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ABSTRACT

This document addresses goals set forth by "Technology for America's Economic Growth: A New Direction To Build Economic Strength". It highlights the important role technology plays in the American economy and the challenges faced in an increasingly competitive, technology-based global economy. This document describes Federal technology initiatives designed to stimulate economic growth and job creation in the United States. It also traces the evolution of U.S. technology policy, identifying milestones in that evolution from the Constitution of the United States to major legislation in the past decade. This document is divided into an executive summary and five chapters. Chapter 1 presents an overview of the piece. Chapter 2 contains information on the tradition of federal support for science and technology. Chapter 3 concerns national technology policy in an era of global economic competition. Chapter 4 discusses meeting the global competitive challenge and a national technology policy for the 21st century. Chapter 5 highlights challenges in the U.S. technology policy. (SAH)

Technology IN THE NATIONAL INTEREST

ABOUT THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

President Clinton established the National Science and Technology Council (NSTC) on November 23, 1993. This cabinet-level council is the principal means for the President to coordinate science, space, and technology policies across the Federal Government. NSTC acts as a "virtual" agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise. The NSTC is chaired by the President. Membership consists of the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other senior White House officials.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research, to improving transportation systems and strengthening fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, contact the NSTC Executive Secretariat at (202) 456-6100.

ABOUT THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on all questions in which science and technology are important elements; articulating the President's science and technology policies and programs, and fostering strong partnerships among Federal, State, and local governments, and the scientific communities in industry and academe.

To obtain additional information regarding the OSTP, contact the OSTP Administrative Office at (202) 395-7347.

TECHNOLOGY IN THE NATIONAL INTEREST

1996

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The volume is dedicated to Katherine Backus Gillman.

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FOREWORD

In February 1993, President Clinton and Vice President Gore set forth the Administration's technology policy, *Technology for America's Economic Growth: A New Direction to Build Economic Strength*. The policy found that American technology must move in a new direction to spur economic growth. The traditional Federal role in technology has been limited to support of basic science and mission-oriented research, a strategy appropriate for a previous generation but not for today's profound challenges.

Technology for America's Economic Growth established three overarching goals:

- Long-term Economic Growth that Creates Jobs and Protects the Environment
- A Government that is More Productive and More Responsive to the Needs of its Citizens
- World Leadership in Basic Science, Mathematics, and Engineering

Technology in the National Interest addresses the first of these goals. It highlights the important role technology plays in the American economy and the challenges we face in an increasingly competitive, technology-based global economy. The document describes Federal technology initiatives designed to stimulate economic growth and job creation in the United States. It also traces the evolution of U.S. technology policy, identifying milestones in that evolution, from the Constitution of the United States to major legislation of the past decade. This history demonstrates a long-standing tradition of bipartisan support for science and technology, and the invaluable contribution the Federal government has made to technological progress and technology-driven economic growth.

Other National Science and Technology Council (NSTC) documents address the need to protect the environment. *Technology for a Sustainable Future: A Framework for Action* initiated a national dialogue that laid the foundation for a public-private partnership to advance environmental technologies. *Bridge to a Sustainable Future: National Environmental Technology Strategy* built on that foundation with a strategy that highlights the roles of individuals and organizations in fostering the development and adoption of environmental technologies and identifies strategic goals for all partners in this important national endeavor.

The second goal is being pursued vigorously in the