradation can have global consequences that threaten the populations of all nations. Our strategy for addressing these challenges rests on three pillars: preventive diplomacy, promoting sustainable economic development, and responding to global threats. In all aspects of this strategy, science and technology play a central role. By investing in research and monitoring, this Administration is seeking to mitigate stresses that can lead to conflict, strengthening efforts in population stabilization, food security, resource stewardship, natural disaster mitigation, infectious disease control, and the promotion of scientific knowledge.

Scientific research and monitoring underlie our ability to respond to threats such as climate change and biodiversity loss. Global surveillance and basic biomedical research are key to addressing emerging and reemerging infectious disease. The Administration is putting into place a national response to this threat and is working to improve international monitoring efforts. Science and technology can also assist population stabilization through education, planning, reproductive health care, and better methods of contraception; food security through increased agricultural productivity and improved food preservation, storage, and distribution; resource stewardship through research that strengthens the sustainable management of temperate and tropical forests, coastal and marine resources; natural disaster mitigation through developing and implementing technologies for both monitoring and mitigation; and the promotion of scientific knowledge about sustainable development through electronic networks.

To strengthen policies in these areas, the Administration has pursued a strategy of comprehensive science and technology cooperation with countries in transition with the goal of promoting scientific discovery and technological innovation. While in each instance the fundamental objective is the advancement of knowledge, these "country strategies" are designed to strengthen the science and technology communities in these countries so that they might contribute to political and economic reform, economic growth, regional stability, and sustainable development.

Strengthening Economic Security

Our nation's security and global stability depend fundamentally on the strength of our economy and a vibrant, open, international economic system. Our ability to exercise international leadership, maintain military readiness, and build a safer and more secure world depends on the vitality of our economy. Our economic engagement with other nations strengthens regional stability and acts to mitigate sources of conflict.

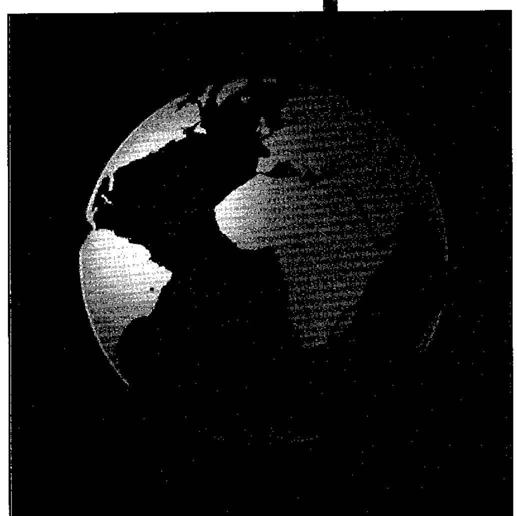


To advance our economic security at home, this Administration places priority on creating a climate that fosters private-sector innovation: supporting industry-led partnerships for advanced technology development, facilitating the rapid deployment of civilian technologies, building a 21st century infrastructure, maintaining strong support for basic science, supporting education in science and technology, leveraging dual-use technologies for commercial markets, and promoting international economic development and trade through international collaboration.

These investments strengthen innovation and the economy by sharing risks, enhancing communication, investing in the creation of new knowledge, improving the infrastructure for societal development, and promoting links to other nations so that we move forward with the best information and with access to global markets, strengthening economic stability globally as we enhance security at home.

Economic security also lies in the creation and expansion of free markets and the integration of other nations into a larger, more open economic order. We pursue these objectives by promoting U.S. trade with and investment in not only established trading partners but also economies in transition. Our engagement with these rapidly changing economies encourages their adoption of the norms of free trade—thereby reducing international tensions; provides the United States with access to capabilities found abroad that strengthen our economy; and promotes economic growth and political stability in regions throughout the world. The Administration's "country strategies" for comprehensive science and technology cooperation are designed to advance these goals.

Other Contributions



Finally, underlying this *National Security Science and Technology Strategy* is a recognition that the Federal Government is but one player in advancing the security of our nation. Industry, academia, nongovernment organizations, and individuals also play important roles. For example, throughout the Cold War, Western scientists and scholars worked with their Soviet counterparts to advance scientific discovery and to build a basis for cooperation in arms reduction and nonproliferation. By sustaining and expanding these professional ties in the post-Soviet era, they can strengthen the Russian scientific community, which is a force for political reform and whose participation in the Russian economy is essential to economic reform. Now private-sector investments in economies in transition can fuel economic growth that is the basis for political stability. Universities, nongovernmental organizations, labor, and industry can all play a major roles in promoting the security of our nation.

In Summary

The security of this nation depends on our unwavering commitment to international engagement and science and technology investments designed to address the complex challenges that we face. This *National Security Science and Technology Strategy* describes the Administration's approach to cooperation and investment in science and technology to keep our nation strong, prosperous, and secure.

rotecting our nation's security—our people, our territory and our way of life—is my Administration's foremost mission and constitutional duty. The end of the Cold War fundamentally changed America's security imperatives. The central security challenge of the past half century—the threat of communist expansion—is gone. The dangers we face today are more diverse. Ethnic conflict is spreading and rogue states pose a serious danger to regional stability in many corners of the globe. The proliferation of weapons of mass destruction represents a major challenge to our security. Large scale environmental degradation, exacerbated by rapid population growth, threatens to undermine political stability in many countries.

William J. Clinton
A National Security Strategy of
Enlargement and Engagement, 1995

I

Introduction

The end of the Cold War has created opportunities for greater peace and prosperity as well as new challenges to our nation's security. To seize the opportunities and meet the challenges of the post Cold War era, the Administration has developed a comprehensive approach to putting science and technology to the service of national security and global stability. This *National Security Science and Technology Strategy* recognizes that our nation's security rests on three pillars: the readiness and capabilities of our military forces, our engagement with other nations to prevent conflict from occurring, and the strength of our economy. The strategy supports the Administration's overall national security policies as articulated in *A National Security Strategy of Engagement and Enlargement* and is grounded in the conviction that advances in science and technology are a vital part of the solution to many of the problems that we face.

A central theme of the Administration's national security policy is the prevention of conflict combined with a readiness to use force, should force be required. Key to this theme is a priority on engagement with other nations. Rather than isolate a state as we did the Soviet Union, we now seek to integrate states such as Russia, China, and others into a larger political and economic order, creating a web of relationships—including scientific and commercial relationships—that give us a shared interest in stability.

For the past five decades, our nation's investment in its science and technology enterprise has been central to ensuring our position as a global leader. U.S. military capabilities and economic prosperity, as well as sustained global economic development are all advanced by progress in science and technology. However, the challenges of international leadership and national security are growing more complex, resulting in greater demands than ever on our investment resources. This *National Security Science and Technology Strategy* describes how our nation's investments in science and technology support our overall national security objectives in this evolving environment.

Military capabilities second to none. Military strength is essential both to prevent and respond to conflict. Unparalleled military capabilities can dissuade an aggressor and enable the United States to act decisively in times of crisis, and technological superiority is essential to our military advantage. For example, stealth, precision guidance, and advanced communications—all products of science and technology—are critical to military success. Although the United States has reduced its nuclear arsenal, we will retain strategic nuclear forces sufficient to deter nuclear attack against the United States, our friends, and allies and to convince future hostile governments that seeking a nuclear advantage would be futile.

However, the use of military force can be costly in American lives and national resources. Because the costs of responding to conflict can quickly outweigh the costs of preventing conflict from occurring in the first place, this Administration places a high priority on conflict prevention.

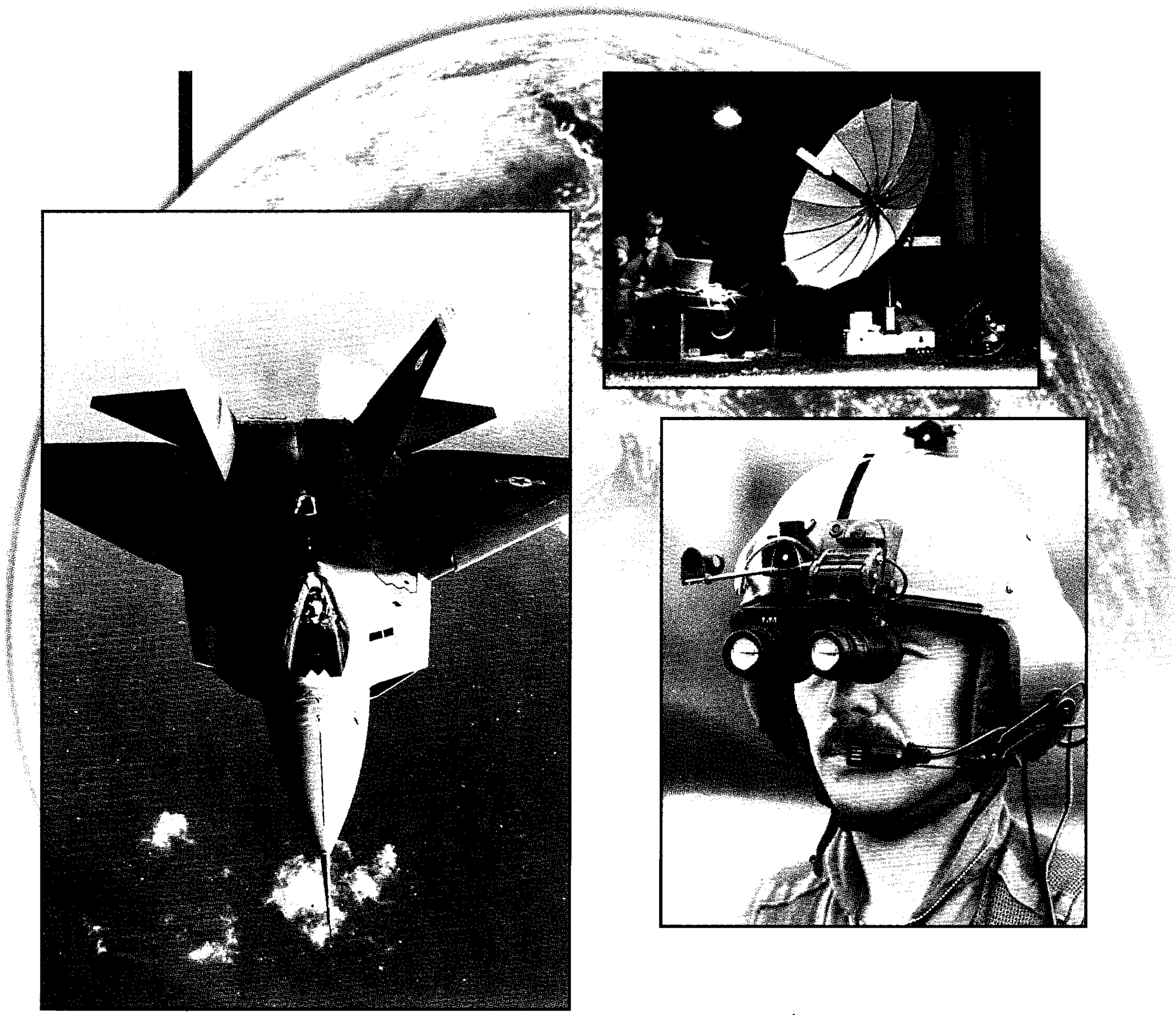
Engagement for the prevention of proliferation. Conflict prevention requires that we not only maintain superior military capabilities but that we address sources of instability as well, including the arms race dynamic that accompanies the accumulation of advanced weaponry by regional powers. Preventing the proliferation of weapons of mass destruction—and countering those that do spread—is a priority that requires both science and technology investments and cooperation. This Administration is expanding and accelerating its cooperation with the States of the former Soviet Union to dismantle the massive arsenals left from the Cold War at an accelerated pace; to ensure that weapons and weapons materials are secure and accounted for; and to employ former weapons scientists in needed civilian research. This Administration is also working to strengthen international efforts to stem the spread of weapons of mass destruction and their delivery systems including new agreements and improved safeguards. Advances in detection and monitoring technologies are fundamental to arms control treaty verification, nonproliferation, and counterproliferation.

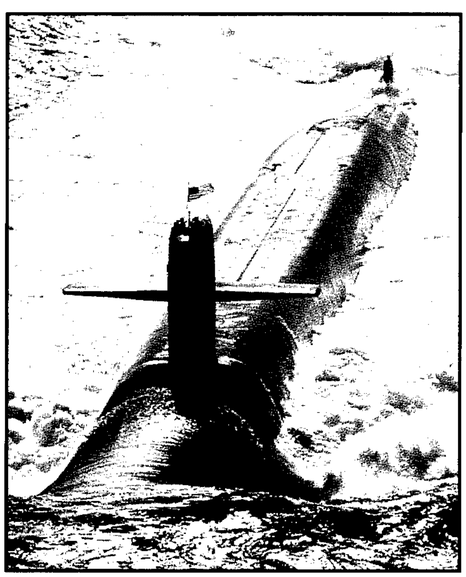
Addressing root causes of conflict. The strategy of conflict prevention also addresses the sources of stress that lead to instability. Endemic poverty, overpopulation, food and resource scarcity, environmental degradation, and the spread of infectious disease can lead to mass migrations, the breakdown of civil order, and ultimately conflict. Mitigating these stresses demands the sustained engagement of many nations, rather than the occasional interventions of one. Cooperation in science and technology plays a vital role in addressing these sources of conflict by contributing to sustained economic development, by building capacity in science and technology, and by promoting the advancement of knowledge.

Building from a strong economy. This Administration recognizes that our nation's security derives from a combination of economic strength and military might. A strong economy provides the United States with the resources for leadership in international affairs. A vibrant high-technology industrial sector enhances our national economic performance while providing the technological base that underpins advanced military capabilities. Policies to accelerate scientific discovery and technological innovation are thus of high priority to this Administration. A key aspect of this effort is international science and technology cooperation which contributes to the development of free market economies, while helping to create and expand markets for U.S. goods and services.

Finally, underlying this strategy is a recognition that the Federal Government is but one player in advancing the security of our nation. Industry, academia, nongovernment organizations, and individuals also play important roles. For example, throughout the Cold War, Western scientists and scholars worked with their Soviet counterparts to advance scientific discovery and build a basis for cooperation in arms reduction and nonproliferation. By sustaining and expanding these professional ties in the post-Soviet era, they can strengthen the Russian scientific community, which is a force for political reform and whose participation in the Russian economy is essential to economic reform. New private-sector investments in economies in transition can fuel economic growth that is the basis for political stability.

The *National Security Science and Technology Strategy* reflects the complexity of the new security environment, sustains our traditional strengths, and enhances our capacity to meet evolving challenges to the long-term security of our nation.





nhancing American security requires, first and foremost, developing and maintaining a strong defense capability of forces ready to fight.

A National Security Strategy of Engagement and Enlargement, 1995

I

Maintaining Military Advantage Through Science and Technology Investment

National defense is fundamental to the President's *National Security Strategy of Engagement and Enlargement.* In pursuing its military strategy, the Administration faces the dual challenge of readying U.S. forces to address a more diverse set of threats while at the same time downsizing and restructuring our forces to respond to the defense needs of the 21st century. The Administration has launched a series of initiatives designed to capture and apply science and technology to respond to these challenges, focusing on the following objectives: supporting our military forces in the range of missions they can be assigned, reducing acquisition costs, and nurturing a healthy national science and technology infrastructure to spawn innovation and the vital industrial capacity to capitalize on it.

Science, Technology, and Military Strength

Our defense science and technology investment enables us to counter military threats and to overcome any advantages that adversaries may seek. It also expands the military options available to policymakers, including options other than warfare in pursuing the objectives of promoting stability and preventing conflict. Science and technology help to counter special threats such as terrorism that cannot be met by conventional warfighting forces, and they underpin the intelligence capabilities necessary to assess the dangers our nation faces. The U.S. military also relies on science and technology to make our advanced military systems more affordable through their entire life cycle. And by maintaining a close dialogue with the warfighters, the defense S&T community not only remains sensitive to user needs but also sensitizes the user to the possibilities that technology offers for responding to evolving threats.

U.S. military capabilities not only protect the United States and its citizens from direct threats, they also help maintain peace and stability in regions critical to U.S. interests and underwrite U.S. defense commitments around the world. Maintaining a strong defense capability means that the U.S. Armed Forces, and the Department of Defense more broadly, must be prepared to conduct the following kinds of missions, as described in the President's national security strategy:

- *Deterring and defeating aggression in major regional conflicts.* U.S. forces must be capable of offsetting the military power of regional states with interests opposed to those of the United States and its allies. To do this, the United States must be able to deter and, if necessary, defeat aggression, in concert with regional allies, by projecting and sustaining U.S. power in two major regional conflicts that occur nearly simultaneously.

- *Providing credible overseas presence.* Some U.S. forces must be forward deployed or stationed in key overseas regions in peacetime. These deployments contribute to a more stable and secure international environment by demonstrating U.S. commitment, deterring aggression, and underwriting important bilateral and multilateral security relationships. Forward stationing and periodic deployments also permit U.S. forces to gain familiarity with overseas operating environments, promote joint and combined training among friendly forces, improve interoperability with friendly forces throughout the world, and respond in a timely manner to crises.

- *Conducting contingency operations.* The United States must be prepared to undertake a wide range of contingency operations in support of U.S. interests. These operations include smaller-scale combat operations, multilateral peace operations, noncombatant evacuations, counterterrorism activities, and humanitarian and disaster relief operations.

- *Countering weapons of mass destruction.* While the United States is redoubling its efforts to prevent the proliferation of weapons of mass destruction and associated missile delivery systems, we must at the same time improve our military capabilities to deter and prevent the effective use of these weapons. We are pursuing this objective by sustaining adequate retaliatory capabilities and by increasing our capabilities to defend against weapons of mass destruction, to locate and neutralize or destroy them before they are used during a conflict, and to fight in an environment in which such weapons have been used.

Finally, to meet all these requirements successfully, U.S. forces must be capable of responding quickly and operating effectively across a wide range of environments. That is, they must be ready to fight. Such high combat readiness demands well qualified and motivated people; adequate amounts of modern, well-maintained equipment; realistic training; strategic mobility; and sufficient support and sustainment capabilities.

The science and technology programs that support our military forces are conducted primarily by the Department of Defense, the Department of Energy, and the Intelligence Community—with contributions from many other Federal agencies. The following strategy elements guide our overall science and technology investment:

- *Maintain technological superiority in warfighting equipment.* Technological superiority underpins our national military strategy, allowing us to field the most potent military forces by making best use of our resources, both economic and human. It is essential for the United States to maintain superiority in those technologies of critical importance to our security.

- *Provide technical solutions to achieve the Future Joint Warfighting Capabilities.* The Joint Chiefs of Staff have identified the warfighting capabilities most needed by our military in the future (see box p. 10, "Future Joint Warfighting Capabilities"). Our S&T investment must be aimed at securing these needed capabilities.

- *Balance basic research and applied technology in pursuing technological advances.* Today's basic research lays the foundation for tomorrow's innovative development. To make possible the greatest range of options and avoid technological surprise, we must apply resources broadly at the basic research level and make further investment decisions as emerging technologies reveal the most promising payoff areas.

- *Incorporate affordability as a design parameter.* The cost of advanced technology systems must not be allowed to spiral upward uncontrolled. Affordability must be integrated into the design of military systems from the beginning, and improvements must be incorporated throughout their life cycle with the integration of new technology.

Defense Research and Engineering

The Defense Department science and technology program is organized to support the missions described in the *National Security Strategy of Engagement and Enlargement.* It is responsive to the warfighting requirements articulated by the Joint Chiefs of Staff as well as to the mission requirements of the military departments. The Director of Defense Research and Engineering is responsible for the direction, overall quality, and content of the Department of Defense science and technology program.

The Department of Defense S&T program is organized into three categories: basic research, exploratory development, and advanced technology development. Basic research is the element of the S&T program that seeks to increase knowledge and understanding of science. It is the foundation on which future technological superiority is based. Twelve fields of inquiry, listed in the box at top right, compose the Defense Department's basic research program. The two other components, exploratory development and advanced technology development, make up the Defense technology program. This program is centered around the 19 technology areas listed in the box at lower right. The exploratory development program provides proof-of-concept experiments and evaluations built around models and laboratory experiments, while the advanced technology development program evaluates the effectiveness of technological advances in providing required military capabilities. In total, the three components that make up the program are highly interrelated, as sharp distinctions between research and development phases no longer apply.

The defense science and technology program is planned and conducted by the military services and Defense agencies. The Departments of the Army, Navy, and Air Force train and equip the military forces and use the S&T program to provide warfighting options for their service components. The defense agencies are responsible for specified cross-service aspects of the overall program and execute designated programs in support of national security objectives. The Advanced Research Projects Agency is charged with seeking breakthrough technology and with investing in technologies that are referred to as "dual use" because they have both defense and commercial applications. The Director of Defense Research and Engineering, in collaboration with the military departments and other Defense agencies, prepares the *Defense Science and Technology Strategy* and a technology plan which describes the focus and content of the overall Defense technology effort, including goals, objectives, and schedules.

Basic Research Fields of Inquiry

Atmospheric and Space Science
Biological and Medical Sciences
Chemistry
Cognitive and Neural Sciences
Computer Sciences
Electronics
Materials Science
Mathematics
Mechanics
Ocean Sciences
Physics
Terrestrial Sciences

Technology Areas for Exploratory Development and Advanced Technology Development

Aerospace Propulsion and Power
Air Vehicles and Space Vehicles
Battlespace Environments
Biomedical Applications
Chemical and Biological Defense
Individual Survivability and Sustainability
Command, Control, and Communications
Computing and Software
Conventional Weapons
Electronics
Electronic Warfare and Directed Energy Weapons
Environmental Quality and Civil Engineering
Human Systems Interface
Manufacturing Science and Technology
Manpower, Personnel, and Training
Materials, Processes, and Structures
Modeling and Simulation
Sensors
Surface/Under Surface Vehicles and Ground Vehicles

Priorities of the Department of Defense S&T Program

Information technology, sensors, and modeling and simulation are high priority S&T programs in the Department of Defense. Information technology and sensors have the potential to dramatically improve all aspects of future military capabilities, while modeling and simulation have already made major contributions to training, readiness, weapons design, and acquisition management. Together, these technologies can significantly reduce combat losses in lives and equipment.

Information technologies have changed the battlefield. They enable better performance of current platforms, weapons, sensors, and people. Today, electronics and software add capability to almost every complex system. Information technologies are the basis for continual improvements in communications; intelligence gathering, analysis, and distribution; precision

Counterproliferation of Weapons of Mass Destruction

In early 1995 the Counterproliferation Program Review Committee, chaired by the Secretary of Defense and composed of the Secretary of Energy (as Vice Chair), the Director of Central Intelligence, and the Chairman of the Joint Chiefs of Staff, conducted a comprehensive assessment of U.S. activities related to countering the proliferation of weapons of mass destruction. As a result of this assessment, the Secretary of Defense has taken measures to significantly strengthen Department of Defense science and technology efforts in counterproliferation to address shortfalls in U.S. operational capability.

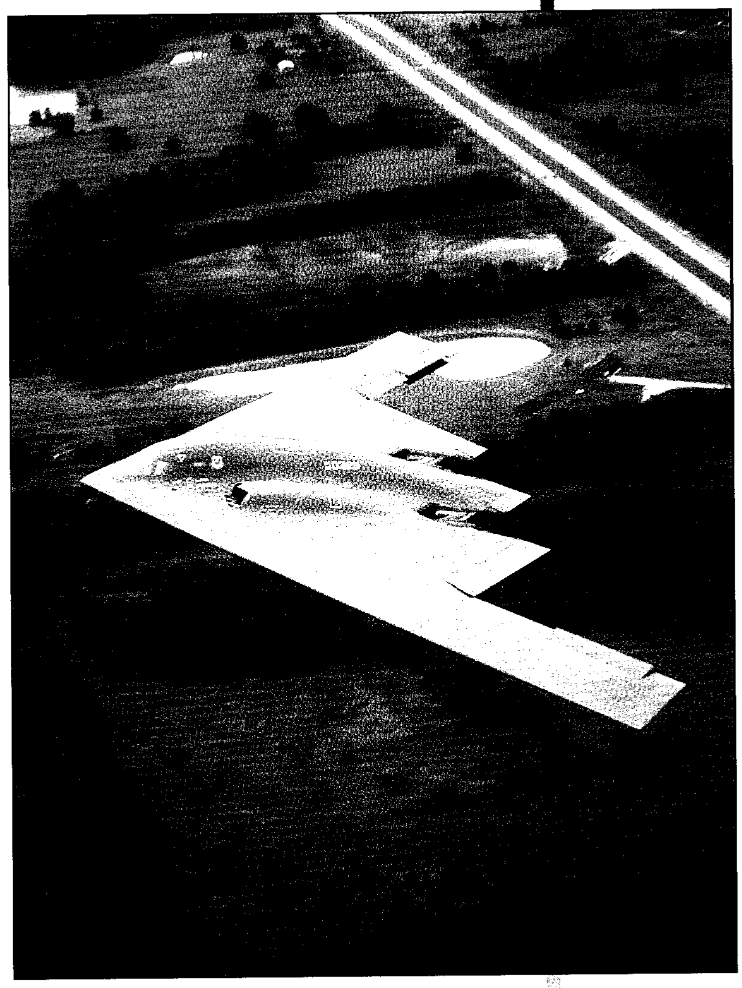
Counterproliferation spans the spectrum of diplomatic activities and military operations. As a Department of Defense mission, it includes support of proliferation prevention and intelligence activities; deterring the use of nuclear, chemical, and biological weapons; defending against such weapons and their effects; and maintaining a robust ability to find and destroy delivery forces and infrastructure elements with minimum collateral effects, should this become necessary.

In 1995, Congress provided $60 million to "jump-start" the counterproliferation program within the Department of Defense, and the Administration has requested $108 million for 1996. These funds are being used to accelerate development and deployment of essential military counterproliferation technologies and capabilities and to leverage existing Department of Defense investments relating to countering proliferation. The Defense Department has placed increased emphasis on detection technology, with a goal of accelerating by six years the deployment of biological and chemical agent remote detection and characterization systems. In addition, it is accelerating development of a new generation of hard target defeat and collateral effects prediction and mitigation capabilities, with the goal of demonstrating them within the next two years. The Department of Defense is also accelerating important proliferation prevention efforts such as initial 1996 fielding of enhanced capabilities to track nuclear, biological, and chemical related foreign shipments.

The Administration's continuing efforts in counterproliferation will focus on the identification and development of the most promising technologies for the detection and characterization of proliferation threats and for developing and providing capabilities to counter the spread of nuclear, chemical, and biological weapons; their infrastructure; and associated delivery systems.

strike capability; platform control; sensor data processing; and human performance. Our troops depend on accurate and timely battlefield information. The ability to collect, integrate, analyze, and deliver this information efficiently and rapidly is critical to battlefield advantage. And because of the amount of tactical information available, a principal challenge is processing the data into meaningful forms for battlefield decisionmaking.

Beyond the battlefield, the management of enormous amounts of data related to logistic support is an increasingly important and demanding requirement. There is often too much administrative overhead associated with ensuring that equipment and supplies are on hand. Information technology programs offer the means to significantly reduce overhead and enhance efficiency by accounting for supplies via automated sensor and computer links. We are applying advanced computer software and systems and communication technology to the task of rapidly sorting through large quantities of data and presenting logistic specialists with information in ways that permit efficient operations and reduced errors. Technology is also needed to help ensure that no enemy can disrupt the information systems on which we depend.



We seek to preserve an information advantage over the adversary in all conflicts. Military forces need 24-hour all-weather surveillance. They need the ability to see through foliage and camouflage, under water, and through the earth's surface. They need the ability to track difficult targets such as cruise, antiship, and ballistic missiles as well as quiet submarines. They need the means to positively distinguish friend from foe in combat. The military also needs to know if and where weapons of mass destruction are being produced and in what quantity.

Our investment in sensor technologies is focused on providing these capabilities. The sensor technology program is broadly based. The United States invests in radar sensors that can detect ground targets concealed by foliage and camouflage; advanced acoustic, magnetic, and laser sensors to detect and locate submarines and mines in shallow water; and sensor technologies that might support detection of buried structures and mines.

We seek to preserve an information advantage over the adversary in all conflicts.

Challenging requirements for sensors to aid in countering weapons of mass destruction must be met. First, the United States needs to be aware of the existence of facilities capable of creating nuclear, biological, or chemical materials. Second, the United States needs to monitor—typically at long distances—the output of such facilities and then track the movement and stockpiling of materials. Third, the United States needs better sensors to detect and identify the attributes of chemical and biological agents when released in the atmosphere or water. Last, the United States requires more accurate wideband radars,

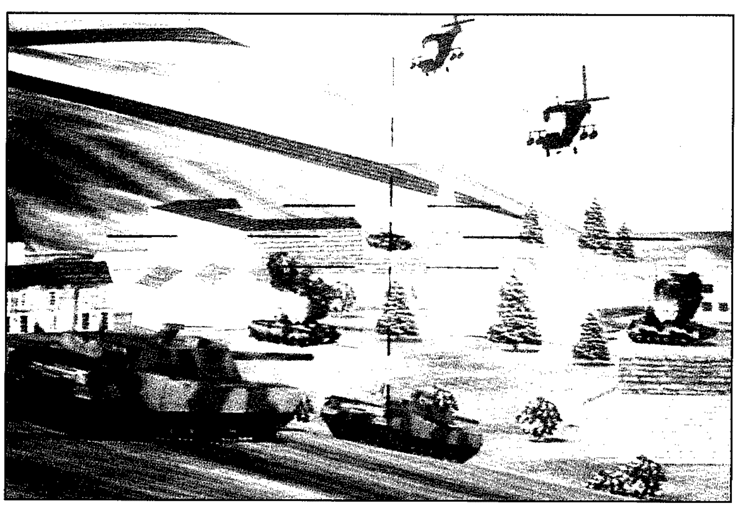
Future Joint Warfighting Capabilities

The National Security Act of 1947, as amended (50 USC Sec. 401), which provided for the organization of the Department of Defense, vested the overall direction and control of defense research and engineering in the Secretary of Defense. The Joint Staff and the Joint Requirements Oversight Council have identified five Future Joint Warfighting Capabilities most needed by our military. Those needs, coupled with technological opportunity, are used by the Director of Defense Research and Engineering to shape the defense investment portfolio.

The five Future Joint Warfighting Capabilities are as follows:

- To maintain near perfect real-time knowledge of the enemy and communicate that to all forces in near-real time.
- To engage regional forces promptly in decisive combat, on a global basis.
- To employ a range of capabilities more suitable to actions at the lower end of the full range of military operations which allow achievement of military objectives with minimum casualties and collateral damage.
- To control the use of space.
- To counter the threat of weapons of mass destruction and future ballistic and cruise missiles to the continental United States and deployed forces.

multispectral electro-optical sensors, and laser radars to detect ballistic missile launch, to target both cruise and ballistic missiles, and to discriminate missiles and reentry vehicles from chaff. Each of these priority needs is addressed in the President's 1996 budget.

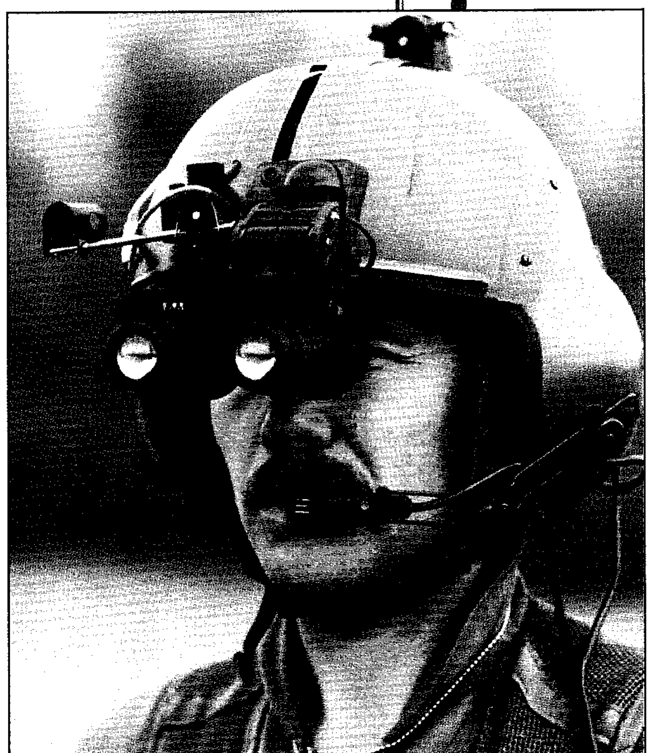


A battlefield sensor is part of a larger system. It must perform within the constraints of that system. It is particularly stressing where there is a requirement for a very rapid military reaction to a sensed input; for example, to detect and target a closing sea-skimming missile, to detect and target a ballistic missile during boost phase, and to perform quick friend versus foe identification. The Defense S&T program seeks both incremental enhancements and breakthroughs in this area.

Modeling and simulation are powerful tools with myriad high payoff applications. We are using them in training, planning, and the employment of our forces. They also offer a cost-effective means of enhancing readiness. In addition, we are using modeling and simulation to expand the range of alternatives evaluated during concept formulation and as an aid to planning and setting priorities for the Defense Department's S&T investment. Modeling and

Information Technologies To Ready Our Forces— Battlefield Digitization Technologies

Advances in information technologies contribute a growing array of strategic capabilities for our forces. New information technologies can provide high-resolution data about terrain, environmental, and tactical conditions that can be communicated to troops and their command instantaneously. One example of the application of these technologies is battlefield digitization.



Digitizing the battlefield is the application of commercial information technologies to acquire, exchange, and employ timely information throughout the battlespace, tailored to the needs of each commander, shooter, and supporter, allowing each to maintain the clear and accurate vision needed to support both planning and execution. Digitization allows the warfighter to communicate vital battlefield information instantly, rather than through slow voice radio and even slower liaison efforts.

The U.S. Army's strategy in digitizing the battlefield focuses Army technology efforts on applying commercial technology and developing critical military technologies. These include data compression; satellite-based communication and sensing; sensor and data fusion; advanced wireless communications; advanced lightweight, large-screen, high fidelity, and flat panel displays; multifunctional digital radios; microelectronics; and advanced distributed simulation.

simulation technology can augment the testing and evaluation of systems and hasten manufacturing with reduced cost. Simulations can be the basis for planning and decision aids to stretch the ability of commanders to train, to plan, and to employ their forces.

Challenges remain in the areas of virtual reality; use of extant communications; linking simulations to real-world exercises on live ranges; variable resolution of simulated entities; realistic semiautomated forces; validation that a simulation performs as specified; verification that a model or simulation sufficiently represents reality; and accreditation of a model or simulation as a suitable basis for exploring a particular issue.

The Defense S&T program will continue to be broad-based, spanning all defense-relevant sciences and technologies. The military services will continue to field robust programs in service-specific technologies: the Army in terrestrial science and armor materials; the Navy in ocean geophysics and acoustic signature analysis; and the Air Force in atmospheric physics and aerospace vehicles and propulsion systems.

Science and Technology To Combat Terrorism

A continuing challenge to the security of our nation stems from the threat of international and domestic terrorism. Terrorists, whether from well-organized or loosely organized groups, have the advantage of being able to take the initiative in the timing and choice of targets. Terrorism involving weapons of mass destruction represents a particularly dangerous potential threat that must be countered.

Countering terrorism effectively requires close day-to-day coordination among many Executive Branch agencies, including the Departments of State, Justice, Energy, and Defense; the Federal Bureau of Investigation; and the Central Intelligence Agency. Part of the challenge is to identify needs, seek common approaches, and coordinate the development of new technologies to counter terrorism. This is accomplished through the interagency Technical Support Working Group. Priority is given to projects that could be of use to more than one agency, such as portable X-ray machines. In addition, individual agencies conduct research and development for their own specialized needs. For example, the Federal Aviation Administration is developing improved aircraft cargo containers that can withstand explosive devices.

Within the past year, accomplishments include:

- A Department of Energy–developed nonintrusive detection system for chemical agents was successfully used by the U.S. Army during a recent excavation in Washington, D.C., of sealed World War I–era canisters containing chemical substances originally intended for military purposes.

- A detection agent for plastic explosives was developed and tested, an important step in support of the international Convention on the Marking of Plastic Explosives for the Purpose of Detection.

- A portable briefcase-size X-ray system has been developed and is going into production for use in identifying potential explosives.

Additional projects under way include a "smart" detector for shielded nuclear materials; the development of enzymatic decontamination foam surfactants for rapid cleanup of chemical or biological agents; detectors for quickly identifying the presence of biological agents; and passive tagging systems and laser data relay systems to support enhanced surveillance and intelligence operations for counterterrorism purposes.

The U.S. Government is also cooperating with other nations in counterterrorist technology development. Work has begun with Britain, Canada, and Israel involving an initial set of 17 joint projects. This international effort will enhance the research efforts for both the United States and participating nations. Fighting terrorism is a goal we share with our allies and a mission that we can more effectively achieve by jointly applying resources and expertise.

Defense Programs in the Department of Energy

Nuclear Stockpile Stewardship

To reduce the global nuclear danger, the United States and Russia are implementing unprecedented arms reduction agreements by rapidly dismantling large portions of the U.S. and former Soviet nuclear arsenals. In 1992 the United States entered a moratorium on underground nuclear testing, halted the development and production of new nuclear weapons; and began closing portions of the weapons complex no longer needed to support the stockpile of the future. But the United States will continue to maintain nuclear forces of sufficient size and capability to deter nuclear attack against the United States or its friends and allies by any future adversary with access to strategic nuclear forces.

The Clinton Administration is committed to ensuring the safety, security, and reliability of our enduring nuclear weapons stockpile and has developed the science-based Stockpile Stewardship and Management Program to meet this national need. This technical program aims to maintain our high level of confidence in the safety and performance of our nuclear weapons as we pursue our arms control and nonproliferation objectives.

The Stockpile Stewardship and Management Program will give us the ability to respond to problems concerning the safety or reliability of the stockpile in a timely manner by maintaining our national expertise in nuclear weapons. The functions of the program are monitoring and evaluating the stockpile; modifying and repairing present weapon systems while ensuring full confidence in their operability; demonstrating manufacturing capability; certifying and recertifying the safety and performance of weapons; and most important, maintaining the competency base of nuclear weapons experts.

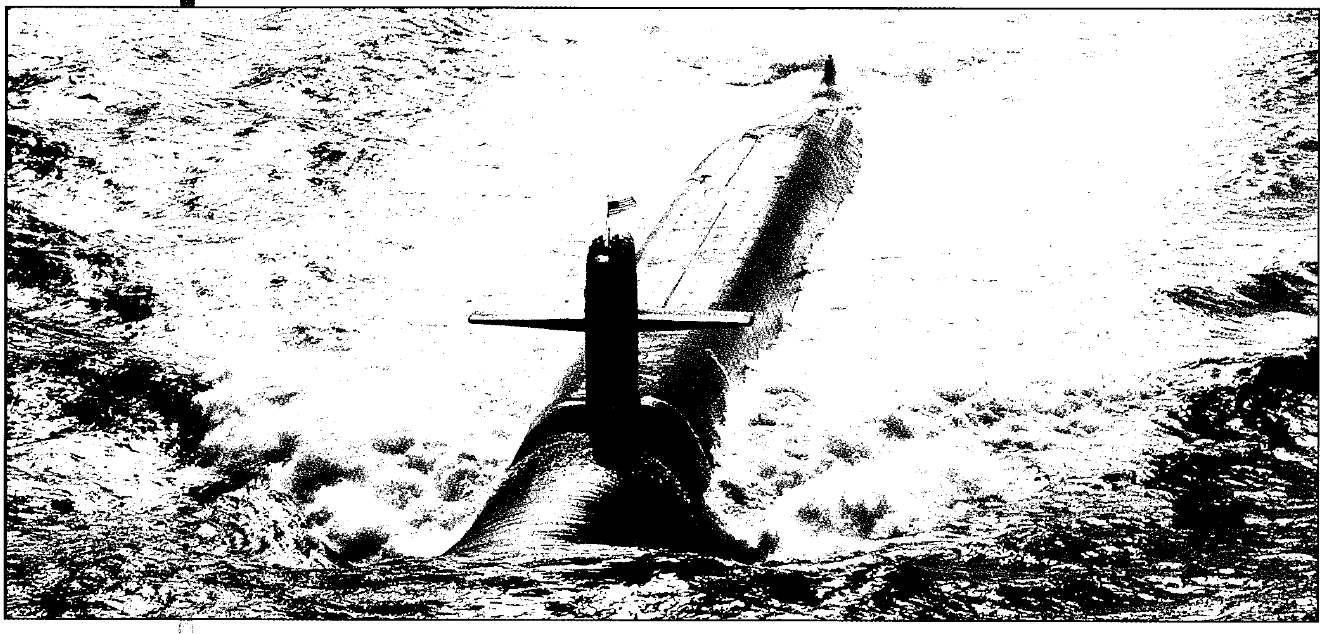
The Clinton Administration is committed to ensuring the safety, security, and reliability of our enduring nuclear weapons stockpile and has developed the science-based Stockpile Stewardship and Management Program to meet this national need.

The new program changes the weapons stewardship paradigm from a large and expensive complex with excess capacity to a capability-based complex able to meet the requirements of the future stockpile. The nuclear weapons laboratories will assume more responsibility for production and remanufacturing capability in addition to their responsibilities for scientific understanding. Retaining the capability to rebuild our stockpile in a national emergency is an important condition to the consideration of further reduction in our active stockpile.

S&T Priorities for Defense Programs in the Department of Energy

The Stockpile Stewardship and Management Program is intended to gain an improved scientific understanding of age-related changes that might affect system safety or performance. Improved understanding of warhead behavior over time will be obtained from enhanced computational and experimental capabilities. Enhancements essential to computational simulations of nuclear weapon performance include a thousand-fold increase in computational speed and data storage; three-dimensional modeling of components; and increases in spatial resolution of models. Improved experimental capabilities will come from high resolution, multiple-time, multiple-view hydrodynamic experiments (dynamic radiography) and pulsed-power and laser-based experiments.

Development of advanced manufacturing and materials technologies will eliminate the need for large facilities and infrastructure. We are developing advanced manufacturing concepts for a smaller, agile production complex to produce replacement weapons components in small batch sizes in a timely, affordable, and safe manner. The advanced



manufacturing and materials technologies to be developed include computer-generated solid models of products; electronic information about materials properties; predictive computer models of manufacturing processes; and sensor-based adaptive process control of manufacturing.

Other research is aimed at continued improvements in the surveillance of the effects of aging on nuclear weapons. This will provide our scientists and engineers a more solid basis for anticipating, identifying, and solving new problems or remedying defects that may occur in the enduring stockpile as it ages. Enhanced weapons and materials surveillance technologies include predictive models based on materials science; nondestructive evaluation technologies to examine weapon components; and sensors built into stockpile weapons to monitor indicators of aging.

Tritium is required for all weapons in the enduring U.S. stockpile. Recycling tritium from dismantled weapons will satisfy stockpile requirements into the next decade, at which time some means of tritium production will be required. The Department of Energy is currently considering several production options, including accelerator; advanced light-water reactor; and modular high-temperature, gas-cooled reactor technologies.

Meeting the expected needs of the future will require upgrades of existing facilities and construction of some new facilities that have applications in scientific research and in strengthening the scientific understanding of weapons physics. Facilities will also be needed to allow for flexible manufacturing of materials and replacement components.

The Intelligence Community

The downsizing of the U.S. military force structure places a priority on the ability of the Intelligence Community to identify and understand emerging threats so that policymakers can rapidly develop effective responses. A critical aspect of this transformation has been a significant increase in reliance on intelligence, surveillance, and reconnaissance to provide decisionmakers and battle commanders dominant battlespace knowledge in a timely manner.

The strategic threat to U.S. national security has receded. However, this change in the strategic environment did not produce a more stable or less violent world. In fact, the change from a bipolar to a multipolar world increased the requirement for U.S. military forces to operate in nontraditional missions and continues to provide the potential for large-scale conventional force engagements.

The military strategy articulated by the Joint Chiefs of Staff addresses the full range of military operations on a global scale, and intelligence support to military operations must accommodate this diversity. Superior intelligence support during planning, deployment, sustainment, employment, and redeployment is needed to achieve national objectives and minimize risk to U.S. forces, our allies, and coalition partners.

Superior intelligence support during planning, deployment, sustainment, employment, and redeployment is needed to achieve national objectives and minimize risk to U.S. forces, our allies, and coalition partners.

Science and technology investments support advances in all phases of the intelligence process from collection through dissemination. Intelligence collection via human sources (HUMINT); from imaging satellites and aircraft (IMINT); from signals interception systems (SIGINT); from analysis of target signatures (MASINT); and from open-source reporting is integrated to support all-source analysis of potential crisis situations and active military engagements. These science and technology investments cover technologies ranging from information processing to new generations of sensors for specialized collection systems to high-performance algorithms for data processing and exploitation.

In the coming years, as a result of the global technology explosion, the Intelligence Community faces both threats and opportunities—threats resulting from the worldwide proliferation of information processing and communications technologies, and opportunities resulting from the rapid advances in these and other technologies in the commercial marketplace. Now more than ever, well-planned S&T investments will position the Intelligence Community to provide timely, comprehensive, and detailed intelligence support to the U.S. warfighter.

Carrying Out the Defense S&T Mission

Research sometimes pays immediate dividends, with a transition directly from laboratory bench to defense systems in the field. But most often the full impact of research is not apparent until much later. It is only in hindsight that the patterns of research which spawned revolutionary military capabilities—radar, digital computers, semiconductor electronics, lasers, fiber optics, and navigation systems capable of great accuracy—are discernible. Thus, in planning our research programs, we focus not only on immediate needs but also on opportunities that will sustain our technological edge far into the future.

A balance of investments is needed at every phase of development to ensure that basic research results are exploited for military applications in a timely manner through technology demonstration and transition. Further, since there are many performers, we must carefully manage our investments to make sure that we capitalize on all their strengths.

About 15 percent of our Defense S&T investment is devoted to basic research, about 36 percent to exploratory development, and the rest to advanced technology development. The majority of the work in the basic research program is conducted at universities and Defense Department laboratories, with the remainder in industry, nonprofit research institutes, and other Federal laboratories. Most of the Defense technology program is performed by industry. Our Department of Energy National Laboratories, Department of Defense, and other government laboratories are involved in both basic research and technology development. Of course, intense interactions among these complementary performers are essential if we are to realize full synergistic benefits.

Universities

The linkage between military-related science and technology and the university community is longstanding. The Department of Defense has supported research and development at academic institutions for over five decades. The research offices of each of the military services were among the first Federal organizations created in the period immediately after World War II to foster science and engineering research in the nation's universities. University research pays dual dividends, providing not only new knowledge but also producing graduate scientists and engineers in disciplines important to national defense. The greatest part of the Defense-supported university effort—over 75 percent—is in basic research conducted within academic departments. In addition, some universities in the World War II period established highly specialized laboratories to perform defense technology development. These organizations are generally separate and distinct from the academic side of the universities, and account for virtually all the Defense Department's development funding awarded to academic institutions.

The defense basic research investment is focused on those disciplines which have a potential relationship to a military function or operation. Funding decisions weigh both technical quality and military relevance.

Laboratories

Both the Department of Defense and the Department of Energy operate large laboratory systems.

The Department of Defense laboratories operated by the military departments are both performers and purchasers of research and technology. The laboratories provide the technical expertise to enable the military services to be smart buyers and users. The Department of Defense laboratories perform such critical functions as:

- Identifying the connections between warfighters' needs and technological opportunity.

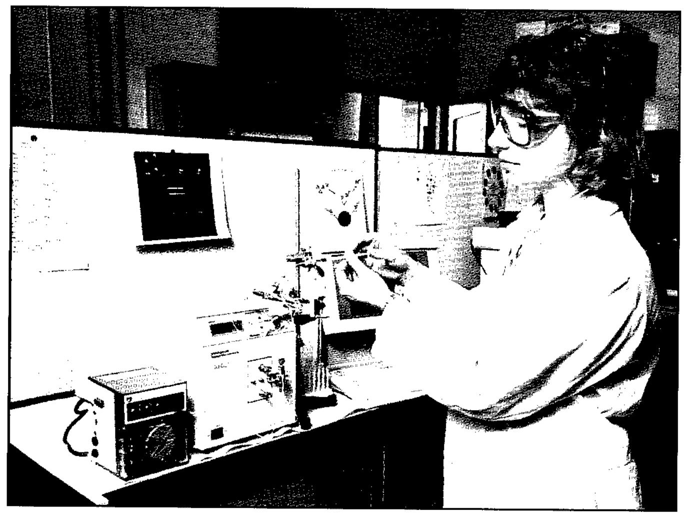
- Rapidly responding with high-quality technical solutions to warfighters' needs as they develop.

- Providing continuity and direct support to acquisition commands—the Program Executive Officers and program managers—through technical expertise, contract management, work force training, and staff support.

Besides directly supporting their military departments, the Defense Department laboratories act as agents for the Advanced Research Projects Agency, Ballistic Missile Defense Organization, and other defense research and technology agencies.

Like other elements of the Department of Defense infrastructure, the laboratories are participating in the processes of reinvention and acquisition reform. The laboratory work force is being reduced; the facilities infrastructure is being restructured, and opportunities for consolidation and cross-service integration are being examined. Accompanying this reduction in size are new personnel demonstration systems designed to reinvigorate in-house quality and new organizational structures and acquisition procedures that stress interaction and partnership with extramural performers.

The Department of Energy national security laboratories have, for more than half a century, provided the science and technology to ensure that U.S. nuclear weapons meet the highest standards of performance and safety. The laboratories' multidisciplinary, multiprogram approach has been extremely successful at solving complex technical problems of national importance. In carrying out their national security mission, the Los Alamos, Sandia, and Lawrence Livermore National Laboratories and the Y-12 facility at Oak Ridge, Tennessee, have created an unmatched pool of scientific and technical expertise. The nuclear weapons work of the laboratories has spurred major inventions and technology breakthroughs that, in turn, have spawned new scientific opportunities and enabled the laboratories to address and solve other important national problems. For example, the supercomputer industry, born in the nuclear weapons program, has not only spurred the growth of a significant segment of the economy, but it has also enabled the labs to tackle such other problems as global climate change and work on the human genome. In their weapons work, the laboratories have vividly demonstrated the success of programmatic integration and interlaboratory collaboration, an approach that is proving equally successful in other areas of investigation. In the future, as in the past, the expertise of the laboratories will continue to evolve as their programs adjust to meet changing national needs within increasing requirements for effectiveness and efficiency.



Private Industry

U.S. commercial industry accounts for the largest portion of the defense S&T investment portfolio. The majority of this investment is in advanced technology development, reflecting the unique strength of industry in integrating advanced technology into military systems. Our industrial capacity is the pride of the United States and the envy of the world. It is vital to developing the military capabilities on which we depend and fundamental to our strength as a nation.

Some industrial capabilities required for national defense are unique to defense. With no commercial counterparts, they must depend on defense markets for survival (for example, building nuclear-powered submarines and the production of most ammunition). As we reduce defense procurement, the Administration seeks to maintain key capabilities of the industrial base that supports defense. We do not seek to preserve every company that supplies defense equipment, but rather to support only those industrial *capabilities* that are both essential to defense and genuinely at risk.

In addition, defense diversification initiatives within the Department of Commerce provide small and medium-sized defense subcontractors with direct access to Federal and state programs designed to assist in this period of declining defense markets and increased foreign competition. Through these initiatives, defense contractors and subcontractors are upgrading production techniques and finding new markets for their technologies and products.

New Ways of Doing Business

The world today is markedly different from what it was during the Cold War. This new environment calls for new ways of conducting the business of defense. The Administration's initiatives in acquisition reform, dual-use technologies, and Advanced Concept Technology Demonstrations characterize our determined response to today's challenges. Sustained and effectively implemented, these new approaches will help get the highest return on defense investments in the future.

Defense Acquisition Reform

In October 1993, President Clinton signed into law the Federal Acquisition Streamlining Act of 1994, legislation that fundamentally reforms Federal procurement. The act provides for three key statutory changes. Most important, it makes it easier for the Defense Department (and other Federal agencies) to buy commercial components, products, and services. Second, it streamlines contracting procedures for small purchases. And third, it authorizes the Defense Department to undertake five pilot programs to test innovative approaches to acquiring commercially derived jet aircraft, aircraft engines, and other items.

The Defense Department is firmly committed to improving the defense acquisition processes to help improve long-term military readiness. Building on a February 1994 paper entitled *Acquisition Reform: A Mandate for Change* which provided the conceptual foundation for acquisition reform, the Defense Department has developed a strategic plan to ensure that reform measures are institutionalized and to create an environment for continuous improvement that will last well into the future.

In June 1994, Defense Secretary William J. Perry announced a reversal of the Pentagon's longstanding policy toward military specifications—"milspecs," the 31,000 specifications and standards that prescribe how military items are to be made and tested, down to the most minute detail. Secretary Perry instructed the military services to use commercial (or performance-based) specifications and standards in lieu of milspecs "unless no practical alternative exists." This decision has already dramatically reduced the number of milspecs for dozens of weapon systems. The required milspecs for the Air Force's Space Based Infrared System dropped from 150 to two; the Navy's SLAM missile, from 104 to six; the Army's BCIS Phase 1 antifratricide digital system, from 467 to 194.

Together, the statutory reforms embodied in the Federal Acquisition Streamlining Act and the administrative reforms such as the milspec policy enable the Pentagon to take full advantage of the inventiveness and efficiency of today's dynamic commercial market. And by simplifying acquisition processes of direct concern to Department of Defense S&T program managers and scientists, they greatly improve the efficiency of the Defense Department science and technology program.

Dual-Use Technologies

Over the last 30 years, barriers were gradually created between the defense and civilian industrial sectors as special defense requirements and business practices increasingly segregated the defense sector of the industrial base. Our dual-use technology policy reflects the recognition that our nation can no longer afford to maintain two distinct industrial bases. Our goal is to move toward a cutting-edge national technology and industrial base that will serve military as well as commercial needs. This dual-use technology strategy will allow the armed forces to exploit the rapid rate of innovation and market-driven efficiencies of commercial industry to meet defense needs. By drawing on commercial technology and capabilities wherever possible—along with the superior systems design and integration skills of U.S. prime contractors—the Defense Department can do its job more effectively and at lower cost. Conversely, the innovation and accomplishments that originate in defense programs and laboratories will move rapidly to the commercial sector.

"Dual use" goes beyond simply incorporating commercial off-the-shelf parts and equipment in military systems. It involves a fundamental shift toward technology that satisfies both civil and military needs—for lower costs and higher quality, as well as increased performance. We are working toward a future in which weapon systems are designed to use state-of-the-art commercial parts and subsystems and are built in integrated facilities. Of course, commercial technology will not meet every military need. But in a great many cases it will, and it will do so less expensively. Moreover, as flexible manufacturing systems are developed and more widely adopted, it will be increasingly possible to produce in a single plant both low-volume military equipment and similar high-volume commercial equipment.

By using components, subsystems, and technologies developed by commercial industry in our military systems wherever possible, we hope to attain three compatible objectives:

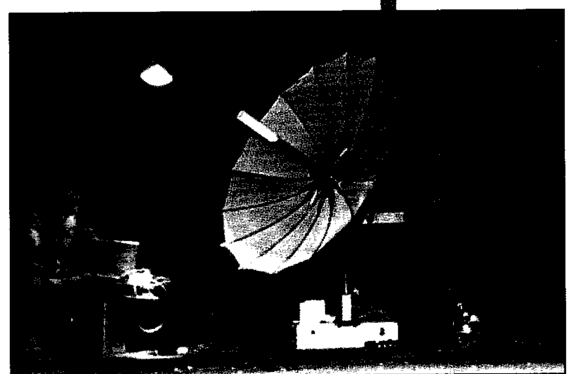
- *Access to leading-edge technology.* This dual-use strategy will provide access to leading-edge technology and allow our military to introduce the commercial sector's continuous stream of innovations and updates both during the development and throughout the life cycle of our military systems. This will shorten development time and increase the pace at which technological improvements are incorporated into new weapons.

- *Affordability.* Greater reliance on commercial capabilities can reduce our costs for procuring military systems incorporating leading-edge technologies. Commercial components, technologies, and subsystems in many instances can meet our functional needs at much lower cost than customized, military-driven technology.

- *Ability to rebuild.* Our dual-use strategy will make it easier to build back military capabilities to a higher level if necessary in the future. Close integration with the private sector is imperative so we can be ready to quickly gear up our nation's industrial capabilities.

We must also direct R&D toward the manufacturing infrastructure that enables our dual-use technology initiatives. (A leading example is advanced metal matrix composites, which have numerous end item applications—both military and civilian—including missiles, defense vehicles, and automobiles.) Such manufacturing process technologies make our domestic commercial and defense industrial infrastructure more competitive and lessen our dependence on foreign sources for critical subtier items.

Our dual-use approach to technology development is supported by the Technology Reinvestment Project (TRP), unveiled by President Clinton in March 1993 (see box p. 22, "Technology Reinvestment Project"). The TRP employs mechanisms to encourage commercial companies to provide the Department of Defense early access to dual-use technology development. The TRP's customer is the Pentagon, which awards funds, on a cost-shared basis, to industry-led projects to create new dual-use technologies that address clear defense needs, both by providing new products and processes and by fostering affordability. Typical TRP projects include technologies to provide for affordable night-vision capability; to improve battlefield casualty treatment; and to make affordable the Army's technically superior but high-cost system for locating combat units on the battlefield in real time. By taking advantage of the potential for a commercial market, these projects offer the prospect of technology with improved performance at lower cost.



Advanced Concept Technology Demonstrations

The Advanced Concept Technology Demonstration (ACTD) program is the Administration's approach to capturing and harnessing innovation for military use rapidly and at reduced cost. ACTDs are acquisition programs designed to foster an intimate alliance directly between the operational forces and the technologists and to remove the barriers between them. Representatives of the forces, including the Joint Staff, the Joint Requirements Oversight Council, and the commanders of unified and specified commands, play a direct role in the management of the ACTDs.

ACTDs are focused on four principal objectives: (1) to gain an understanding of and to evaluate the military utility of new technology applications before committing to acquisition; (2) to develop corresponding concepts of operation and doctrine that make the best use of the new capability; (3) to provide residual operational capability to the forces; and (4) to facilitate a more informed acquisition decision.

ACTDs are not only for new technologies but also seek new ways to integrate existing technologies to make platforms more effective in battle. ACTDs typically last two to four years, and the concepts are then given to one of the military services or a defense agency for formal acquisition.

The intent of the ACTD process is to provide the user with detailed interactions very early in development as a means for a rapid and cost-effective introduction of new capabilities to operational forces. Examples of ACTDs include Unmanned Air Vehicles, Cruise Missile Defense, Mine Countermeasures, Advanced Joint Planning, and Synthetic Theater of War. Additional demonstrations are planned for Combat Identification, Navigation Warfare, Miniature Air-Launched Decoy, and others.

Technology Reinvestment Project

The mission of the Technology Reinvestment Project (TRP) is to increase the Department of Defense's access to affordable, leading-edge technology by leveraging commercial know-how, investments, and markets for military use. Advanced technology remains the linchpin of U.S. military superiority even as tight defense budgets shrink the specialized defense supplier base. Two forces are shaping the future of defense technology. First, much of the best emerging technology is now in the commercial sector. Second, as the cost of weapons becomes more crucial, commercial practices are the key to affordable defense. TRP is a forward-looking response to these new realities.

The primary focus of this project, led by the Pentagon's Advanced Research Projects Agency, is the development of dual-use technologies. Every TRP development project is selected on the basis of its technical merit and its defense relevance. TRP's ends are affordable, leading edge defense technology; leveraging commercial technology is its means. Two strategies, depending largely on the state of the military technology, are used by TRP:

- *Leveraging emerging commercial technology.* Getting access to emerging commercial technology by using the commercial world's drive and ability to quickly develop and apply new technology. This begins by leveraging commercial know-how and investments and eventually drives markets to lower the price.

- *Embedding defense technology.* Finding a new market for existing defense technologies that have nondefense uses, principally to lower the price. This strategy seeks commercial efficiencies in processing and production and strives to take advantage of commercial market size. It also sustains technologies that might otherwise disappear due to insufficient demand from the Department of Defense alone.

Through two competitions, TRP has funded dual-use technology effort in areas such as military mobility; battlefield casualty treatment; command, control, communications, and computers; battlefield sensors; mechanical systems; and electronics manufacturing.

In addition to this focus on technology development, TRP has also funded projects of longer term benefit to the Department of Defense. These include technology deployment; efforts to ensure that small manufacturers have the technology to remain viable for future Department of Defense acquisitions; and manufacturing education and training as well as efforts to improve undergraduate manufacturing curriculums and retrain defense workers. TRP also conducts a Small Business Innovation Research (SBIR) program linked to its technology development goals. Future competitions are expected to concentrate exclusively on technology development with SBIR.

The International Dimension

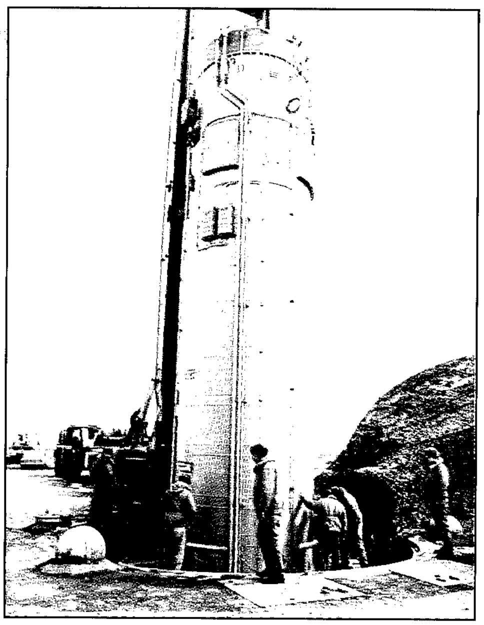
International cooperation in defense technology is an important factor in advancing our national security and foreign policy goals. International technology cooperation can enhance mutual defense capabilities through standardization and interoperability with the forces of friendly and allied countries. It can spread the burden of financing development, promote U.S. access to foreign technologies and innovations; and deepen mutual understanding. International cooperation is also a large and indispensable element of our economic security, offering global market opportunities to U.S. industry. Through broad-based international programs undertaken by the private and public sectors we seek to take advantage of the best the world has to offer.

Fundamentally, international cooperation in defense-related technology areas is conducted among private-sector companies. Mechanisms for cooperation include research and development joint ventures; contractor teaming arrangements; prime/subcontractor relationships; coproduction and technical assistance agreements; and direct sales and purchases. At the basic research level, the scientific community—both public and private—also engages in many forms of international cooperation and collaboration, including laboratory-to-laboratory projects; exchange programs; university fellowships and visiting professorships; field research; networking; and participation in a wide range of international forums for the exchange of scientific knowledge.

Despite its many benefits, however, international cooperation in defense technology also presents risks. This Administration is committed to striking a balance between sharing our technology and protecting it so that the benefits continue to outweigh these risks. For the many cooperative activities conducted under the auspices of government-to-government agreements, the agreements themselves explicitly address national security and industrial base concerns, such as technology transfer and retransfer rules, data rights, and procedures for the handling of classified information. For private-sector ventures involving munitions, certain dual-use goods, and technical data, export licensing regulations are used to protect our national security interests. To preserve the competitive posture of American manufacturers in an environment in which other nations are often inclined to exercise less stringent controls on technology transfer, we seek multilateral export control approaches where possible.

There are transactions in three areas of global trade and technology transfer that are occurring with increasing frequency and that have the potential for broad national security or economic impact. Sales and contracts with foreign buyers imposing conditions leading to technology transfer, joint ventures with foreign partners involving technology sharing and next-generation development, and foreign investments in U.S. industry that create technology transfer opportunities may raise either economic or national security concerns that can temper the benefit we perceive as a nation.

We will continue to encourage international cooperation in defense technology because the payoff can be great. But we will also continue to expect our international partners to provide protections and assurances comparable to our own in sensitive areas. And we will continue to strike a judicious balance between risks and benefits to ensure that all our international science and technology cooperation activities make positive contributions to our national security and economic well-being.



critical priority for the United States is to stem the proliferation of nuclear weapons and other weapons of mass destruction and their missile delivery systems. Countries' weapons programs, and their levels of cooperation with our nonproliferation efforts, will be among our most important criteria in judging the nature of our bilateral relations.... Arms control can help reduce incentives to initiate attack; enhance predictability regarding the size and structure of forces, thus reducing fear of aggressive intent; reduce the size of national defense industry establishments and thus permit the growth of more vital, nonmilitary industries; ensure confidence in compliance through effective monitoring and verification; and, ultimately, contribute to a more stable and calculable balance of power.

A National Security Strategy of Engagement and Enlargement, 1995

I

Controlling Arms and Stemming the Proliferation of Weapons of Mass Destruction

Arms control and nonproliferation measures are an integral part of U.S. security strategy. These measures, designed to reduce existing military threats and prevent new ones from arising, are an essential complement to our military programs to respond to such threats, allowing the United States to maintain greater security at lower cost. Today, as a result of arms reduction and nonproliferation measures already undertaken, thousands of nuclear warheads once aimed at the United States have been removed from their launchers and shipped to dismantlement plants, and a wide range of countries are not armed with weapons of mass destruction that might otherwise have acquired such weapons. The Clinton Administration is committed to seizing the opportunities of the post–Cold War period—and responding to its dangers—by building a still broader and more effective international arms reduction and nonproliferation regime. In that effort, science and technology (S&T) will be critical.

The Arms Control and Nonproliferation Imperative

Ever since Bernard Baruch presented the U.S. plan for international control of atomic power as a choice "between the quick and the dead," the U.S. Government has recognized the fundamental importance of limiting the threats posed by weapons of mass destruction and other advanced weaponry. The United States seeks stabilizing reductions in nuclear arms and arms limitations and confidence-building measures that contribute to global and regional security. We seek to prevent additional countries from acquiring chemical, biological, and nuclear weapons and their missile delivery systems and to promote restraint in transfers of conventional arms that may be destabilizing or dangerous to international peace.

With the end of the Cold War, these efforts have become even more essential—and even more complex. The end of Cold War confrontation has enabled historic reductions in nuclear arms and other weapons of mass destruction, and the specter of nuclear annihilation has receded dramatically. At the same time, political fragmentation and economic disarray in the former Soviet Union, along with the worldwide diffusion of technology, raise new proliferation risks and complications for arms control.

Despite the large-scale arms reductions now under way, nuclear weapons remain a central threat to U.S. security. Russia is expected to maintain a formidable nuclear force with thousands of nuclear weapons into the foreseeable future. Britain, France, and China also acknowledge having substantial nuclear forces, and Israel, India, and Pakistan are believed to have nuclear weapons or the capability to assemble them very rapidly.

All told, some twenty nations have or are seeking weapons of mass destruction, and many are also seeking the missiles to deliver them. In addition, a wide range of nations have significant conventional arsenals that could pose threats to regional security. Limiting these threats, to the extent possible, is a top national security priority.

Controlling technologies and materials for weapons of mass destruction is complicated by the fact that a significant fraction of the technology and much of the equipment required for a weapons program is "dual use," with both military and civilian applications.

Nuclear weapons, offering the possibility of destroying an entire city instantaneously with a single bomb, pose a particularly devastating threat. The primary technical barrier limiting the spread of nuclear weapons is limits on access to the nuclear materials needed to make them—plutonium or highly enriched uranium (HEU), both of which require a significant technical effort to produce. Hence, the rising incidence of nuclear smuggling poses an urgent proliferation threat that must be addressed.

Unfortunately, chemical and biological weapons are also within the reach of many nations, subnational groups, and even terrorists. Chemical weapons, including nerve gas, blister and blood agents, and others, require significantly less technical sophistication to produce and employ than nuclear weapons. Because chemical protective equipment is highly effective, chemical weapons are most effective against civilians or unprepared troops. The quantities of chemical agent required are relatively small when compared to industrial production of similar commercial chemicals, raising significant complications for control and detection. Biological weapons—which include both living organisms such as bacteria and viruses and the poisons they produce, known as toxins—can also pose a devastating threat and are difficult to detect, either on the battlefield or in production. Like chemical weapons, biological weapons are easier to acquire than nuclear arms. Today, genetic engineering and other new technologies offer new ways to produce dangerous organisms and toxins.

Controlling technologies and materials for weapons of mass destruction is complicated by the fact that a significant fraction of the technology and much of the equipment required for a weapons program is "dual use," with both military and civilian applications. Peaceful nuclear power programs, for example, can provide part of the infrastructure and expertise needed for establishing a nuclear weapons program. Electronic devices used to trigger nuclear bombs are also used in oil exploration. Chemicals used to make nerve agents are also used to make plastics and to process foodstuffs, and facilities producing pesticides, insecticides, and fire-retardant chemicals could be modified to produce chemical agents. A modern pharmaceutical industry could potentially provide the facilities and expertise needed to produce biological warfare agents. High-speed computers used for everything from climate modeling to designing airliners can also be used to design nuclear bombs. High technologies are increasingly difficult to control, due to advances in global scientific literacy and the worldwide mobility of people and information.

Given these realities, arms control and nonproliferation efforts must be firmly based in the technical realities of a broad spectrum of modern technologies. It is essential to focus efforts on key restraints that will genuinely constrain military threats to U.S. and international security while ensuring that the United States and its allies can maintain the robust defense forces they need and allowing trade in key civilian technologies that are the engines of economic growth.

The Role of S&T

U.S. arms control and nonproliferation efforts make use of two principal classes of tools:

- *Negotiated measures,* agreements designed to reduce arms, stem their spread, and build confidence. These include global agreements such as the Nuclear Nonproliferation Treaty (NPT) and the chemical and biological weapons conventions as well as strategic and regional security arrangements and measures worked out with individual countries. In addition to arms reduction, these measures address both the "supply side" of proliferation—through controls and monitoring of particular technologies—and the "demand side,"—through measures to build security so that nations feel less need to acquire weapons of mass destruction.

- *Noncooperative measures,* designed to limit the "supply side" of proliferation, make it more difficult for potential proliferators to gain access to the essential technologies, materials, and know-how needed for advanced weapons programs.

Science and technology play critical roles in supporting both these types of tools. Our strategy for science and technology support to nonproliferation and arms control focuses on three critical elements:

- *Apply technical know-how to build effective arms restraints.* In-depth understanding of the technologies to be controlled is essential to our efforts to build effective arms reduction and nonproliferation regimes. From implementing effective export controls to stop proliferation at its source, to designing verification provisions that will offer high assurance of compliance, to assessing the impact of proposed restraints on U.S. military programs and on civilian economies, it is critical to maintain a strong cadre of technical experts to support arms reduction and nonproliferation efforts—in Federal agencies, in the national laboratories, and in private industry (see box p. 28, "Government-Industry Collaboration in Nonproliferation").

- *Continually improve detection, monitoring, and verification capabilities.* The remarkable global network of satellites, planes, ships, and ground stations the United States has developed to detect and monitor potentially threatening military activities is one of the great technical achievements of the 20th century. At the same time, advanced technologies for on-site inspections have enabled an impressive global effort to ensure that treaties are abided by and that technologies supplied for peaceful uses are not diverted to military purposes. But in a world of ever-changing technology, these technologies must continually be improved. A robust range of monitoring and verification capabilities offers policymakers the greatest flexibility in crafting arms control and nonproliferation regimes. And early detection of proliferant weapons programs—demanding ever more sophisticated means to measure the often minute or concealed indications of weapons-related activity and to piece together activities that may be harmless in isolation but add together to form a threatening program—enables us to focus on problems before they become crises.

- *Use science and technology cooperation to advance arms reduction and nonproliferation goals.* International cooperation in science and technology can engage the technical community to resolve issues that otherwise could contribute to proliferation pressures. In addition, professional interactions within the international scientific community can build the trust and confidence needed to make progress in arms control and nonproliferation.

Government—Industry Collaboration in Nonproliferation: The Chemical Manufacturers Association and the Chemical Weapons Convention

Partnership between government and industry is becoming an increasingly important part of our nonproliferation efforts. The role of the Chemical Manufacturers Association (CMA) in supporting the Chemical Weapons Convention is one example of an effective public-private collaboration to strengthen arms control and nonproliferation.

Efforts to eliminate the threat of chemical weapons date from the mid-19th century. Until recently, however, the major achievement was the Geneva Protocol of 1925, which banned the use of chemical weapons in warfare but still allowed nations to build up chemical weapons stockpiles for defensive purposes. Today, a more comprehensive chemical weapons arms control regime is needed to prevent the spread of chemical weapons. The only way to ensure that chemical weapons are not used in the future is to eliminate them, prohibit their reintroduction, and provide the means to verify both.

The CMA has provided technical assistance and input to the U.S. Government delegation negotiating the Chemical Weapons Convention for more than 15 years. Although the U.S. chemical industry does not produce chemical weapons, the CMA agreed that commercial chemical facilities must be covered by the CWC verification program in order to prevent the illegal diversion of legitimate commercial chemicals into weapons. Throughout this partnership with the government, CMA has been an unequivocal supporter of a ban on the manufacture, use, and storage of chemical weapons.

CMA helped to coordinate U.S. industry support for the Convention. The Association worked with representatives of other U.S. industry sectors, such as the pharmaceutical manufacturers and the synthetic organic chemical manufacturers. A number of CMA member companies volunteered their facilities in order to test the on-site inspection procedures being considered under both the CWC and a bilateral agreement with Russia.

The Administration has been working closely with the chemical industry in crafting the U.S. CWC implementing legislation. That legislation, once enacted, will ensure that the CWC provides a strong deterrent against illegal uses of chemicals, establishes an effective verification program, minimizes the administrative burden of commercial compliance with the CWC, protects company interests in proprietary information, and minimizes the intrusiveness of the verification process. There is little question that the efforts of the CMA have helped to produce a highly valuable arms control agreement.

In all these efforts, our ability as a nation to draw on a wide range of scientific and technical resources, and to coordinate those resources will be crucial. The reminder of this chapter outlines the contribution of S&T in each of these critical areas.

S&T's Role in Building Effective Arms Restraints

Controlling arms begins with understanding the technology that should be controlled. The close and active participation of the technical community—both inside and outside government—is essential to the formulation of effective policy across the broad spectrum of efforts to build effective arms control and nonproliferation measures, including the following:

- Treaties and agreements designed to limit arms, build confidence, and constrain proliferation.
- Export controls to limit commerce in relevant technologies and materials.
- Strengthened national controls worldwide to prevent unauthorized transfers of weapons, materials, technologies, and know-how.

Treaties and Agreements

Negotiated measures—bilateral, multilateral, and regional agreements which limit arms, build confidence, and constrain proliferation—are among the most important tools in our comprehensive arms control and nonproliferation program.

Strategic nuclear arms have been the focus of intensive arms control efforts for decades, seeking a more stable nuclear balance at lower force levels. Under the 1991 Strategic Arms Reduction Treaty (START I), which entered into force in December 1994, the United States and Russia are carrying out substantial reductions in their strategic nuclear forces. START I established a verification regime of unprecedented stringency, incorporating some twelve types of on-site inspections. With U.S. assistance under the Nunn-Lugar program, hundreds of strategic launchers in the former Soviet Union have already been eliminated to comply with START I's provisions. Under the Lisbon Protocol to START I, and the January 1994 Trilateral Agreement between the United States, Russia, and Ukraine, all the nuclear weapons on the territories of Belarus, Ukraine, and Kazakstan are being shipped back to Russia—a major victory for U.S. arms control and nonproliferation policy.

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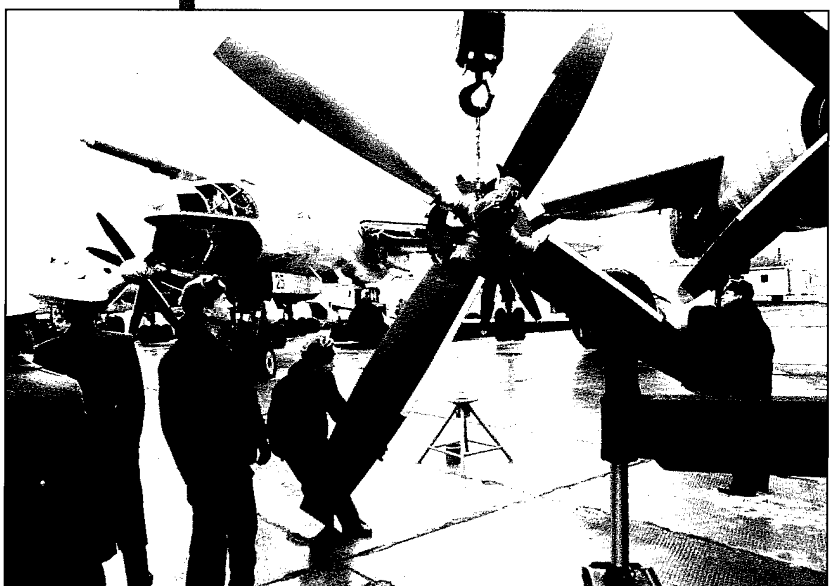
START II, signed in January 1993 but still awaiting ratification, calls for still deeper reductions, to some 3,500 deployed strategic warheads in the United States and Russia, along with the complete elimination of destabilizing multiple-warhead land-based intercontinental ballistic missiles (ICBMs). At their September 1994 summit, President Clinton and President Yeltsin agreed to consider still deeper cuts and additional limitations as soon as START II is ratified. START II ratification is a top priority, as the treaty will greatly benefit both U.S. and Russian security. As these reductions in long-range strategic arms continue, the United States and the former Soviet Union have already eliminated their land-based missiles with ranges between 500 and 5,500 kilometers, under the 1987 Intermediate-Range Nuclear Forces (INF) Treaty, which established the precedent for incorporating extensive on-site inspections in such arms agreements.

The 1972 Anti-Ballistic Missile (ABM) Treaty, in which both the United States and the Soviet Union agreed not to build nationwide defenses against strategic ballistic missiles, provides the confidence in each side's deterrent effectiveness that has allowed these large-scale arms reductions. The ABM Treaty is a key element of our arms control and nuclear deterrence policy and is crucial to strategic stability, START I implementation, and START II ratification. At the same time, the growing threat posed by the proliferation of theater ballistic missiles demands that we develop highly effective theater ballistic missile defenses. Hence, we are engaging in discussions with Russia and the other former Soviet successor states to clarify the boundaries between permitted theater defenses and strictly limited strategic defenses—while maintaining the viability of the ABM Treaty as a guarantor of strategic stability.



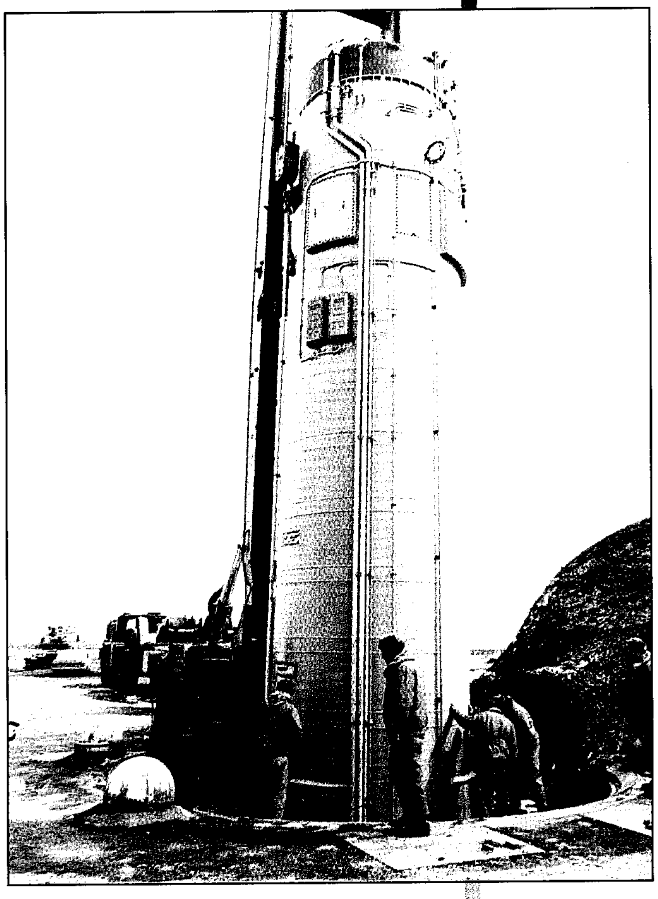
These past arms control agreements focused on the strategic missiles, bombers, and launchers that would have launched a deliberate nuclear attack. Today, when the principal risk is less a deliberate attack than the possibility of loss of control, it is critical also to build confidence in the reduction and secure management of nuclear weapons themselves, and the plutonium and HEU needed to make them.

At their January 1994 summit, Presidents Clinton and Yeltsin took a major step in this direction, agreeing to establish a joint working group to explore measures to ensure the "transparency and irreversibility of the process of reduction of nuclear weapons" and to expand cooperation in ensuring effective security and accounting for nuclear materials. In June of 1994, Vice President Al Gore and Prime Minister Viktor Chernomyrdin signed an agreement cutting off production of plutonium for weapons. At the September 1994 Clinton-Yeltsin summit, the two Presidents agreed that, for the first time ever, the United States and Russia would tell each other how many nuclear weapons, and how much plutonium and HEU each has. And at their meeting in May 1995, the two Presidents agreed on an agenda for confidence-building data exchanges and reciprocal inspections and on a commitment that neither side would ever again use excess plutonium or HEU from dismantled weapons, from civilian programs, or from new production for new weapons.

Proliferation of weapons of mass destruction has also been the focus of intensive international negotiations for decades. The centerpiece of global efforts to stop the spread of nuclear weapons is the NPT, which requires all its non-nuclear-weapon-state parties to forswear nuclear weapons and place their nuclear activities under comprehensive International Atomic Energy Agency (IAEA) safeguards. In return, all parties are to have access to peaceful nuclear technologies and to negotiate in good faith toward arms reduction and disarmament. In June 1995, the NPT was extended indefinitely—and in the aftermath of post–Desert Storm discoveries about Iraq's nuclear weapons, the IAEA safeguards system is being substantially strengthened, with a renewed focus on detecting undeclared nuclear activities.

Existing global treaties covering chemical weapons and biological weapons go even further, banning these abhorrent weapons entirely. The recently completed Chemical Weapons Convention (CWC) bans the development, production, possession, and use of chemical weapons and establishes the most comprehensive monitoring and inspection regime yet formulated in an international treaty. Prompt Senate ratification of this treaty is a high priority. The Biological Weapons Convention (BWC), which entered into force in 1975, bans development, production, and stockpiling of biological agents or toxins except for peaceful or defensive purposes. The United States supports international efforts to develop a legally binding protocol to strengthen the BWC.

To strengthen the global nonproliferation regime and meet our commitment to ending the nuclear arms race, the United States is actively pursuing a true "zero yield" Comprehensive Test Ban Treaty (CTBT), with the goal of completing a treaty as soon as possible and no later than September 1996. The CTBT, a goal of both Democratic and Republican Presidents reaching back to Dwight Eisenhower, is supported by nearly all the world's nations. At the same time, we are working to bolster the nonproliferation regime with a global treaty ending forever the production of fissile material for weapons.



These global regimes are complemented by regional arrangements, such as nuclear-weapon-free zones in Latin America and the South Pacific, and nuclear agreements between Argentina and Brazil, North and South Korea, and Russia, Ukraine, and the United States. Such regional arrangements can be tailored to the needs of particular regions. The framework accord reached with North Korea in 1994, for example, represents a major Clinton Administration accomplishment, requiring North Korea to roll back its dangerous nuclear weapons program and renew its dialogue with the South. The Trilateral Agreement between Russia, Ukraine, and the United States, to take another example, commits Ukraine to send all the nuclear weapons on its soil back to Russia for dismantlement, in return for commitments to respect Ukraine's sovereignty and territorial integrity, and Russia's provision of reactor fuel as compensation for the value of the uranium in the warheads sent back to Russia. Such regional security agreements can build security and confidence between potential adversaries and reduce the demand for weapons of mass destruction.

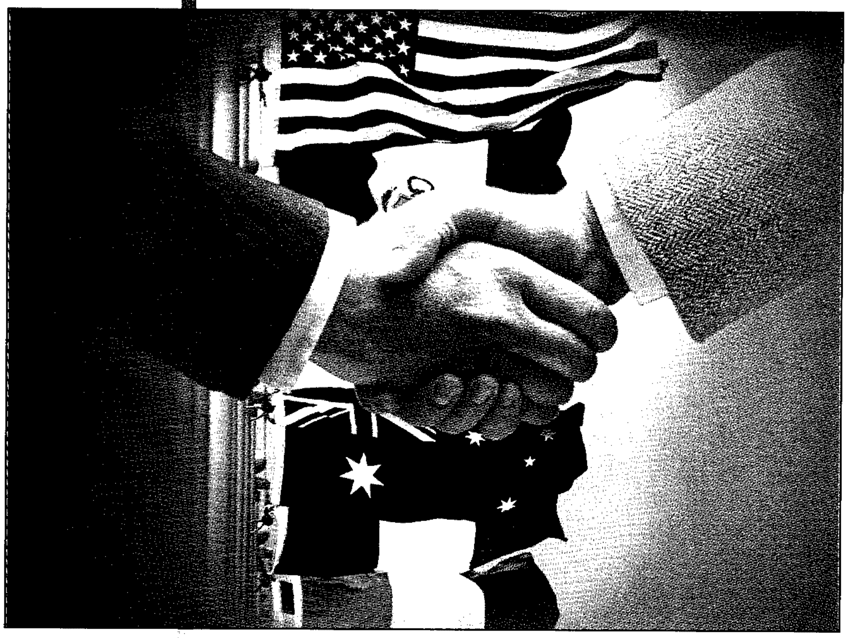
Conventional arms control and confidence-building measures are another major focus of international negotiations and agreements. The 30-nation Conventional Armed Forces in Europe Treaty (CFE), which entered into force in 1992, mandates steep reductions in five key categories of conventional arms in Europe. Several agreements under the auspices of the Organization for Security and Cooperation in Europe limit military exercises and require states to give notifications, permit observation of exercises, and exchange information about defense doctrines and budgets. The Open Skies Treaty, signed in 1992 but still awaiting entry into force, allows its parties—states in Europe and North America—to fly unarmed aerial observation missions over one another's territory to help build confidence and enhance transparency. We are working to promote similar arms reduction and confidence-building measures in other regions.

We are also committed to increasing participation in a global confidence-building effort, the United Nations Register of Conventional Arms, under which member nations voluntarily provide data on exports and imports of conventional arms. We are taking the lead to expand the Register to include military holdings and procurement through national production, thereby providing a more complete picture of change in a nation's military capabilities each year.

Detailed participation from the technical community has been and continues to be critical in the design and implementation of all of these agreements. From devising safeguard technologies to ensure, at minimum cost, that nuclear material is not diverted, to devising conventional arms limits that will effectively constrain offensive strike capabilities while allowing for robust defenses, to exploring restraints that can allow effective theater defenses while maintaining the strength of the ABM Treaty's limits on strategic missile defenses, the technical community's role in these efforts has been indispensable.

Export Controls

These treaties and agreements are supported by national measures designed to prevent the advanced weapons-related technologies, materials, and know-how from falling into the hands of potential proliferators. Export controls in particular are an essential element of our approach to nonproliferation. Here too, technical support—in understanding what technologies must be controlled, and how—is indispensable. Fundamentally, the spread of scientific and technical know-how is the crux of the supply side of the proliferation problem. Technological advances on which modern society depends also make it easier to design, manufacture, and use advanced weapons. Our firm goal is to draw a balance that will allow countries around the world to reap the economic benefits of these advances, without compromising national security.



Our domestic export control system addresses the full range of weapons-related exports, from weapons of mass destruction to dual-use equipment and technology. The Department of State, pursuant to the provisions of the Arms Export Control Act, regulates the export of munitions items including weapon systems, missiles, specially designed components for those systems, and related technology. The Department of Commerce regulates the export of dual-use items under the Export Administration Act. Nuclear-related exports are controlled by the Nuclear Regulatory Commission, the Department of Energy, and the Department of Commerce pursuant to the Atomic Energy Act and in coordination with the Departments of State and Defense and the Arms Control and Disarmament Agency.

Our domestic export control system addresses the full range of weapons-related exports, from weapons of mass destruction to dual-use equipment and technology.

The United States is a member of all the non-proliferation-related multilateral export control regimes: the Missile Technology Control Regime, for missiles capable of delivering weapons of mass destruction; the Australia Group, for chemical and biological weapons related materials; the Nuclear Suppliers Group, for nuclear and dual-use equipment and materials and related technologies; and the Zangger Committee, also for nuclear supplies. Each of these regimes coordinates the controls of member states on the export of equipment, material, and technology that has a particular utility in the development of weapons of mass destruction and delivery systems.

The United States has also proposed that a new regime be established to succeed the Coordinating Committee on Multilateral Export Controls (COCOM), focusing on conventional arms sales and dual-use technologies. Our goals for this regime are to increase transparency of transfers of conventional arms and related technology, to establish effective international controls, and to promote restraint—particularly to regions of tension and to states that are likely to pose a threat to international peace and security.

Potential proliferators unable to buy technologies in one country are likely to turn to another, so the international export control system is only as strong as its weakest links. Therefore, the United States has taken the lead in assisting other countries in developing their own export controls on weapons-related technology and materials. Around the globe, the United States has conducted international seminars on export control, provided equipment, and helped set up legal infrastructures to implement effective national export control systems.

National Controls To Prevent Unauthorized Transfers

Each nation that possesses advanced weapons and weapons-related technologies, materials, and know-how bears the responsibility for ensuring that these items do not fall into the wrong hands through theft or diversion. The global black market in conventional arms, ever-increasing reports of smuggling of deadly nuclear materials, and the unauthorized leakage of chemical and biological technologies pose serious threats to international security that must be addressed.

Within the United States, programs to ensure against theft and diversion of such items are extensive and highly effective. As just one example, the Department of Energy spends some $800 million every year on safeguards and security in the U.S. nuclear weapons complex.

Our science and technology program in detection and monitoring is extremely broad, encompassing sensors for virtually every part of the electromagnetic spectrum as well as detectors of other indicators of weapons-related activities.

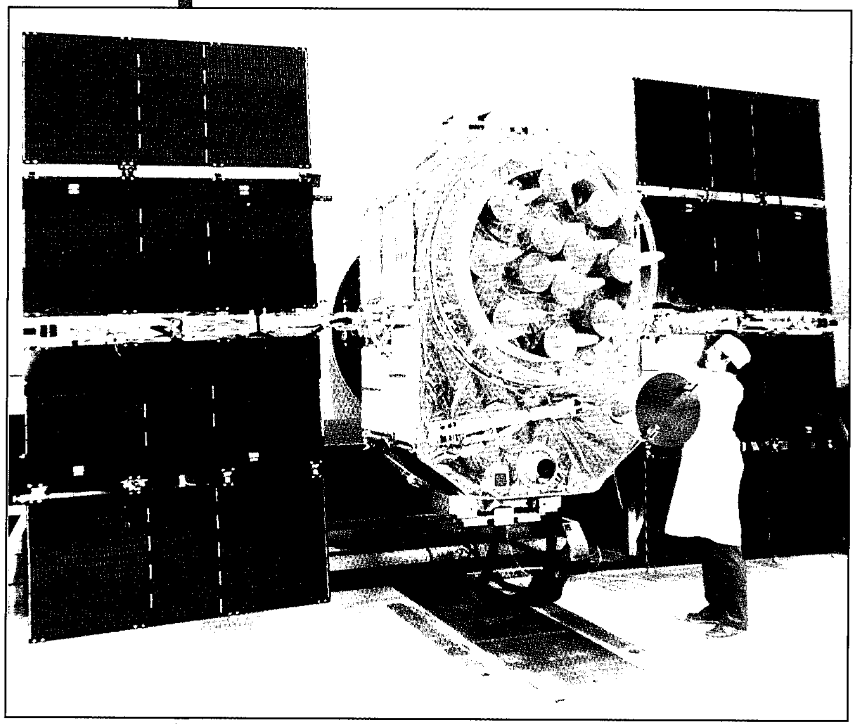
In addition, the Administration supports a wide range of cooperative programs to combat these threats around the world. In particular, the United States is a leader in cooperative efforts to stop nuclear smuggling and to ensure that all stocks of fissile materials worldwide are held under the highest standards of safety, security, and international accountability. Some of the initiatives we have undertaken include converting research reactors to run on non-weapons-usable low-enriched uranium and taking back spent U.S.-origin HEU fuel for safe storage in the United States. We are working actively with other countries to end the accumulation of excess stocks of plutonium and HEU, and, over time, to reduce these stocks.

Detection, Monitoring, and Verification

Technologies for detection, monitoring, and verification are the centerpiece of the U.S. nonproliferation and arms control S&T program. From satellites that can snap pictures of a new weapons facility under construction, to airborne sensors that can "sniff" the effluent from a chemical weapons production plant, to ships that can track missiles as they streak across the sky, the United States has developed and deployed a wide-ranging global network of national technical means of verification that can support arms reduction and nonproliferation monitoring. National technical means of verification are the cornerstone of our national monitoring capability and provide a vital underpinning for cooperative measures as well, offering critical clues to focus inspection efforts. In addition, the United States is a world leader in developing new technologies and approaches for cost-effective on-site inspections—a critical part of most international regimes.

All these programs rely heavily on advanced science and technology. Technological advancements are the key to better and cheaper detection and monitoring, which, in turn, can facilitate new agreements to enhance national security.

Our science and technology program in detection and monitoring is extremely broad, encompassing sensors for virtually every part of the electromagnetic spectrum as well as detectors of other indicators of weapons-related activities. Most activities are directed at establishing technological feasibility, although some develop operational capabilities. These systems are designed to operate on a variety of platforms, under conditions ranging from cooperative to noncooperative. They depend on sophisticated control, communications, data processing, and analysis methods. Much of the R&D in this area is conducted at Federally funded laboratories, including those of the Departments of Energy and Defense, and by commercial firms under contract to the U.S. Government. To maintain the ability of these laboratories to respond to specific requirements that emerge, often with little lead time, a continuing broad-based program of basic science in fields as diverse as biology, chemistry, optics, and solid-state physics is essential.



Detection technologies can be placed into three broad categories: space-based, land-sea-air-based, and on-site.

Space-Based Detection Technologies

Satellites are used for a vast array of monitoring tasks, from photoreconnaissance to detection of atmospheric nuclear tests. We are conducting a wide-ranging program of research and development on new monitoring technologies, which includes the design and fabrication for actual deployment of sensor systems needed for treaty verification and proliferation detection. The technology of satellite detection is expensive and exacting, but it must be supported if our monitoring capabilities are to keep pace with a fast-changing world.

As one critical example, we are expanding our research and development efforts to detect nuclear proliferant activities before the assembly of weapons. New space-based sensor systems may offer the capability to identify some of the signatures associated with the early stages of nuclear weapons development programs—such as waste heat from a hidden nuclear reactor.

Land-Sea-Air-Based Detection Technologies

Ground stations around the world are used to track potentially threatening activities, with radar, radio, and other sensors. Aircraft can take photographs, listen to radio signals, and pick up air samples for chemical analysis. Ships at sea are particularly useful for monitoring missile tests and naval and coastal activities.

In all these areas, too, our ongoing S&T program is opening new opportunities for arms control and nonproliferation. For example, we have established research and development programs to develop the capability to remotely detect trace gases associated with proliferant activities through active or passive sensing techniques, to analyze extremely small samples and detect small concentrations of key chemical signatures, and to extract critical information from huge amounts of data from multiple sources. These technologies will be key to our ability to detect, characterize, and locate proliferation activities.

Detecting Proliferant Activity With Laser Technology

Nuclear weapons manufacturing processes produce distinctive chemical effluents which might be amenable to detection using airborne platform. However, the effluent quantities are minute; they are not terribly different from naturally occurring elements; and, since circumstances may not allow on-site visits, they must be detected from long standoff ranges. These factors in combination present enormous technical challenges. Programs underway within the Air Force, the Army, and the Department of Energy are each exploring approaches to the active detection of proliferation-related effluents.

Within the Department of Energy, the Office of Nonproliferation and National Security has teamed researchers at five national laboratories—Brookhaven, Lawrence Livermore, Los Alamos, Pacific Northwest, and Sandia—to develop and assess an active optical remote sensing capability. This program, labeled CALIOPE (Chemical Analysis by Laser Interrogation of Proliferation Effluents) got under way in 1993 and is aimed at using laser systems to detect trace amounts of chemicals and gaseous effluents that result from activities such as nuclear fuel manufacturing, enrichment, and reprocessing, and to do it remotely. CALIOPE draws upon the core competencies of each of the above Energy Department laboratories. There is no other national capability that can match the combination of expertise in nuclear weapons design and manufacturing, chemical analysis, process modeling, sensor and laser technology, atmospheric research, spectroscopy, and large system integration and deployment available in this joint team.

The minute quantities of the effluents anticipated require optical detection techniques which are several orders of magnitude more sensitive than existing active remote-sensing systems. Recent advances in the technology of tunable, high-power laser sources in the relevant wavelength ranges and in sensing techniques may make optical detection practical for this application. The CALIOPE team is addressing difficult technical challenges in the areas of frequency-agile lasers, rugged detectors, and new nonlinear optical materials. Other technical components of their program include signature identification and spectral characterization; laser transmitter and detector/receiver development; and airborne demonstrations.

The program successfully completed its first ground-based system field test in October 1994. The first elevated platform field test is planned for late 1996, leading up to an airborne system demonstration using more rugged components planned before the year 2000.

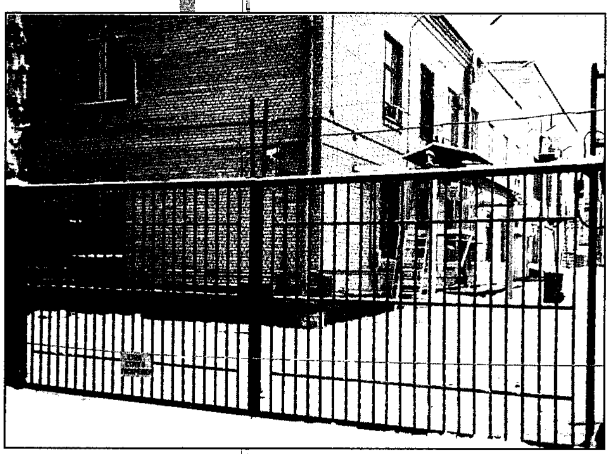
Technologies for On-Site Inspection

From the NPT, which relies on the IAEA safeguards system to confirm that nuclear material is not being diverted to military purposes, to the CWC, whose monitors will face the challenge of dealing with some 25,000 facilities in 65 countries, technologies for on-site inspection are critical to arms reduction and nonproliferation efforts.

On-site inspectors need procedures and equipment that are simple, reliable, and tamperproof. We are focusing on enabling technologies that can make treaty monitoring and verification tasks as simple and reliable as possible. Technology can also provide cheaper and potentially less intrusive on-site inspections. For example, technologies for remotely operated on-site monitoring can cut down on the frequency and cost of inspector visits.

Cooperation To Control Fissile Materials

Under Clinton Administration leadership, the United States and Russia, as the world's largest nuclear powers, have undertaken a wide-ranging cooperative effort to control their huge stocks of weapons-usable plutonium and HEU. This cooperation includes dozens of initiatives in four key areas: (1) securing nuclear materials, thereby reducing the risk of theft or diversion; (2) building confidence through openness, with data exchanges, reciprocal inspections, and other cooperative measures designed to build each side's confidence in its understanding of the size, character, security, and rate of reduction of the other's stockpiles of nuclear weapons and weapons-usable materials; (3) halting accumulation of excess stocks, including the 1994 agreement halting production of additional plutonium for weapons; and (4) disposition of excess materials, transforming excess plutonium and HEU into forms that no longer pose substantial security threats. In all these areas, intensive U.S.-Russian cooperation is already under way.



A key example of the mutual benefit of such science and technology cooperation is the new security and accounting system recently installed at the Kurchatov Institute in Moscow. In just two months in late 1994, for less than $1 million, Russian and U.S. scientists installed a radically improved system to protect and account for the weapons-usable material used in a building housing two critical facilities at Kurchatov. The system includes a computerized material accounting system, nuclear material detectors to detect any attempted theft, motion detectors, alarms, closed-circuit television monitors, and a double security fence. Today, similar cooperative efforts are under way to modernize security and accounting systems elsewhere at Kurchatov and at a wide range of other facilities throughout the former Soviet Union, directly reducing the risk that such materials could fall into the wrong hands through nuclear theft and nuclear smuggling.

A key example of U.S. leadership in providing technology for international on-site monitoring is our support for the IAEA safeguards system. Since 1967 the United States has funded a program to research, develop, test, and deploy new technologies for IAEA safeguards, including methods and equipment for sealing and for providing long-term surveillance of material and equipment; new methods and equipment for measuring nuclear materials and monitoring the operation of nuclear processes, such as reprocessing spent fuel and separating plutonium; and new information management methods and technologies. This program is conducted through the Department of Energy's national laboratories as well as commercial firms. The national laboratories provide a solid foundation of basic and applied research on which IAEA safeguards also depend. The IAEA considers the U.S. program—the first and largest of several such national programs—essential to the IAEA's ability to keep up with evolving technologies and national capabilities.

Improving Worldwide Adherence to Nonproliferation Norms

We must not limit ourselves to controlling the supply of weapons of mass destruction and their missile delivery systems; we must also concentrate on reducing the demand for them. International science and technology cooperation plays an important role in this connection—providing incentives for cooperative arms control and nonproliferation policies, offering new civilian opportunities for weapons experts, fostering reform-minded science and technology communities, supporting efforts to peacefully resolve conflicts and build confidence, and bringing international science and technology efforts to bear in addressing security problems and regional pressures that can contribute to proliferation.

Both the United States and the nations of the former Soviet Union are faced with the challenge of redirecting the talents of thousands of weapons scientists and engineers to new and productive tasks. The sweeping economic transformations shaking the former Soviet Union make this problem both more urgent—because of the risk of a "brain drain" to countries interested in acquiring weapons of mass destruction—and more difficult to resolve. To meet this challenge, the United States has established a wide range of cooperative programs to bring the extraordinary talents of former weapons scientists to bear on key civilian and national security problems.

Both the United States and the nations of the former Soviet Union are faced with the challenge of redirecting the talents of thousands of weapons scientists and engineers to new and productive tasks.

Our international collaborative efforts to reduce proliferation risks include improving protection, accounting, and control of nuclear materials; preparing for entry into force of the CWC; integrating a global seismic network to detect nuclear blasts; finding new approaches to strengthen the BWC; and jointly exploring plutonium disposition options with Russian and other scientists. In regional contexts, collaborative efforts in arms control monitoring can serve as technical confidence-building measures. To this end, we have encouraged foreign government officials and scientists to participate in workshops at the Cooperative Monitoring Center at Sandia National Laboratory, where they can see for themselves technologies that can be applied to build security and confidence between potential adversaries.

International S&T cooperation can provide displaced weapons scientists with new challenges in civilian research, reducing possible incentives to sell their weapons expertise to potential proliferators. International S&T cooperation can also increase mutual understanding between the scientific communities of participating states of each others' activities and objectives and thereby build confidence. The United States and Russia have established extensive laboratory-to-laboratory contacts, and such contacts between the United States and China are developing. Laboratory-to-laboratory cooperation programs have included civilian research in such areas as high-intensity magnetic fields, plasma physics, and computing. These projects have not only kept former weapons scientists employed, but they have also made key technological contributions to scientific and security problems—to the benefit of both sides.

Similarly, we have worked with the European Union, Japan, and other nations to establish the International Science and Technology Center in Moscow and a similar organization in Kiev. These centers are already employing thousands of former weapons scientists in work on

The Cooperative Threat Reduction Program

In the fall of 1991, conditions in the disintegrating Soviet Union posed a clear threat to nuclear safety and global stability. An estimated 30,000 nuclear weapons were spread among the former Soviet republics. About 3,200 strategic nuclear warheads were located outside Russia in the territories of Belarus, Kazakstan, and Ukraine. Political, social, and economic upheaval heightened the prospects that the former Soviet republics would not be able to provide for safe and secure storage or disposition of these nuclear weapons or other weapons of mass destruction.

The dangers posed by this situation were clear: new nuclear nations could spring fully formed from the collapse of the former Soviet Union; weapons might be diverted or used in an unauthorized manner; warheads and fissile materials might be sold to countries or groups with goals that are contrary to ours; and former Soviet weapons scientists and engineers might export their expertise or services to rogue countries and groups.

Congress responded to these conditions and associated threats by initiating the Cooperative Threat Reduction (CTR) program in November 1991. Often referred to as the Nunn-Lugar program, after the Senators who spearheaded the effort, this initiative provided the Department of Defense authority and funding to assist the eligible states of the former Soviet Union in weapons dismantlement and destruction, strengthening the security of nuclear warheads and fissile materials in connection with warhead dismantlement, and demilitarization of the Newly Independent States infrastructure.

The Administration has championed this program and made it an operational success. The CTR program is helping to ensure that nuclear and other weapons of mass destruction are adequately controlled and safeguarded and to prevent proliferation of these weapons and expertise. CTR assistance is facilitating the former Soviet states in meeting and even accelerating their START obligations. To date, CTR has contributed to the removal of over 2,500 warheads from missile and bomber bases into secure central storage in Russia; the return to Russia of over 1,000 warheads that were located in Belarus, Ukraine, and Kazakstan; the deactivation of four regiments of SS-19 ICBMs in Ukraine; the removal of 750 missiles from their launchers and elimination of

nonmilitary projects, chosen through a painstaking process for their outstanding scientific or economic merit. In addition, at the Clinton-Yeltsin summit in May 1995, a new Civilian Research and Development Foundation was announced, which will provide funding to maintain Russia's world-class basic research enterprise.

To complement these programs with a more direct tie-in to economic applications, the Department of Energy has established the Industrial Partnering Program, which brings the talents of U.S. and Russian weapons laboratories together with the interests of industry. Every dollar the U.S. Government provides for a project in the Industrial Partnering Program is matched by industry. This is truly a partnership between government, industry, and the laboratories to bring new technologies out of the laboratory and into the marketplace. Industry has been an enthusiastic participant, and hundreds of projects are already under way.

The Cooperative Threat Reduction Program (continued)

approximately 575 launchers and bombers throughout the former Soviet Union; and the current or projected reemployment of over 5,000 Russian weapon scientists and engineers on peaceful, civilian research projects. The Project Sapphire mission in November 1994 to remove 600 kilograms of highly enriched uranium to the United States from poorly secured storage in Kazakstan was partially funded through CTR. In addition, CTR is assisting the Russians in preparing to implement the Chemical Weapons Convention.

Science and technology are at the heart of many of the CTR program activities. The science and technology centers in Moscow, Kiev, and Almaty help to redirect weapons scientists to commercial research. Defense conversion serves a similar goal, helping weapons manufacturers transfer their technological strengths into civilian products, with the assistance of U.S. companies. Providing environmentally sound destruction methods is helping ensure continued compliance with arms control treaties. And U.S. technology has provided solutions to some important bottlenecks in the dismantlement process. For example, U.S. experts are contributing to the design of a plutonium storage facility in Russia (including the features that will ensure that the material is secure and accounted for), and are helping to build a pilot plant for chemical weapon destruction. U.S. experts will also review Ukrainian proposals for safe disposition of liquid rocket fuel removed from SS-19s based in Ukraine. Developing solutions to these problems will allow dismantlement efforts to continue more quickly.

CTR is not traditional foreign aid. Rather, by directly addressing the dangers in the former Soviet Union concerning weapons of mass destruction, it is defense by other means. The United States spent many billions of dollars during the Cold War to deter and defend against the Soviet Union's weapons of mass destruction. The CTR program is on a significantly smaller scale, but the payoff is tremendous. The results, unlike deterrence, are tangible, observable, and in some cases, immediate. The program also is helping to prevent the emergence of new threats as the new independent states continue to deal with the uncertainties and instabilities of post-Soviet sovereignty and independence.

Finally, international S&T cooperation can help engage and foster scientific communities that can be critical voices for reform. American scientists can influence the views of foreign counterparts in positive ways. From Andrei Sakharov in the former Soviet Union to Jose Goldemberg in Brazil, scientists with an international perspective—resulting in part from their participation in international S&T cooperation and other international forums—have played leading roles in national decisions to restrain weapons programs that threaten international security. Nongovernment organizations also can constructively engage scientists in threshold states and other problem countries to advance international nonproliferation norms. The Administration will continue to encourage international cooperation as a means of engaging the scientific community in the nonproliferation effort.

Conducting the Arms Control and Nonproliferation S&T Program

The United States will pursue a robust and focused S&T strategy to support our arms control and nonproliferation objectives. In particular, we will do the following:

- Focus our export controls on maintaining high walls around a small number of key, proliferation-critical technologies while expanding trade in less sensitive items that can be the engine of economic development. To do this, we will maintain a systematic technical analysis effort to identify critical leverage-point technologies and approaches to their control.

- Maintain a robust, broad-based development program in detection, monitoring, and verification technologies, including space-based, ground-based, sea-based, air-based, and on-site systems, and a strong foundation of basic science.

- Maintain a robust technical program to provide improved technologies and methods to support international nonproliferation and arms control regimes, including IAEA safeguards, chemical and biological detection, detection of nuclear testing, and other technologies.

- Continue broad-scale programs of international S&T cooperation designed to reduce proliferation risks, including cooperative programs to ensure that all weapons-usable nuclear materials are secure and accounted for.

- Continue in-depth technical analysis of what types of future controls and reductions could most benefit U.S. and international security in the post–Cold War era.

Arms control and nonproliferation S&T is fundamentally an interagency activity which involves many federal agencies, including the Arms Control and Disarmament Agency, the Departments of State, Energy, and Defense, and the Intelligence Community. Because no single agency has purview over both requirements and S&T resources, we have substantially improved coordination among these agencies through the National Science and Technology Council to ensure requirements are identified and addressed effectively.

In August 1994, following a comprehensive review, the President established the interagency Nonproliferation and Arms Control Technology Working Group (NPAC TWG), designating the Arms Control and Disarmament Agency, Department of Energy, and Department of Defense as cochairs. The NPAC TWG coordinates arms control and non-proliferation-related research and development governmentwide to help guard against redundancies and gaps.

Currently, the NPAC TWG is developing in-depth analysis of our R&D activities in chemical and biological warfare detection technologies, fieldable nuclear detectors, proliferation modeling, multispectral and active electro-optical sensing, underground detection techniques, research and development database consolidation, START verification sensors, nuclear test monitoring and verification technologies, and unattended remote sensors. In the future, additional in-depth analysis will be developed in other areas, including data fusion, advanced conventional weapons detection technologies, and other existing and future treaty-specific monitoring and verification technologies.

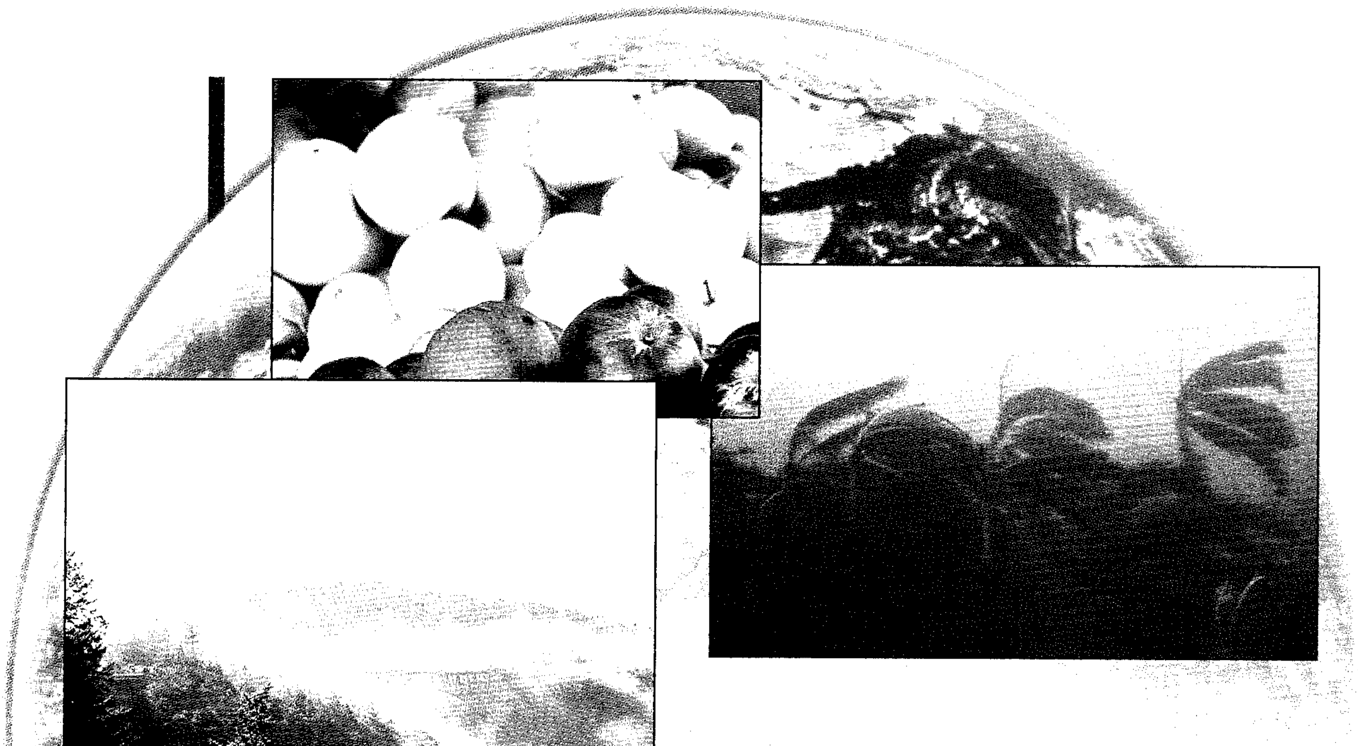
The Challenges Ahead

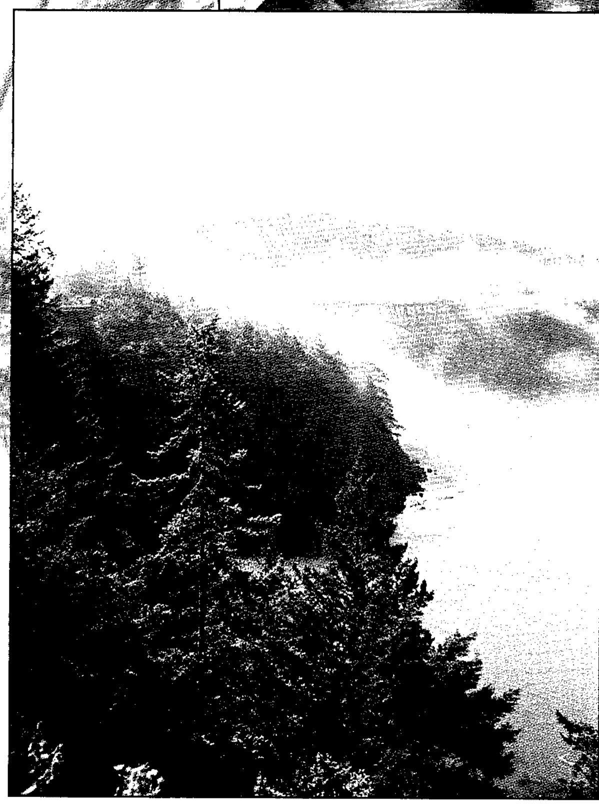
Arms control and nonproliferation require a dynamic blend of policy, technology, and diplomacy. There is an inevitable tension, however, between the competing incentives for controlling technology and sharing it. The technologies in which the United States has the lead are the most marketable in today's global economy, and emerging markets are among the most attractive for future economic growth. But advanced technologies can be used for destructive as well as constructive purposes. And emerging markets are often associated with developing nations and regions with less stable economic and political arrangements.

We are steadfast in our commitment to applying our scientific and technical resources to the challenges of arms control and nonproliferation.

Purely economic factors would have us relax export controls on U.S. goods and services, while narrow security goals might lead us to protect all our own technology and intelligence products. Our nonproliferation goals, on the other hand, motivate us toward restrictive control of weapons-related technologies and increased sharing of detection, monitoring, and verification technology and intelligence products. We balance these competing imperatives by restraining trade—both ours and that of other countries—in potentially dangerous technologies and materials, promoting commercial interests without compromising security, and participating in carefully constructed monitoring and verification regimes.

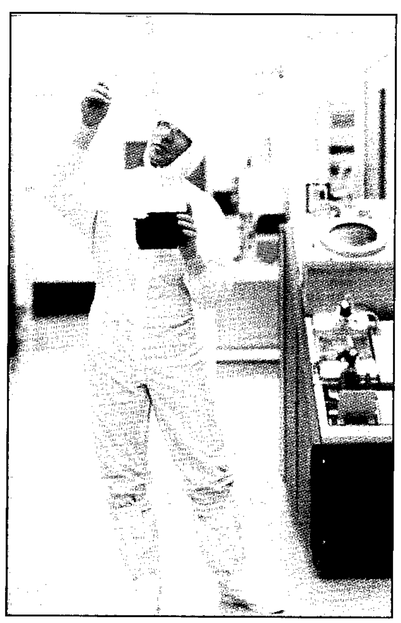
While the inexorable spread of technology is a fundamental part of the nonproliferation problem, at the same time science and technology are great enablers for arms control and nonproliferation, broadening the range of the possible and offering an expanding array of options for policymakers and diplomats alike. The close engagement of the scientific community which we have fostered is indispensable for making sure our technology control policies are wise and effective, our S&T investments are well chosen, and our international cooperative efforts are most fruitful. We are steadfast in our commitment to applying our scientific and technical resources to the challenges of arms control and nonproliferation. To meet these challenges successfully will require not just the technology of today but also constant improvements that enable us to maintain our leadership position.





he decisions we make today regarding military force structures typically influence our ability to respond to threats 20 to 30 years in the future. Similarly, our current decisions regarding the environment and natural resources will affect the magnitude of their security risks over at least a comparable period of time. The measure of our difficulties in the future will be settled by the steps we take in the present.

...Rapid population growth in the developing world and unsustainable consumption patterns in industrialized nations are the root of both present and potentially even greater forms of environmental degradation and resource depletion. A conservative estimate of the globe's population projects 8.5 billion people on the planet by the year 2025. Even when making the most generous allowances for advances in science and technology, one cannot help but conclude that population growth and environmental pressures will feed into immense social unrest and make the world substantially more vulnerable to serious international frictions.



A National Security Strategy of Engagement and Enlargement, 1995

Meeting the Challenge of Global Threats

The Problem

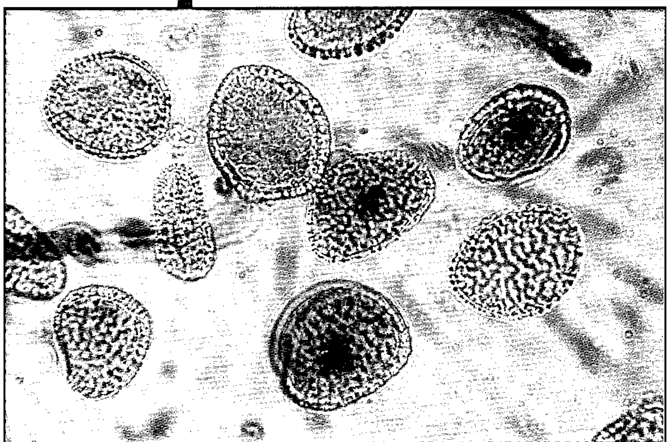
The President's 1995 *National Security Strategy of Engagement and Enlargement* recognizes that a broad class of global threats evident in the post–Cold War world affect our nation's security. The United States is not isolated from the effects of disease, disasters, or misery elsewhere in the world. In the modern world, diseases readily cross borders, and environmental degradation can have global consequences that threaten the populations of all nations. Great human suffering due to natural disasters or to other environmental, economic, or social and political factors may lead not only to large numbers of refugees crossing international borders but also to instability that increases the likelihood of ethnic and regional civil conflict. Understood in these terms, the security of the United States therefore requires engagement with the developing world and with countries in transition to democracy, to take steps to prevent deadly conflict, to encourage economic development that can be sustained for growing populations, and to respond to threats to the environment and human health.

Outbreaks of new or reemerging infectious diseases may endanger the health of U.S. citizens even if the root causes of the problem lie in distant parts of the world. The tragedy of HIV/AIDS has already made this clear. Diseases affecting humans, plants, and animals are spreading rapidly as a result of trade and travel and, especially when combined with malnutrition, threaten public health and productivity on a broad scale. The rapidly growing human population, widespread pollution, and the deterioration of other environmental factors that contribute to the maintenance of good health, as well as the lack of dependable supplies of clean drinking water for fully a fifth of the world's people, contribute to the acceleration and spread of such diseases.

The United States is not isolated from the effects of disease, disasters, or misery elsewhere in the world. In the modern world, diseases readily cross borders, and environmental degradation can have global consequences that threaten the populations of all nations.

Natural disasters, the burden of which falls disproportionately on the poor, pose an especially dramatic threat to sustainable development. The costs of natural disasters are high and have been escalating. For example, domestic natural disasters (ranging from hurricanes, earthquakes, and floods to wildfires and ice storms) now cost the United States more than $1 billion each week. Internationally, the impacts can be greater still. In addition to causing widespread human tragedy and loss of life, for the poorest nations of the world a single natural disaster can reduce the gross national product for that year by as much as 25 percent. Losses of this magnitude represent enormous setbacks to a nation's or region's economic and human development. And in a number of regions, these events occur frequently.

Whereas natural disasters threaten human life and sustainable development in a catastrophic manner, global threats such as climate change, ozone depletion, and ocean pollution may take years or even decades to become apparent and build toward crisis. Yet each of these poses challenges to the health and long-term well-being of both U.S. citizens and people throughout the world.



The loss of biodiversity is an especially urgent threat, the consequences of which are irreversible. The permanent loss of species means we will no longer have these organisms as sources of medicines, oils, fibers, food, chemicals, and other commodities of importance to both industrial and developing societies.

The explosive growth of the world's population is of primary importance and exacerbates many of the dilemmas already discussed. Recent history has shown that, in some developing countries, even the most impressive gains in total economic output can be offset by rapid population growth. Population pressures already contribute to violent disorder and mass dislocations in poor societies. Internally displaced persons—who might become refugees—pose a long-term threat to the integrity of their own and other nations as well as to global stability.

As the world's population grows to exceed 8 billion people by 2025, most of this increase will occur in the cities of developing countries. Worldwide, urban population is expected to increase from 1 billion people in 1985 to 4 billion in 2025. Increases in income, greater urbanization (which leads to a shift in diet from roots, tubers, and lower quality grains to higher quality cereals, livestock, and vegetables), and overall population growth could mean that the demand for food in 2025 will be more than double that of current levels of production.

Individually or collectively, threats such as these can increase the likelihood of destabilization of countries in the developing world. Regional or civil conflicts, hastened or exacerbated by environmental stress, could involve the United States in costly and hazardous military interventions, peacekeeping, or humanitarian operations. As is the case in Haiti, severe environmental degradation and resource depletion may make economic recovery much more difficult, thereby prolonging dependence on aid and impeding a nation's recovery from social or political chaos and progress toward democracy and prosperity.

The Challenge to Science and Technology

Research in the natural and social sciences helps us to understand the origins, characteristics, and consequences of global problems. Finding solutions to these problems, and elucidating the complex chains of cause and effect through which they may be linked, requires a coordinated effort by natural and social scientists, engineers, and policymakers. U.S leadership in science and technology is therefore an important element of our national security.

In some cases, research and monitoring programs offer the only substantial warning to government officials and to the public of an emerging problem. For example, through remote sensing, we can have warning of famine and continue to accumulate a record of the state and evolution of the basic components of our biosphere. Such observations and measurements, coupled with the development of predictive models, are necessary tools for policymaking in the post–Cold War security environment.

Transforming scientific breakthroughs into new technologies can have a profound impact on development. Wise stewardship of these technologies is essential. One challenge is to use technology in such a way that it achieves advances in productivity without compromising long-term natural resource viability. For example, technology helped bring about the Green Revolution, which resulted in increased agricultural productivity worldwide. But at the same time, poorly designed irrigation systems led to soil degradation in some areas. In the decades ahead, technology will be required to feed and provide energy for a growing world population while minimizing impact on the integrity of soil, water, air, forests, and other natural resources. In addition, insights from the social sciences can provide the basis for redesigning research and resource management institutions to achieve the efficient use of resources with minimal disruption to the environment. A major parallel challenge to science and technology will be to make contraception more affordable and effective.

The Administration's strategy for meeting the challenges described above rests on three pillars: preventive diplomacy, promoting sustainable development, and responding to global threats.

Policy Response

The Administration's strategy for meeting the challenges described above rests on three pillars: preventive diplomacy, promoting sustainable development, and responding to global threats. Preventive diplomacy endeavors to resolve problems, reduce tensions, and defuse conflicts before they become crises. The promotion of sustainable development seeks to ensure that development occurs in a manner that can be maintained for the long term, thereby avoiding environmental, resource, or other degradation that fosters poverty and instability. Finally, there is a class of global threats that may take years or decades to become apparent or to build toward crisis but which may directly threaten the well-being of U.S. citizens as well as people around the globe. Responding to these threats will require decisive domestic action as well as international cooperation.

Preventive Diplomacy

The Administration emphasizes support for democracy, sustainable development, traditional diplomacy, and military strength to prevent conflicts from escalating into violence and to contain conflicts that do occur. This strategy defines the practice of preventive diplomacy. When combined with timely early warning systems, and a commitment to use the warning information, preventive diplomacy is a wise investment in national security, offering the prospect of resolving problems with the least human and material cost. The tools of social science are required to identify the most significant factors involved in producing conflicts, and information technologies are needed to detect changes in these factors and to provide early warning. Because this strategy is based on prevention, its successes will often have to be measured in terms of undesirable events that do not happen.

Many conflicts that have occurred since the end of the Cold War may owe more to struggles for political or economic control rather than to environmental stress or population growth. In the case of those conflicts that are essentially political in derivation, the role for science and technology narrowly conceived to prevent or manage them will necessarily be constrained.

Promoting Sustainable Development

As part of its prevention strategy, the Administration is vigorously promoting sustainable development, both at home and abroad. Sustainable development requires that the economies of the world, including our own, try to meet contemporary needs without compromising the resources available to future generations.

Science and Technology for the Prevention of Civil Conflict

The Administration is seeking greater understanding of the role of factors such as endemic poverty, environmental degradation, food scarcity, demographic tensions, and communicable disease in leading to conflict, in order to better design policies of prevention and mitigation. The costs of prevention are most often outweighed by the costs of military intervention once violence has erupted.

The President has asked the President's Committee of Advisors on Science and Technology (PCAST) to examine the interaction between the outbreak of conflict and physical and societal stresses. PCAST will also assess the role that international cooperation in science and technology can play in alleviating these stress factors, thereby contributing to sustainable development and economic and political stability. PCAST will also examine cases of successful and unsuccessful interventions by intergovernmental organizations, international financial institutions, other governments, and nongovernmental organizations.

Domestically, the United States works to halt local and cross-border environmental degradation. In addition, the United States fosters environmental technology, targeting pollution prevention, control, and cleanup. Companies that invest in energy efficiency, clean manufacturing, and environmental services today will create the high-quality, high-wage jobs of tomorrow. By providing access to these types of technologies, our exports can also provide the means for other nations to achieve environmentally sustainable economic growth. At the same time, we are taking ambitious steps at home to better manage our natural resources and reduce energy and other consumption, decrease waste generation, and increase our recycling efforts.

Internationally, the Administration's foreign assistance program focuses on four key elements of sustainable development: broad-based economic growth; the environment; population, health, and nutrition; and democracy and governance. We will continue to advocate environmentally sound private investment and responsible approaches by international lenders. At our urging, the multilateral development banks are now placing increased emphasis upon sustainable development in their funding decisions, to include a commitment to perform environmental assessments on projects for both internal and public scrutiny. In particular, the Global Environmental Facility (GEF), established in 1994, will provide a source of financial assistance to the developing world for climate change, biodiversity, and oceans initiatives.

Population Stabilization

Very early, multiple, closely spaced pregnancies drastically increase the health risks to women and their children, limit opportunities for women, and diminish the ability of families to invest in their children's education and health.

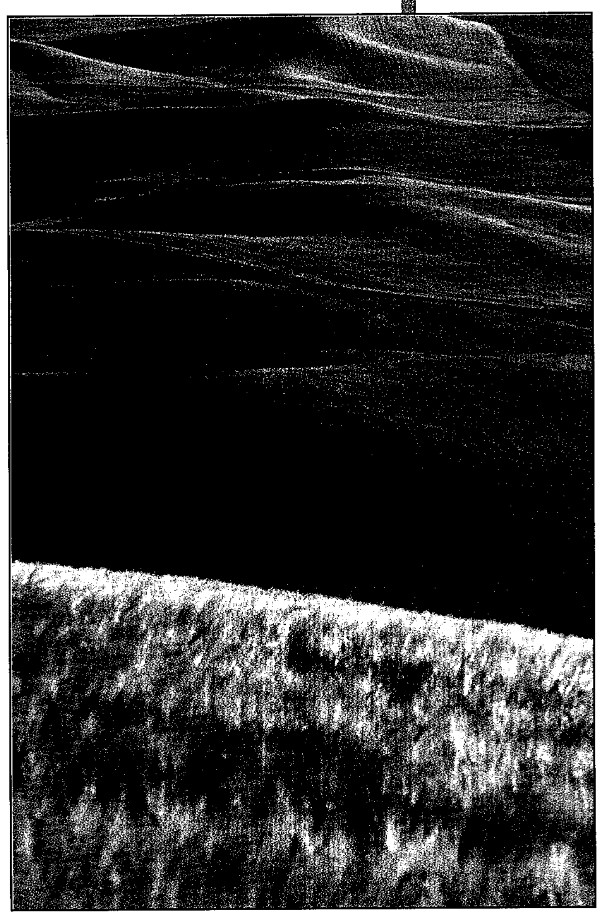
The Administration is leading a renewed global effort to address population problems and promote international consensus for stabilizing world population growth. The United States supports further research to improve existing methods of contraception and to provide a better variety of methods appropriate to different phases of couples' reproductive lives. In addition, the Administration's comprehensive approach stresses family planning and reproductive health care, maternal and child health, education, and improving the status of women. The International Conference on Population Development, held in September 1994 in Cairo, endorsed these approaches as important strategies in achieving global population goals.

Defining Sustainable Development

The most commonly used definition of the term "sustainable development" is one that originated with the 1987 report, *Our Common Future*, by the World Commission on Environment and Development (known as the Bruntland Commission). By that formulation, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Since the release of the Bruntland Commission report, the phrase has been broadened and modified. The term "sustainable" has gained usage because of increasing concern over exploitation of natural resources and economic development at the expense of environmental quality. Although disagreement exists as to the precise meaning of the term beyond respect for the quality of life of future generations, most definitions refer to the viability of natural resources and ecosystems over time and to the maintenance of human living standards and economic growth. The popularity of the term stems from the melding of the dual objectives of environmental protection and economic growth. A sustainable agricultural system, for example, can be defined as one that can indefinitely meet the demands for food and fiber at socially acceptable economic costs and environmental impacts.

In the past, research and development in the field of contraception has emphasized methods with high inherent contraceptive efficacy and safety. Both in the United States and abroad, the increasing need to simultaneously address prevention of sexually transmitted diseases, along with prevention of unintended pregnancies, calls for a shift in emphasis. For this reason, the Administration is now giving highest priority in research and development to products or methods that meet these needs. In addition, the Administration seeks further research specific to the needs of particular countries or regions on the acceptability and use-efficacy of present and future methods.

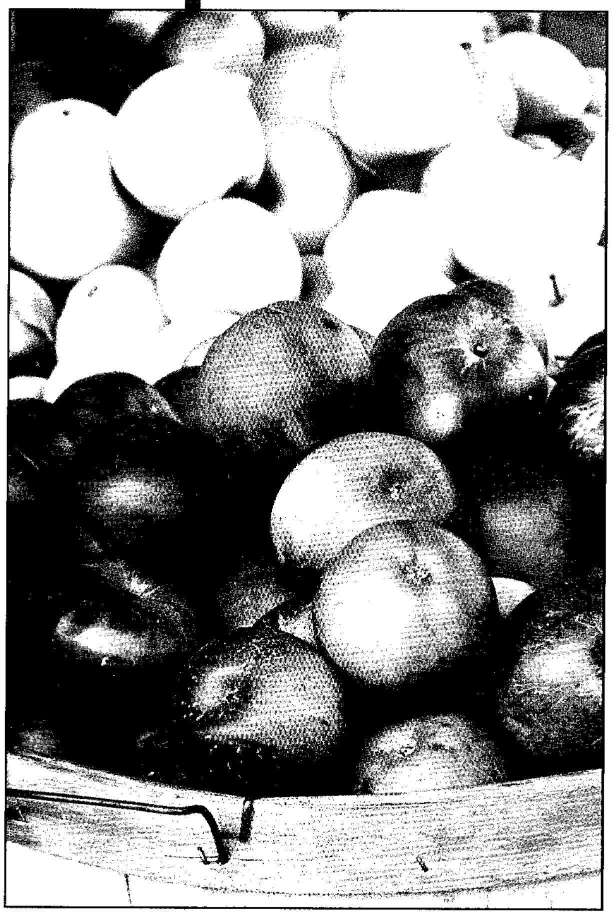


Food Security

The enhancement of international food security plays an important role in achieving U.S. foreign policy objectives. Chronic hunger can set off a cycle of instability, migration, and, in the worst case, war.

Science and technology have valuable contributions to make by increasing agricultural productivity; sustaining the natural resource base on which productivity depends; adapting crops to changing environmental conditions; furthering good nutrition through the development of better food crops; and improving food preservation, storage, and distribution. This science-based approach will not only enhance food security, it will also foster more sustainable management of natural resources.

With the global population forecast to increase at nearly 90 million people per year, there is no acceptable alternative to increasing productivity of agricultural and other land- and water-use systems. Scientific research is key to increasing yields of land-use systems; past gains stemming from area expansion, and even fertilizer use in some areas of Asia, can no longer be continued.



The scientific intensification of agriculture must continue in favored areas, but research applications must also target more marginal areas, many of which are those most threatened by nonsustainable practices and environmental degradation. For example, better management of agricultural chemical use in developing countries can lead to higher yields and less crop loss while limiting the risks to the environment and the health of farm workers. Integrated pest management, conservation tillage, and integrated nutrient management when adapted to resource conditions through research are likely to offer useful technological alternatives.

As a starting point, the United States recognizes the need for a comprehensive program to acquire, document, and conserve genetic resources of economic plants and animals. Germplasm conservation is integral to sustainable agricultural productivity. To this end, the United States conducts a domestic agro-biodiversity conservation program and provides support to important multilateral initiatives.

In some areas, where crop production activities may remain marginally economic, food security will be enhanced through the development and application of science-based, resource-efficient production of livestock, fuel, fiber, or forest products. In this light, enhanced research emphasis is being placed on developing agro-forestry and other systems that provide livelihoods to rural families while protecting the natural resource base. Moreover, postharvest processing, prevention of losses, and many other income-generating activities can contribute to food security. U.S. programs therefore also include research to reduce postharvest losses and to develop further applications of agro-industrial crops. U.S. assets are also engaged in remote-sensing endeavors that forewarn of impending famine.

Natural Resource Stewardship

The Administration is acting to ensure the sustainable management of U.S. forests by the year 2000. In addition, U.S. bilateral forest assistance programs are being expanded, and the United States is promoting sustainable management of temperate and tropical forests. The sustainable use of forests is essential to ensuring that these resources will continue to be available to fuel development through the future.

In the wake of the 1992 United Nations Conference on Environment and Development, the United States has sought to reduce land-based sources of marine pollution, to maintain populations of marine species at healthy and productive levels, and to protect endangered marine mammals.

The Administration also places high priority on protecting the ocean and coastal environment and conserving living marine resources, reflecting the important national security, environmental, and economic interests at stake regarding ocean resources. The United States has five principal

Postconflict Landmine Clearance

Landmine clearance is an important step toward resumption of economic activity and stabilization following war or civil conflict, and thereby a means of reducing the likelihood of future conflict. Frequently, it is also a prerequisite for the repatriation of refugees. Thus, it is genuinely a development issue.

Humanitarian mine clearance is not the same as clearing mines for military purposes—technologies for breaching are often not appropriate for clearing large settlement areas. However, technological solutions can be improved through communication and cooperation between applicable military technologies and humanitarian mine clearance communities. In the long run, clearance capacity must be built through development of indigenous capabilities that are sensitive to local priorities, policies, socioeconomic factors, and that can continue for the long time required.

The Administration has identified a number of priorities in this area:

- The effectiveness of current capabilities for humanitarian mine clearance needs to be improved dramatically. The U.N. has set a goal of improving it on the order of 50 times the current rate. (According to the UN, only 84,000 mines were cleared in 1993, as compared with 2-3 million new mines laid.) The current costs of approximately $300 per mine cleared must also be cut dramatically.

- Improved technology is needed for locating and discriminating mines (especially from nonmine metal fragments).

- The humanitarian community must develop more specific, systematic technical requirements for the technology it needs—both for incremental improvements to existing technologies and for R&D priorities in hopes of making significant improvements in the future.

- Greater national and international cooperation and coordination of efforts are also needed, including increased public awareness and support, much improved cooperation among military, humanitarian, and economic development agencies in donor and recipient countries, and improved organization and sharing of information.

Mine clearance is a subset of the broader issue of the clearance of unexploded ordnance (UXO), which presents a greater technological problem in detection, characterization, and removal. Whereas landmines are located near the surface, UXO may be buried down to 30 feet. UXO may also have much greater explosive charges. Investment in UXO clearance technology is needed both for the U.S. armed forces and for international economic development.

objectives in this area: (1) becoming a party to the 1982 U.N. Convention on the Law of the Sea, as modified in 1994; (2) ensuring sustainable management of ocean fisheries; (3) supporting integrated coastal resource management and reducing marine and coastal pollution; (4) promoting the conservation of marine biodiversity, including whales and other protected species; and (5) conducting scientific research and ocean monitoring both to support these objectives and to more fully understand oceanic and atmospheric processes of global importance.

An understanding of the changing ocean and coastal environment is essential in order to manage ocean resources in a sustainable manner. This Administration places a priority on ocean monitoring and supports appropriate research on fisheries and marine biodiversity, as well as on the marine physical system and ocean-atmosphere relationships important to understanding climate change. The United States will continue to cooperate with other countries and international bodies in support of the Global Ocean Observing System. We will continue to vigorously promote the consistent and equitable implementation by nations of the provisions of the U.N. Law of the Sea Convention on marine scientific research to ensure maximum access to oceanographic data vital to managing ocean resources, as well as for understanding global change. And we will continue to push for international acceptance of the principle of full and open access to oceanographic and meteorological data. This increased emphasis on oceanographic research and monitoring will directly benefit global maritime operations—both civil and military.

Natural Disaster Mitigation

To be sustainable, a society must be resilient to natural hazards. Natural hazards, ranging from earthquakes to pestilence, are inevitable. By contrast, natural disasters—defined as long-lasting disruption of entire communities exceeding the communities' ability to recover unaided—are as much a product of societal behavior and practice as of nature. Natural disasters can and should be mitigated.

The United States is a world leader in developing and implementing technologies for both monitoring natural hazards and mitigating natural disasters. The United States is in the final stages of major improvements in weather forecasting and is working to improve the dissemination of this information. In keeping with its strategy of prevention, the United States provides technical assistance and equipment to other countries to help them predict and assess changes in the natural environment and minimize the loss of lives and property due to natural disasters.

Multilaterally, the United States is participating in a U.N. initiative intended to ensure that by the year 2000 all countries will have incorporated into their plans for achieving sustainable development comprehensive national assessments of risks posed by natural hazards and mitigation plans for these risks at the national and local levels. Countries will also have incorporated into their plans ready access to global, regional, national, and local warning systems.

Promotion of Knowledge

The preceding discussion makes clear the central role that the dissemination of knowledge and expertise plays in any sustainable development strategy. An effective way to promote sustainable practices globally is through partnerships in teaching and research among developed and developing countries. A global community of scholars, united by a shared understanding of scientific methodology and responsibility, and linked via modern telecommunication networks, will be a positive force for promoting stability, democracy, and economic development. This is one reason why the Clinton Administration has made the development of national and global information infrastructures national priorities.

To promote scientific knowledge abroad, the United States enters into cooperative science and technology agreements with countries around the world. These agreements provide the protocols for cooperative research by government-sponsored scientists and engineers. The United States maintains these agreements, and the intellectual property rights protection contained within them, both for geopolitical reasons and because U.S. scientific and technological leadership can be strengthened through international cooperation. Some of today's most difficult challenges cannot be solved by the United States (or any country) acting alone. During a time of severe budgetary constraints, some projects are too costly for any one nation. Sometimes the work must be done in situ; for example, assessing and preserving biodiversity or monitoring disease outbreaks. Other issues naturally invite collaboration because of unique foreign expertise or facilities. Cooperation builds bridges among nations, sometimes even when no other avenues are available.

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The Administration fosters international collaborative research by universities, government, and private sector laboratories with counterparts in developing countries and will also build on the opportunities in existing multilateral efforts. Of particular note are the international agricultural research centers sponsored by the Consultative Group on International Agricultural Research (CGIAR). These centers, which are funded largely by the United States and other OECD donors, link closely to research institutions here and in other developed countries. They represent a key means of developing and delivering food-security enhancing, public-goods technologies to developing countries. With a large contingent of U.S. and U.S.-trained scientists, they represent an excellent means of linking to domestic research.

There are an estimated 1 billion illiterate people in the world. High levels of illiteracy undermine sustainable development goals. Clearly, scientific and technical literacy is required as well. Technology transfer and the development of locally appropriate solutions cannot take place if countries with nearly 80 percent of the world's population (and over 90 percent of population growth) continue to have only 6 percent of the world's scientists. Training students from the less developed sectors of the world who then do not return to their own countries, or organizing training without adequate concern for promoting infrastructure for them at home, will serve to undermine the role of the U.S. education sector as a tool for global sustainable development.

On Earth Day 1994, Vice President Gore announced the Global Learning and Observations to Benefit the Environment (GLOBE) program. GLOBE is an international environmental education and science effort designed to enable students, educators, and scientists to work together to monitor the global environment and provide information for developing a worldwide environmental database. The GLOBE program, with participating schools around the world, will allow students to perform environmental measurements that will greatly augment Earth

The Global Information Infrastructure and Sustainable Development

The Global Information Infrastructure (GII) has an important role to play in sustainable development. The GII fosters dialogue between nations and ethnic groups and enables applications such as collaborative scientific research, distance learning, telemedicine, and electronic commerce. Electronic networking is transforming communications and the conduct of research around the world. While this transformation is fastest in the industrialized world, it is taking place in the developing world as well.

Facilitating services and research. HealthNet in Africa links physicians, researchers, medical educators, and other health care workers to their colleagues abroad. ARCCNET (African Regional Centre for Computing Network) serves as a platform for computer training and research, facilitating cooperation and improved linkages between the computer industry, academia, and policymaking institutions.

Improving management of natural resources. The United States Geological Survey is providing computer hardware, software, and technical support to establish Geographic Information System (GIS) facilities at different sites in the world through cooperative programs. These facilities compile, digitize, analyze, and distribute geologic, environmental, and related information to support programs in energy and mineral resources, sustainable economic development, and environmental protection.

Strengthening healthcare. By linking hospitals around the world to the United States on the Internet, the United States Centers for Disease Control share information on, and create databases for, communicable diseases.

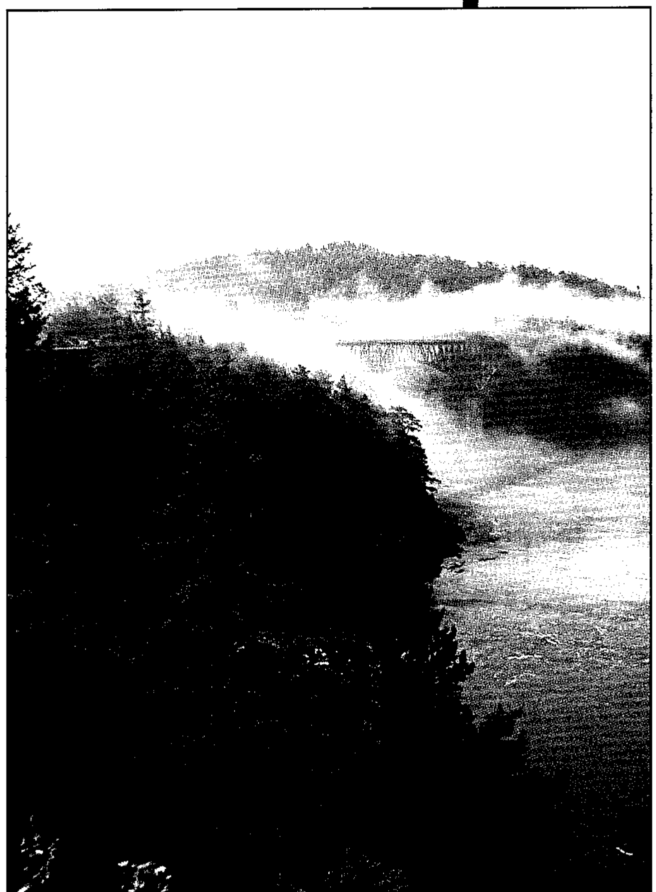
Promoting scientific advances. In conjunction with the International Research and Exchanges Board (IREX), the United States Information Agency intends to bring Newly Independent States (NIS) scholars and members of nongovernmental organizations and related professional and governmental groups in contact with one another and link them into international databanks via computer communications. For example, a group of 60 Russian educators visiting the United States in 1995 will be linked to their American colleagues and one another through an IREX electronic mail network upon their return to Russia.

The goal of the Administration's GII initiative is to foster the communication and cooperation that will be needed to spur the transformation of a thousand discrete networks in the developed and developing worlds into a connected, interoperable global information infrastructure.

observations from existing satellite and ground-based systems. Scientists and educators are working together to design experiments that will provide hands-on science and mathematical experience for elementary through high school students and generate useful environmental data for scientists.

An Environmental Technology Strategy

Not only knowledge but also appropriate technology must be promoted if we are to foster global sustainability. The Clinton Administration has crafted a forward-looking environmental technology strategy that should allow us to move expeditiously toward sustainable development. The result of working with thousands of stakeholders over two years to identify a core set of five themes to guide future activities, this national strategy is presented in the Administration document, *Bridge to a Sustainable Future*. The five themes are designed to establish a framework for partnerships, goal setting, policy development, and action. Within each theme, a series of findings, goals, and initiatives have been identified that together articulate a technological path leading toward sustainable development. The agencies of the Federal Government are developing specific action plans for implementing this strategy, but industry, labor, communities, nongovernmental organizations, individuals, state governments, and nations around the world all have important responsibilities as well. The key to progress is to build on the strengths of each sector in order to achieve goals collectively that cannot be achieved individually.



Broadly, the five themes of the strategy comprise: (1) the development of a new generation of incentive-based policies and programs that stress performance, flexibility, and accountability; (2) shifting from reacting to environmental damage to anticipating and avoiding it; (3) supporting investment in and the diffusion of successful technologies; (4) moving rural and urban communities toward sustainability; and (5) building more effective, open, and productive collaboration among stakeholders.

Specific goals of the national environmental technology strategy include improving substantially the nation's environmental monitoring data and information systems over the next five years through public-private partnerships designed to share information essential for sustainable development, and promoting the use of environmentally sound and socially appropriate technologies in developing nations throughout the world.

Responding to Global Threats

A strategy of sustainable development and preventive diplomacy also requires a robust response to global threats such as emerging or reemerging infectious diseases, climate change, and biodiversity loss. Whereas natural disasters threaten sustainable development in a particular nation or region in a catastrophic manner, these other threats are potentially global in scope but may have onsets that take years or decades to become apparent or build these global threats.

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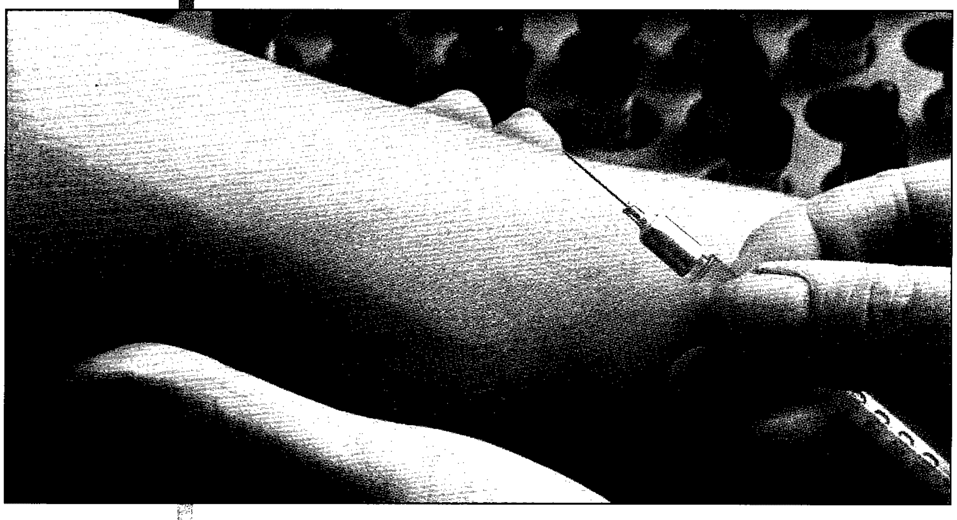
Infectious Diseases

Modern transportation, international trade, and population shifts all contribute to the spread of diseases in developed and developing countries. As a result, infectious diseases that originate in distant parts of the world represent a potential health risk to U.S. citizens. Early detection and vigorous intervention efforts are essential to containing new and reemerging diseases before they spread. In the United States and in other industrialized nations, however, the majority of health care funds pay for treatment of those who are already ill. The key to dealing effectively with new or re-emerging infectious diseases is global surveillance and response, and basic biomedical research.



Infectious diseases can prevent U.S. troops operating abroad from being an effective fighting force. Techniques to prevent, detect, and control these diseases are important to keeping our troops healthy.

A well-designed surveillance program can detect and track unusual clusters of illness and establish their geographic and demographic characteristics. Effective surveillance and prevention strategies must be based on an understanding of the complex interactions between humans and microbes as well as an understanding of the evolutionary and genetic factors that cause epidemics.

The Administration is putting into place a national response to the threat of infectious diseases. While continuing to support research and training in basic and applied research to support U.S. leadership in disease surveillance, the United States will strengthen its ability to respond to epidemics by increasing U.S. "surge" capacity for the emergency production of diagnostic tests, drugs, and vaccines. Internationally, the United States will work with multilateral organizations and other countries to improve worldwide disease surveillance, reporting, and response, encouraging other countries to make infectious disease detection and control national priorities. U.S. Government laboratories and field stations abroad will be coordinated to form regional hubs in a global disease surveillance system. Our ultimate goal is to foster the creation of a worldwide disease surveillance and response network.

The key to dealing effectively with new or reemerging infectious diseases is global surveillance and response, and basic biomedical research.

Climate Change

In 1992 the United States joined the international community in signing the Framework Convention on Climate Change. It was a treaty that called on all nations to work together to protect the global environment. Specifically, the industrialized countries were urged to take the lead by stabilizing greenhouse gas emissions to 1990 levels by the year 2000. Soon after taking office, the Administration went beyond the nonbinding language of the treaty to declare that the United States would meet this goal.

The Administration has developed a plan aimed at fulfilling this commitment. The government has signed voluntary agreements with the bulk of the U.S. utility industry to keep greenhouse gas emissions down. Similar partnerships have been forged with U.S. industry on energy-efficient computers, buildings, and lighting systems. The Administration has launched a

The Importance of Surveillance Systems for Infectious Diseases

The outbreaks of Ebola in Zaire and plague in India have emphasized the importance of national and international surveillance and response capabilities to infectious diseases. Our past experience has demonstrated that allowing surveillance capabilities to dwindle may have serious consequences. Prevention or early intervention is both more humane and less expensive than mounting a late, emergency response.

For example, for many years the United States had in place a surveillance system to monitor cases of tuberculosis (TB). However, during the 1980s Federal and local spending on infectious disease control declined, and in 1986 the surveillance system for multi-drug-resistant TB was discontinued. Consequently, there was no warning signal when drug-resistant TB emerged in the late 1980s. This lack of early warning undoubtedly contributed to the more than $700 million in direct costs for TB treatment incurred in 1991 alone. Surveillance of drug-resistant TB was not reinstated until 1993, by which time multi-drug-resistant TB had become a public health crisis and millions of Federal dollars had been allocated.

AIDS is a new disease that was unknown before the 1980s and thus was not on any surveillance lists. AIDS weakens the immune system, allowing other infections to take hold. Therefore, it can be difficult to diagnose, since its clinical presentation may involve a variety of symptoms, and its incubation period (the time between infection and the appearance of symptoms) is several years. Nevertheless, long before AIDS was diagnosed in the United States and Europe, a distinct syndrome called Slim Disease (now known to be a form of AIDS) that causes its victims to waste away was recognized by African doctors. In fact, an aggressive, Slim-associated, generalized form of Kaposi's sarcoma, distinct from the classical form, has been described in Uganda since at least 1962. If a global surveillance system with the capacity to identify new diseases had been in place in the 1970s, AIDS might have been identified earlier, perhaps before it became well established in the United States. Epidemiologists might have gained a headstart in learning how AIDS is transmitted and prevented, and many lives might have been saved.

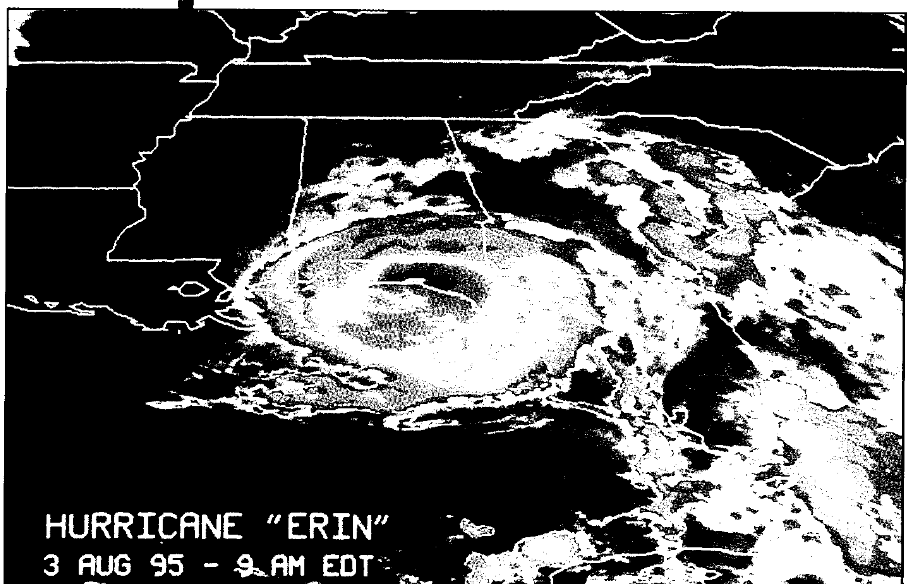
partnership for a new generation of vehicles—the Clean Car Initiative. And the United States has pledged $430 million to the Global Environmental Facility (GEF) for its second phase, the largest contribution of any nation in the world.

But in addition to these action-oriented steps, the Administration also recognizes that our understanding of climate change and other environmental issues rests on fundamental research, the data for which must come from comprehensive observations. The Administration has therefore identified environmental observations and data management as an area to receive enhanced emphasis.

Observations and Data Management

Extensive Earth observation and monitoring are a critical component of environmental and natural resource research aimed at advancing scientific understanding and developing predictive capabilities. The coordination of observation and data management efforts ensures that the data necessary to answer the questions of highest priority to both scientists and policymakers are being gathered and distributed and that U.S. efforts are taking full advantage of, and being sufficiently coordinated with, international efforts.

The Administration has identified four areas for enhanced emphasis: (1) linking local-scale data collection efforts to regional- and global-scale efforts; (2) linking remote sensing data from satellites to in situ measurements; (3) linking socioeconomic data to data on the natural environment; and (4) making Federal agency environmental data and information available in forms useful to the public, educators, policymakers at all levels, business activities, and researchers.



Although the United States and many other nations are collecting critical environmental and natural resource data, successfully understanding many aspects of environmental science will require the implementation of an international policy of open and stable exchange of data and information. The United States promotes the continuance and extension of the full and open exchange of all environmental data and related information at no more than the marginal cost of fulfilling specific user requests.

Finally, the Administration is acting to put hard-won and expensive data collected during the Cold War to the service of environmental understanding. Following a Presidential Executive Order, some 800,000 spy satellite photographs taken between 1960 and 1972 are to be released. Selectively declassifying information gathered during the Cold War will allow these images to shed new light on the progression of deforestation, the loss of fresh water, desertification, and other issues.

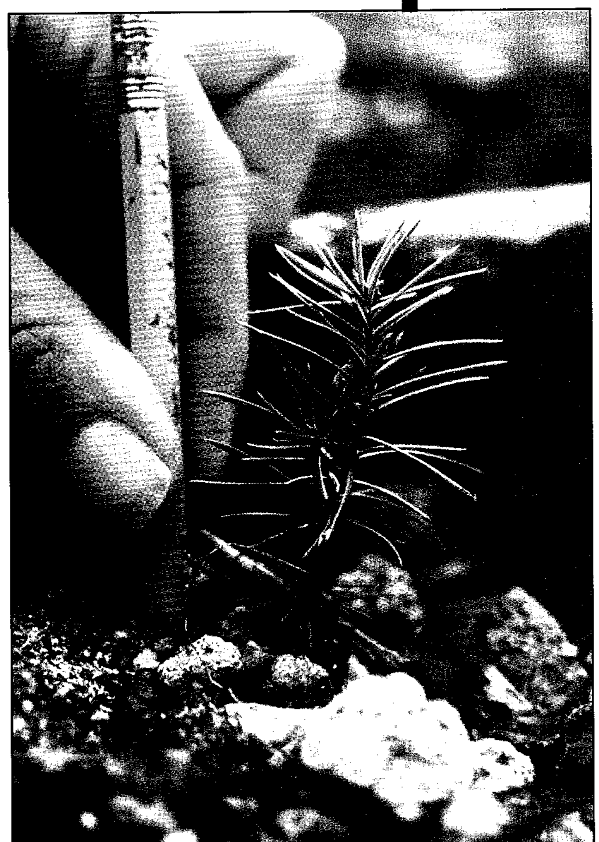
Biodiversity and Ecosystem Research

In June 1993, the United States signed the Convention on Biological Diversity, which aims to protect and utilize the world's genetic inheritance. The Interior Department has been directed to create a national biological survey to help protect species and to help the agricultural and biotechnology industries identify new sources of food, fiber, and medications.

The Administration has set a goal of developing the understanding of ecological systems necessary for assessing the ecological consequences of environmental change. This goal will promote the efficient use of natural resources, while sustaining ecosystem integrity for future generations by developing science-based management principles and a predictive understanding of the ecological impacts of environmental change.

It is imperative that we understand and quantify the drivers of change in ecological systems. Understanding the importance of the influence and magnitude of different drivers of change is critical to developing strategies for sustainable development. To this end, the Administration has identified six areas for enhanced emphasis in ecosystem research: (1) documenting change in ecological systems; (2) understanding processes in ecological systems; (3) synthesizing and assessing ecological data and information; (4) predicting ecological change; (5) understanding the interactions of human and ecological systems; (6) and the restoration, rehabilitation, and management of ecological systems.

An example of the Administration's increased emphasis on ecosystem research, and its importance for preserving biodiversity, is provided by the Coral Reef Initiative. The declining health of coral reef ecosystems links the larger issues of climate change and increased stress from human population growth. Some scientists estimate that 10 percent of reefs have already been degraded beyond recovery, and that 10 to 20 percent more could be gone by the year 2010. Not only does this mean the loss of a large fraction of the ocean's most biodiverse ecosystems, but also this decline is bad for tourism and fisheries, and hence for development. To address this degradation, the U.S. Government is forming partnerships with states and territories, other nations, multilateral development banks, and nongovernmental organizations. The Initiative's goal is to enable countries to use existing resources to sustainably manage coral reef ecosystems over the long term.



Socioeconomic Dimensions

The social and economic sciences represent a critical component of any research agenda on environmental change. Research in the social and economic sciences aims to clarify how human activities affect the environment; how environmental changes affect our society and its component groups; and how we and our institutions respond to environmental change.

Long-term research is needed on human-environmental interactions and system dynamics. Their complexity requires greater collaboration of physical, life, and engineering scientists with social scientists than usually prevails. The Administration has identified three research areas for enhanced emphasis: (1) fundamental human and social processes that affect our use of the Earth; (2) the development of a better portfolio of policy instruments and decision tools; and (3) improving the flow of information between the research and policy communities and within the public and private sectors.

Science Policy Tools

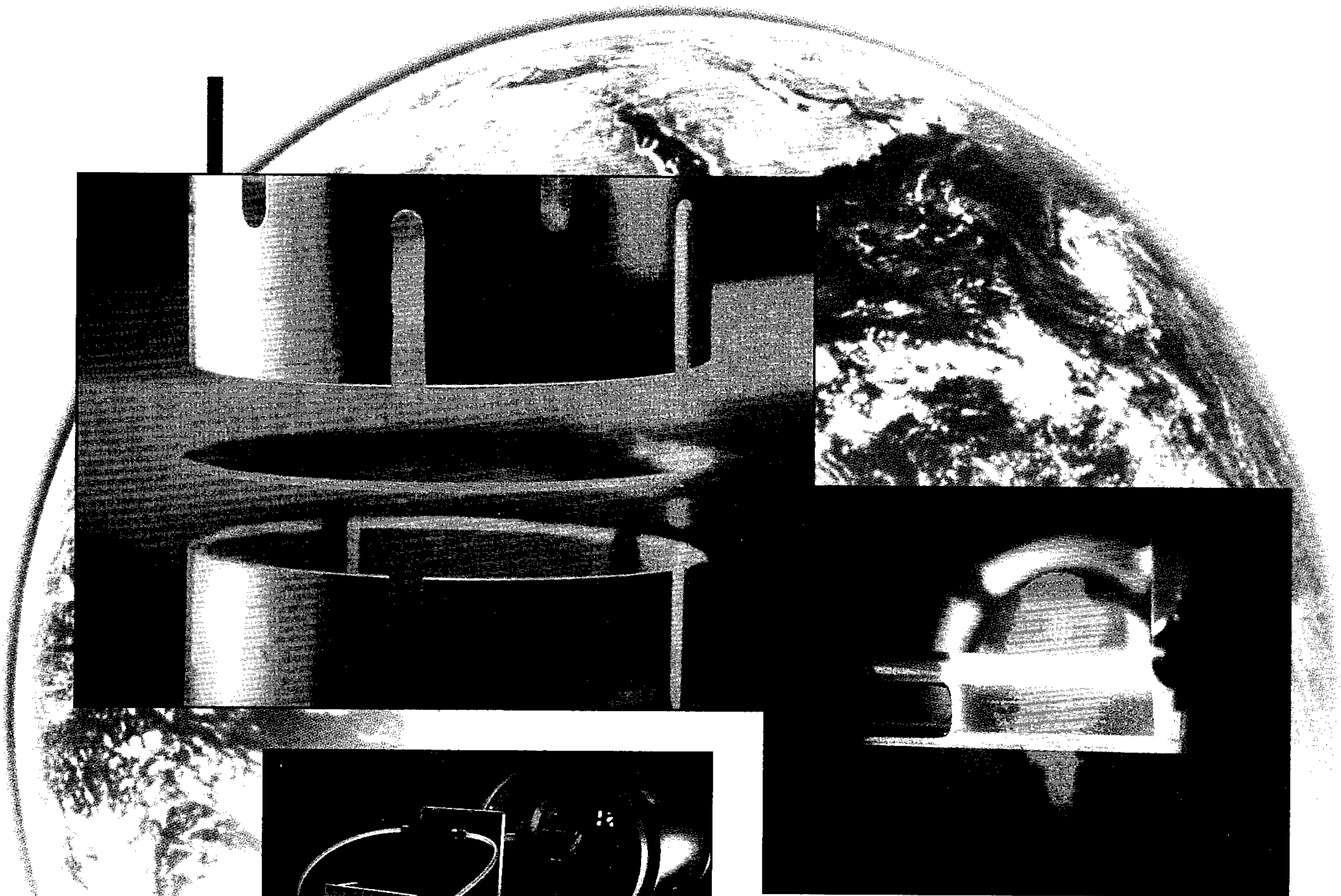
Science policy tools for decisionmaking provide the links between the physical, natural, social, and economic sciences and environmental policy. Technical assessments are key tools in formulating national and international environmental policies. To be useful, however, these assessments must be credible to all stakeholders, including the Administration, Congress, industry, nongovernmental organizations, and the public.

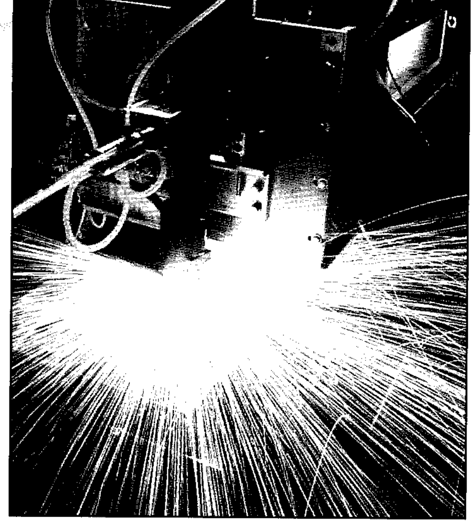
The Administration's goal is to use assessment methods to characterize, prevent, and reduce health and environmental hazards in the most effective, efficient, and fair manner. The Administration is committed to strengthening the methods used to perform risk and integrated assessments of health and environmental hazards.

The declining health of coral reef ecosystems links the larger issues of climate change and increased stress from human population growth.

Strategic International Cooperation

As a world leader in science and technology, the United States has an opportunity to apply its science and technology capabilities to support international initiatives that benefit the United States and the global community. To realize this potential, the Office of Science and Technology Policy is developing strategies for cooperation with other nations—"country strategies"—placing a priority on those that are key to the stability of their region, have the scientific and technological base to attract long-term investments and trade, and offer emerging markets for U.S. goods and services. By strengthening the progress of science and technology and the communities of researchers and scholars, international cooperation can contribute to positive political and economic reform, regional stability, sustainable development, and economic growth.





A central goal of our nation's national security strategy is to promote America's prosperity through efforts both at home and abroad. Our economic and security interests are increasingly inseparable. Our prosperity at home depends on engaging actively abroad. The strength of our diplomacy, our ability to maintain an unrivaled military, the attractiveness of our values abroad—all these depend in part on the strength of our economy.

A National Security Strategy of Engagement and Enlargement, 1995

Strengthening Economic Security

The Policy Challenge

Over the past several decades, the U.S. economy has experienced a profound transformation. Thirty years ago the U.S. economy accounted for well over a third of the world's total, and U.S. companies were leaders in most manufacturing industries. By 1994 the U.S. contribution had fallen to about a fifth of the world economy, with industries in Europe and Asia now fierce competitors. Since World War II other nations have rebuilt their industries, made improvements in technology, upgraded their education systems, and adopted new and innovative management practices. With the end of the Cold War, the globalization of markets, and rapid technological progress worldwide, foreign competition has put unprecedented pressure on American industry. Advanced technology has been at the heart of America's competitive advantage, and today technological leadership means the difference between success and failure in the new global economy.

The technology base that propels the economy is in turn increasingly crucial for national defense. In a number of important technologies, the defense industry no longer leads the commercial sector. For example, the new technologies that are most critical to our military advantage—software, computers, semiconductors, telecommunications, advanced materials, and manufacturing technologies—are being driven by fast-growing and changing commercial demand. In the past, it was more common to think of technologies as "spinning off" from military development to civilian markets. Technologies today are in growing numbers "spinning on" from civilian labs and commercial products to military uses. These dynamic commercial markets must be tapped to provide for a more sophisticated military defense at a lower cost to the taxpayer.

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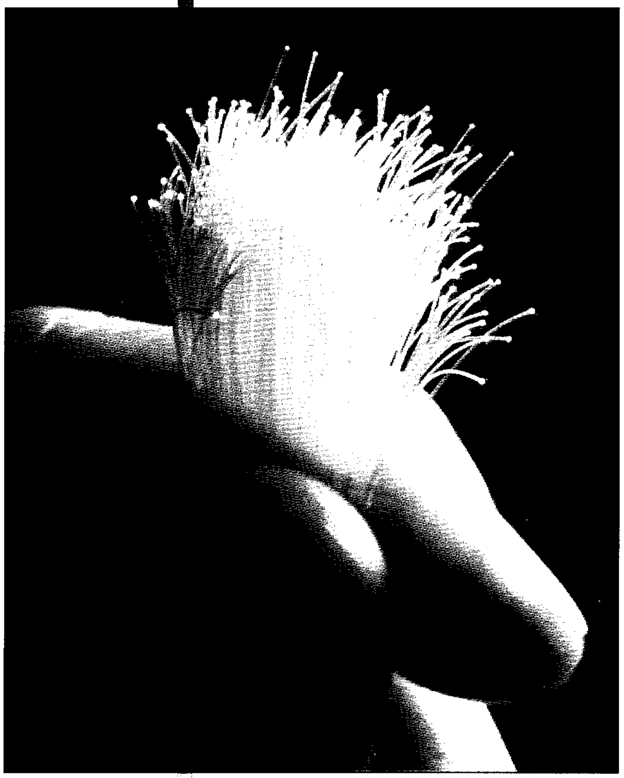
Through engagement abroad, U.S. leadership in commercial technology also strengthens the stability of strategic nations, working to prevent conflict before it occurs. A combination of competition and cooperation in science and technology with these economies promotes their stability, enhances integration with the global economy, and contributes to growth in the United States.

Fully exploiting the technology base to meet economic, defense, and global stability goals is thus a growing demand of policy and is increasingly important in the face of tight Federal budgets. The need to reduce the size of the Federal deficit means that every dollar invested by the government must bring a maximum return to the public and leverage to the greatest extent possible the capabilities of the private sector.

This chapter describes Administration policies in science and technology that are designed to bolster the nation's long-term economic security through both domestic economic growth and international trade.



Administration Policy

Now, more than ever, science and technology are critical to our nation's future. It is the belief of this Administration that technology is the engine of economic growth, and science is the fuel that stokes this engine. From the steam engine to the airplane, from electrical power to the transistor, from the telephone to the microchip—scientific discovery combined with technological innovation have dramatically changed our lives, the workplace, and our economy. In the process, entirely new industries and new high-wage jobs have been created. However, international and domestic changes bring continuing challenges to sustaining U.S. leadership.

Science and technology are cornerstones of the Administration's strategy for economic security. To address the new global challenges, the Administration is pursuing a strategy designed to equip American companies and workers to compete and win in the international economy. Elements of this strategy are the following:

- Creating a climate that fosters private-sector innovation and commercialization.
- Supporting industry-led technology development partnerships.
- Facilitating the rapid deployment of civilian technologies.
- Building a 21st-century infrastructure.
- Maintaining strong support for basic science.
- Supporting education in science and technology.
- Leveraging dual-use technologies for commercial markets.
- Promoting international economic development and trade through international collaboration.

Each of these policy priorities is summarized below.

Creating a climate that fosters private-sector innovation and commercialization. A broad range of factors affect the ability of U.S. companies to develop technology, turn innovations into products and services, and bring them to global markets. Continued emphasis on debt reduction is essential to free up capital for private-sector investment in research and development, plant and equipment, and new or expanding businesses. Other measures include tax policies that encourage innovation including extension of the research and experimentation tax credit; reform of regulatory barriers to innovation while safeguarding the environmental and health goals that are the object of regulation; and reducing outdated Cold War export controls.

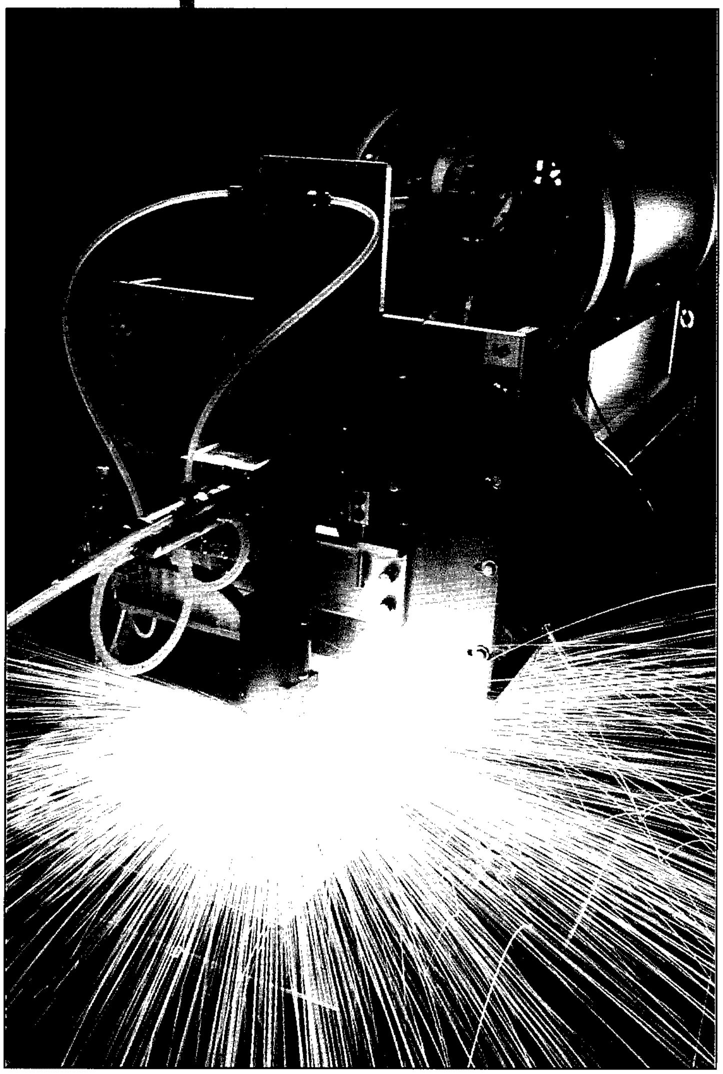
Export Control Reform

The end of the Cold War, the outbreak of regional conflicts, and the emergence of countries that have repeatedly provided support for acts of international terrorism have led the Administration to fundamentally reevaluate U.S. export control policies. With the demise of the Soviet Union and the Warsaw Pact, the United States is involved in negotiations to establish a new multilateral export control regime to succeed the Coordinating Committee for Multilateral Export Controls (COCOM), which ceased to exist after March 31, 1994. The COCOM successor regime is aimed at controlling exports of sensitive dual-use items and conventional weapons on a worldwide basis, with special focus on certain countries of concern and countries located in geographic areas where the military balance could easily be altered or destabilized.

Although the Administration has addressed the shifting focus of U.S. export controls from their previous emphasis on the strategic concerns of the Cold War to a more balanced consideration of proliferation concerns and regional stability interests, it has not failed to recognize that export controls can have a significant effect on domestic businesses and industries, the well-being of which is critical to U.S. economic security. One of the most important objectives listed in the September 1993 report to Congress by the Trade Policy Coordinating Committee (TPCC) was the Administration's determination to "ensure that U.S. economic interests play a key role in decisions on export controls." Accordingly, the TPCC report announced a number of measures designed to lessen the negative economic impact of export controls on U.S. businesses, consistent with our national security interests. The measures included liberalizing controls on telecommunications equipment and computers. For example, the performance threshold above which prior written permission is required to export computers was raised from 195 to 1,000 MTOPS (million theoretical operations per second) for most destinations. These recommendations have removed over $32 billion worth of exports from the requirement of advance approval.

The Administration has addressed economic security issues vis a vis the export control system in other significant ways. In April 1994, it acted to reduce the economic burden of export controls by establishing a new General License, GLX, which authorized exports without prior written permission of a wide range of dual-use commodities to civil end users in the People's Republic of China, Russia, and other newly independent countries of the former Soviet Union and Eastern Europe. Export control liberalization has also provided the former Soviet Union and China with the telecommunications equipment they need, enhancing business with the United States. The Administration is continuing further reform of the export control system through its ongoing efforts to streamline the export license review process and to resolve longstanding problems with the commodity jurisdiction process. For example, the number of licenses required fell from 25,000 in 1993 to fewer than 15,000 in 1994, with a further drop expected this year. The Administration has also, in consultation with industry, issued the first comprehensive rewrite of the dual-use export control regulations since they were first implemented. Successful completion of these initiatives will significantly reduce the burden of export controls and will enhance overall efforts to bolster U.S. economic activity.

Support for industry-led technology development partnerships. The accelerating pace of technological advance, increasing cost of research and development, ever-shorter product cycles, and rapid worldwide diffusion of technologies mean that many companies are finding it harder to afford investment in risky or longer term research and development than in the past. For example, in the electronics industry, the lifetime of a personal computer model is less than two years, forcing firms to manage three generations of the technology at once and squeezing out resources for longer term technology-base R&D. In the semiconductor industry, new plant investments can exceed 1 billion dollars, with the next generation running two or three times that much, again drawing resources away from the longer term R&D that would form the base for future industries. Overall, we find that industries are devoting 80 to 90 percent of their R&D resources to short-term product development and process improvement. We are thus seeing a gap in the innovation system, in funding for mid- and long-range R&D, which threatens to dry up the wells of new technology from which our companies must draw in the future to remain competitive. Pressure to realize near-term returns is aggravating, in particular, the gap in R&D in the five- to seven-year time frame.

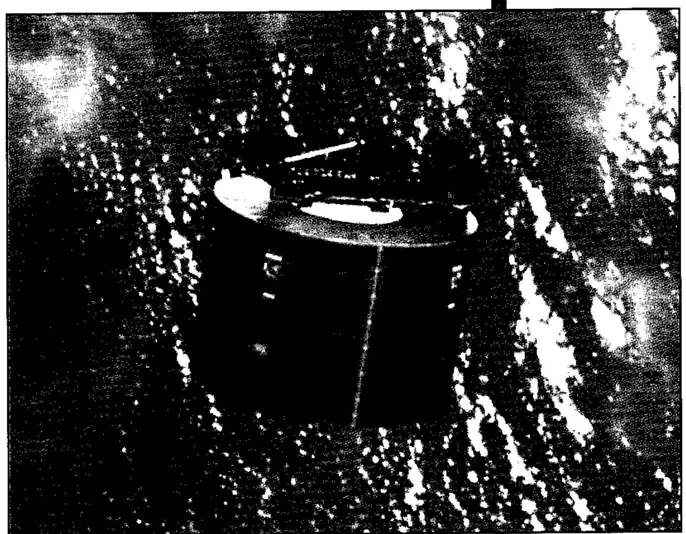


Individual companies are particularly reluctant to move forward with research and development projects, when a substantial fraction of the total return may not be captured by the investing company. Government risk-sharing can provide a bridge that mitigates underinvestment in research and development and supports broad diffusion to society of the benefits of R&D. The social rate of return on R&D investments, where the benefits accrue to many firms and to consumers in the form of less costly and higher quality products, is about twice as high as the average private rate of return on investment for individual firms.

The problem of capturing private returns on precommercial research and development investments is especially great in widely dispersed and fragmented industries such as building and construction. And where the benefits of technological advance include public returns—to the environment, public health, or national defense—the arguments for government risk-sharing are especially strong. If government fails to support advances in precommercial technologies for these purposes, at least on a cost shared basis, it is very likely that they will not get developed...or will be developed by international competitors.

The Administration has redesigned government partnership programs to ensure that they are:

- Market-driven, with industry leading the joint research agenda.
- Cost-shared, with the private sector providing half or more of the money, as a test to make sure the technological risk is worth taking.
- Competitive, merit-based, and peer-reviewed.
- Evaluated periodically and rigorously to make sure the projects have the intended effect.



Industry-government partnerships such as the Partnership for New Generation Vehicles, Advanced Battery Consortium, American Textile Consortium, and projects in the Advanced Technology Program all are examples of the industry identifying its longer term needs and sharing the risks and uncertainties in pursuing those developments with the government. In addition to the government, universities are increasingly being sought not only as sources of educated students but also as partners in joint research and development. Addressing longer term research and development needs in a commercial environment that emphasizes near-term returns is a growing challenge for industry and public policy. Joint government-industry funding can extend time horizons, increase the number of riskier projects in the national portfolio, and fill the gaps that open in our nation's complex and dynamic science and technology system.

Facilitating the rapid deployment of civilian technologies. Stimulating the development of technologies is only part of successful innovation. Another essential aspect is to make sure that all U.S. industry, including the small and medium-sized firms that constitute the foundation of American manufacturing, get access to efficient, up-to-date production methods. The Manufacturing Extension Partnership operated by the National Institute of Standards and Technology (NIST) in the Department of Commerce is a grassroots effort to provide such information and training to improve the competitiveness of the nation's 380,000 smaller manufacturers. Currently, the network includes 43 centers, and the goal is to create a national network of 100 centers able to meet the needs of America's smaller manufacturers. NIST is also addressing work force involvement in technology development to ensure that technology is adopted and diffused as effectively as possible and that work force education and training issues are considered from the start of the technology development cycle.

The fullest use of technologies developed by our public laboratories is also a continuing challenge. If our public R&D investments are to continue to pay the kinds of economic dividends we have enjoyed in the past, government must improve on the management of its own technology-related assets. We must narrow the time gap of technology transfer by bringing technology creators and users closer together. One such mechanism is the cooperative research and development agreement (CRADA) between companies and Federal labs which creates market pull on the Federal research enterprise.

Building a 21st-century infrastructure. Development of the National Information Infrastructure (NII) and the emerging Global Information Infrastructure (GII) is a top priority. Our nation leads the world in developing and applying information technology that can revolutionize the way we live, learn, and work. Because of the strategic value of these technologies and their potential for fostering economic growth, nations around the globe are investing heavily in the development and deployment of computer systems and telecommunications networks. Our vision for Federal investment in information technology is to accelerate the evolution of existing technology and to nurture innovation that will lead to universal, accessible, and affordable application to enhance U.S. economic and national security in the 21st-century.

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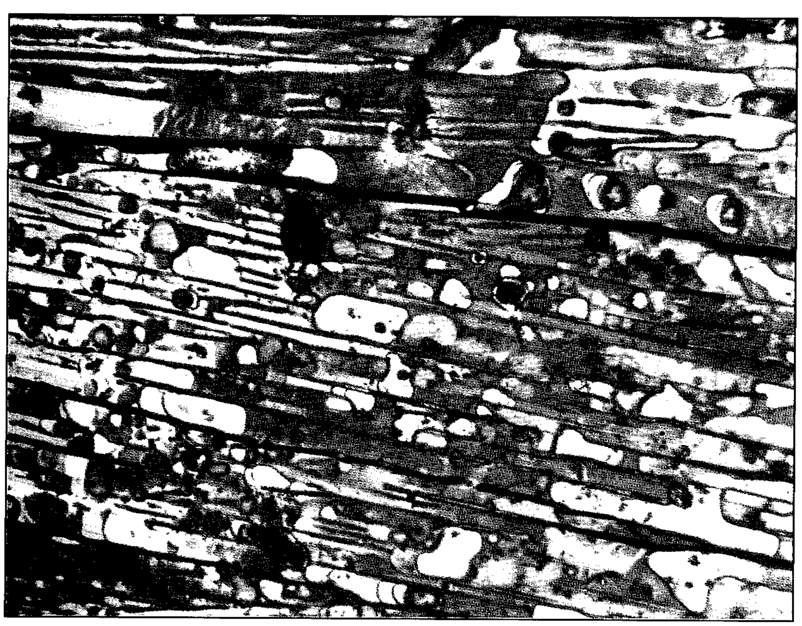
The NII includes the Internet, the public switched network, and cable, wireless, and satellite communications. It includes public and private networks. As these networks become more interconnected, individuals, organizations, and governments will use the NII to engage in multimedia communications, buy and sell goods electronically, share information holdings, and receive government services and benefits. Information security is critical to the development and operation of a viable NII. One of the goals of *The National Information Infrastructure*: *Agenda for Action* is to ensure information security and network reliability. Without confidence that information will go where and when it is supposed to go—and nowhere else—the NII will not be used to support health, education, commerce, public services, and advanced communications to the fullest extent. In the NII, elements of effective security include assuring confidentiality—the assurance that information will be held in confidence with access limited to appropriate persons; integrity—the confidence that information will not be accidentally or maliciously altered or destroyed; reliability—the confidence that systems will perform consistently and at an acceptable level of quality; and availability—the assurance that information and communications services will be ready for use when expected. These are important building blocks of the NII strategy.

Also of prime importance to economic growth in the next century is a renewed and efficient transportation system. Our highway, air, and rail systems have given Americans the benefits of flexibility, low cost, and personal freedom, but they are in urgent need of renewal. In addition, other countries experiencing rapid economic growth are investing heavily in infrastructural development, creating major opportunities for U.S. goods and services. A coordinated public and private research and development effort should meet these domestic and international objectives for future transportation needs: safe and reliable physical infrastructure, information infrastructure for transportation, and next-generation transportation vehicles.



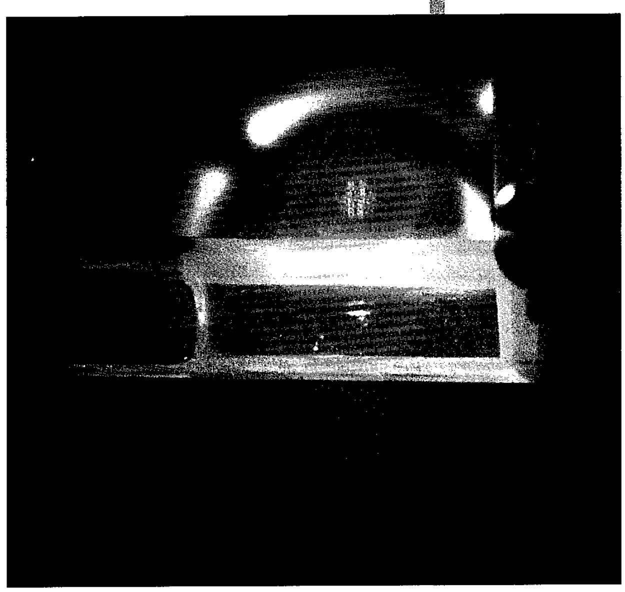
Support for basic science. America's future demands an expanding knowledge base, which requires investment in our people, institutions, and ideas and cooperation with international partners to expand our access to data and information. Science lies at the heart of that investment—it is an endless, sustainable, and renewable resource with extraordinary dividends. Today's investments in basic science build a foundation for commercial products and services of the future. The nation's commitment to world leadership in science, engineering, and mathematics created the world's leading scientific enterprise, whether measured in terms of discoveries, citations, awards and prizes, advanced education, or contributions to industrial and informational innovation. Our scientific strength is a treasure we must sustain and build on for the future, and this Administration is firmly committed to its support.

The Administration has developed a research and development initiative aimed at using the power of modern information technology to achieve the Administration's lifelong learning goals—including the Goals 2000 and School-to-Work programs.

The United States has refined a system for selecting excellence in ideas, individuals, and institutions that is extremely competitive and productive. It is a system that achieves quality by emphasizing peer review and promoting creativity. The system cannot always predict the exact areas or nature of scientific breakthroughs or the timeline for fundamental discoveries. Over decades, however, it reliably produces discoveries that enrich the lives and prospects of our citizens and, when transformed to practical cost-effective products, reorganizes old businesses and creates new ones.

Firms are increasingly turning to universities as partners in research as a result of shrinking private-sector resources for these long-term investments. This pooling of resources can invigorate university research and is a healthy development as long as it does not compromise the basic research conducted by universities which serve as the well-spring of new knowledge.

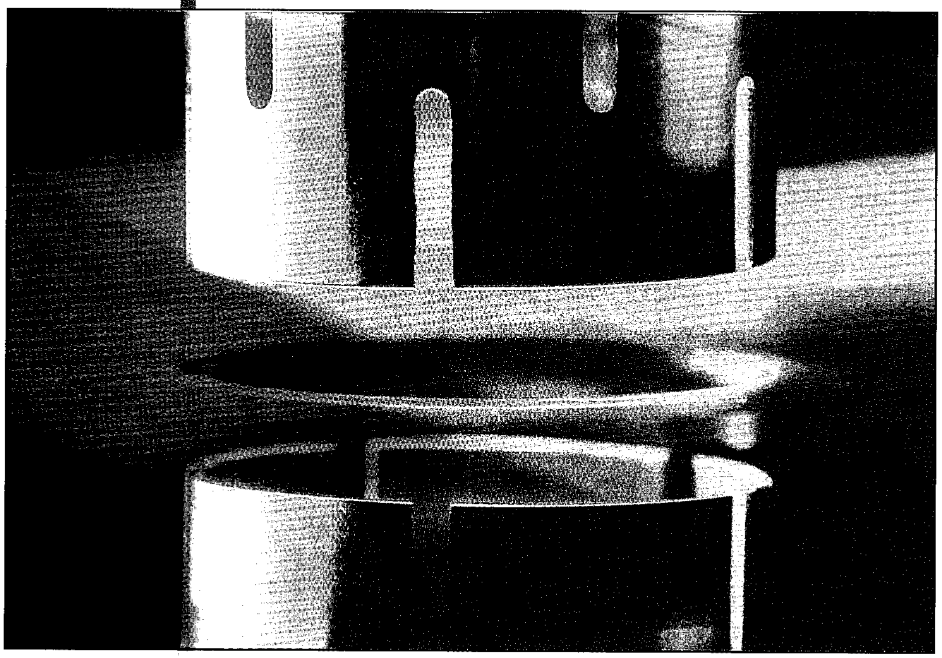
The Federal Government has long played a vital role in ensuring American leadership in science, mathematics, and engineering, and investment in basic science continues to be an essential component of our innovation portfolio.



Education and training. The Administration is committed to sustaining a high-quality system of education. Few enterprises touch the lives of as many people as those concerned with education and training. High-quality education and training benefit the individual whose knowledge and skills are upgraded, the business seeking a competitive edge, and the nation in increasing overall productivity and competitiveness in the global marketplace. It is essential that all Americans have access to the education and training they need and that the teaching and learning enterprise itself becomes a high-performance activity.

The Administration has developed a research and development initiative aimed at using the power of modern information technology to achieve the Administration's lifelong learning goals—including the Goals 2000 and School-to-Work programs. We believe computer and multimedia technology will make individualized, learner-centered, exploratory learning possible at affordable prices. And by using communications systems to connect homes, schools, and workplaces, we enhance the potential for learning outside school and continuing learning throughout our lifetimes.

Federal investment priorities include five main areas: (1) demonstrations that test advanced concepts in learning technologies will expand the state of the art in curriculum design, learner-centered and exploratory instructional strategies, and use of advanced software design; (2) fundamental research on the way people learn will focus on the way new technologies can be used to enhance learning; (3) development of learning tools will ensure availability of tools for synthetic learning environments, collaborative problem-solving environments, software interfaces, instructional software development tools, interactive instructional systems, intelligent learning associates, and tools for searching multimedia databases and digital libraries; (4) development of assessment tools will undoubtedly change our expectations about learning and about the kinds of skills that can be measured; and (5) digitization of Federal resources will provide key resources for commercial developers interested in marketing interactive systems to both education and entertainment markets.



While virtually all other sectors of the economy have been transformed by technological innovation and accompanying structural reorganization in the 20th century, methods used for education and training look much like they have for generations. By accelerating the development and adoption of information education and training, we hope to ensure all Americans access—anytime and anyplace—to quality education and training tailored to their needs.

Dual-use technologies. The role of the Administration's dual-use technology policy in supporting our nation's defense needs was described in Chapter 2, with a focus on its value in strengthening defense capabilities. The other half of the dual-use strategy is its contribution to economic growth. Commercial benefits arise from the "spinoff" of technologies from military use to commercial markets, the "spin-on" of technologies from civilian to military use, and the process of dual-use technology development. Commercial industries have historically benefited from the spinoff of technologies developed for defense purposes into commercial markets. For example, this spinoff of technologies has been central to the launching of the U.S. aerospace, computer, and semiconductor industries, all of which are major sectors of today's economy. In addition, both industry and the military are benefiting increasingly from the opposite, spin-on process as well. As described in Chapter 2, commercial technologies are leading military technologies in performance and cost in a growing number of areas. Increasing the use of civilian technologies in military applications increases the markets available to commercial firms through Department of Defense procurements and strengthens innovation. This spin-on of technologies is enhanced by the Administration's commitment to defense acquisition reform. Finally, there is the strategy of dual-use research and development which captures the energy and capabilities of both our civilian and military technology bases to speed innovations in advanced technologies. The National Flat Panel Display Initiative is an example of a program which develops an advanced technology by combining military need with the vitality and incentives of the commercial markets.

Innovation, Economic Integration, and Trade

A key component of economic security lies in economic integration with the world's nations. Such integration would increase opportunities for U.S. firms in rapidly growing markets; encourage other nations to adopt the norms of free trade, thereby reducing international tensions; provide the United States with access to the capabilities found abroad that strengthen our economy; and strengthen international economic growth and political stability.

Promoting Economic Integration and Trade Through Innovation Policies

Rapid economic growth in other economies of the world provide the United States with vast opportunities for increased integration and trade with these nations. This Administration has placed a high priority on facilitating this integration by pressing for the removal of barriers to trade and investment and through its strong support of the formation of the World Trade Organization.

In October of 1994, the Administration released the National Export Strategy, which describes the priority it places on promoting trade and removing impediments to exports. The Administration is targeting 65 areas in which it improves its support for the export opportunities of the nation's firms. Types of actions undertaken include supporting U.S. bidders in global competitions, improving trade finance, removing obstacles to exporting such as export controls, helping small and medium-sized businesses, and promoting U.S. exports of environmental technologies and services.

A key component of economic security lies in economic integration with the world's nations.

A central element of the National Export Strategy is the attention it gives to high-priority emerging markets. Ten economies are expected to account for over 40 percent of total global imports over the next 20 years: Mexico, Argentina, Brazil, the Chinese Economic Area, India, Indonesia, South Korea, Poland, Turkey, and South Africa. These countries are geographically large, have significant populations, are growing very rapidly, and represent major markets for a wide range of products.

An important link in strengthening economic and political integration, as well as trade, with these economies is collaboration in science and technology. The Office of Science and Technology Policy is coordinating the development of strategies in international collaboration to support and complement the National Export Strategy and the Big Emerging Market Strategies of the Department of Commerce. As noted in the examples of South Africa and China in the box on page 68 entitled, "Strategic Science and Technology Cooperation and Emerging Markets," this coordination of strategies enhances the economic and political value of our international science and technology activities.

In addition to collaboration, this Administration will continue to press for the removal of barriers to collaboration and trade, and promote the use of internationally recognized standards for technology development and testing. The Administration has placed a high priority on ensuring the protection of intellectual property rights, which fosters innovation and the absence of which inhibits international joint ventures.

Strategic Science and Technology Cooperation and Emerging Markets

The White House Office of Science and Technology Policy (OSTP) is developing strategic priorities for science and technology cooperation with other countries. As decribed in Chapter 4, priority is placed on countries that are key to the stability of their region, that have a sufficient science and technology base to attract long-term trade and investment, and that represent emerging markets for U.S. goods and services. The primary objectives of these "country strategies" are to identify strategic goals that agencies may wish to pursue in planning future cooperative activities and to promote the integration of cooperative science and technology policy into the larger realm of U.S. foreign and economic policy.

Trade promotion is an important aspect of the "country strategies." OSTP is seeking to use cooperation in science and technology to create opportunities for U.S. industries to increase exports, expand their investment base, and gain access to useful science and technology investments. To achieve this goal, each "country strategy" is based on an analysis of potential markets for U.S. technologies and includes bilateral cooperative activities that can expand U.S. market share. Areas of collaboration include energy, environment, telecommunications, health, agriculture, space, standards, and basic science. Some specific examples follow.

Energy. In the energy sector, the United States and China have signed agreements on clean coal technology utilization and fossil energy research and development, and the Department of Energy is currently planning a joint demonstration combined-cycle coal-fired power plant. These projects are positioning U.S. firms to capture a share of China's projected $90 billion market in power-generating equipment. At the same time, they contribute to the strategic goals of environmental stability and economic development of the region.

Standards. U.S. manufacturers often face standards-related barriers which limit or delay their access to export markets. The Department of Commerce's National Institute of Standards and Technology (NIST) seeks to remove these barriers by collaborating with emerging markets on the development of standards. NIST now has standards experts in

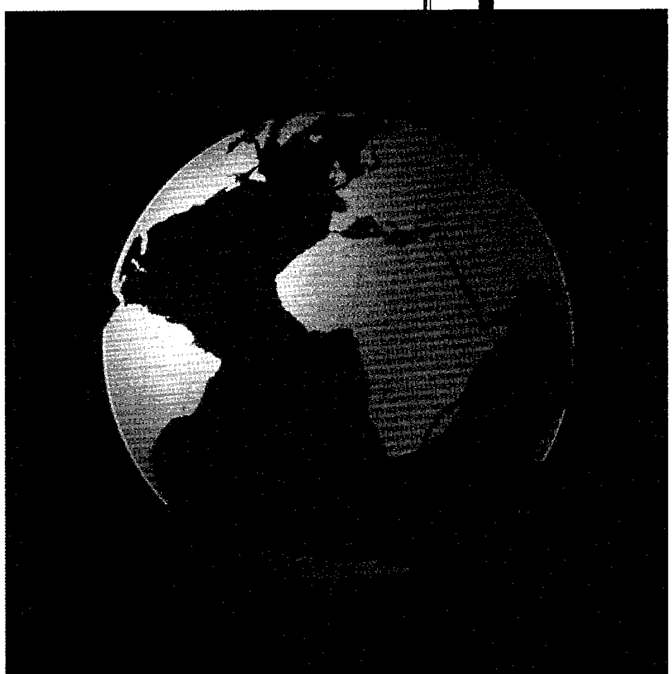
Promoting Innovation Through Collaboration With Other Economies

Recognizing that leading-edge technology is now increasingly developed overseas, the United States must take advantage of opportunities to understand and access foreign scientific knowledge and innovations to enhance domestic economic growth and the competitiveness of U.S. firms. Assessing technologies against international benchmarks and integrating international developments into domestic research and development in a timely manner are challenges that have begun to receive greater priority by both government and industry in the United States.

The U.S. Government assists industry, particularly small and medium-size enterprises, by facilitating international, industry-led cooperative efforts to develop advanced technology and by providing information on foreign technical expertise. For example, programs such as the Manufacturing Technology Fellowship Program and the Intelligent Manufacturing Systems

Strategic Science and Technology Cooperation and Emerging Markets (continued)

many important markets. Workshops with U.S. and foreign standards and trade specialists are used to develop contacts needed to successfully negotiate the removal of technical barriers to trade. In South Africa, the new government has recognized that sound technical standards contribute to more efficient economic growth and has begun reviewing all standards, accreditation, and certification programs. NIST is taking advantage of the opportunity to influence the development of standards through science and technology cooperation. For example, NIST is developing a cooperative agreement with the South African Council for Scientific and Industrial Research on materials, manufacturing, and building technologies, which will facilitate trade in these sectors. NIST is also working with the South African Bureau of Standards to organize a workshop in Pretoria on the use of standard reference materials.



Telecommunications. International cooperation in telecommunications is critical to expanding trade with countries that represent big emerging markets. The current $33 billion market for telecommunications outside the United States is projected to double to $64 billion by 1998, with the highest demand for know-how, technology, and investment expected in developing countries. The development of a Global Information Infrastructure (GII) will facilitate the sharing of information, creating a global information marketplace. A GII could serve U.S. industry by opening overseas markets, eliminating barriers caused by incompatible standards, and examining international and domestic regulations.

Initiative expose U.S. engineers and firms to the best foreign manufacturing practices and improve communication with foreign firms which may become customers, suppliers, or partners. These projects also establish international "rules of the game" for collaboration. Ensuring adequate protection of intellectual property rights and accommodating the array of international competitive dimensions of our agreements are important to realizing effective global cooperation in technology. To balance the benefits and the risks inherent in international agreements, we must also be vigilant of the potential for an adverse national security impact.

Finally, other programs such as the Japan Technical Literature Program allow U.S. firms access to hard-to-obtain information on the technological capabilities of our international competitors. This makes it possible for U.S. firms to more readily obtain the world's best technology and management practices. The National Critical Technologies Report also provides information that compares the state of advance of science and technology in the United States with principal competitors overseas to identify areas of our strengths as well as areas of possible policy concern.

Epilogue

Five decades ago, the Manhattan project highlighted the power of science and technology and dramatically changed our nation's approach to security. Since that time the essential role of science and technology in assuring the security of our nation has become increasingly apparent, as the challenges to our security have become far more diverse. In addition to sustaining our military readiness, we must seek to reduce existing nuclear arsenals, limit the spread of weapons of mass destruction, address threats to society such as emerging diseases and environmental degradation, and keep vital the economy that is the source of much of our strength and influence. Our strategy for national security has evolved beyond a focus on weapons to a focus on the prevention of conflict. Advances in science and technology have enabled this transition by enhancing our ability to identify, understand, address, and plan around a wide range of threats to our society.

Successfully meeting today's challenges to our national security also requires enhanced engagement with other nations, rather than a retreat to isolationism. Today we have the potential to use science and technology to reach out to former adversaries, create new partnerships and develop the basis for working together. Advances in science and technology promote the integration of economies and our interests.

However, the work of preventing conflict requires a steady and long-term commitment and an engaged constituency. As our government and others face tightening budgets, we must not lose sight of the need to sustain our investments in our nation's security and global stability. Retreating from our efforts in prevention today invites the greater danger of crisis in the future. The challenge before us is to build an understanding of the importance of a comprehensive strategy for our security, to invest where needed, and to move our country forward. This *National Security Science and Technology Strategy* is a step toward building a broader consensus on the investments that we need to assure our future security.

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Internet Access: http://www. whitehouse.gov/White_House/EOP/OSTP/nssts/html/nssts.html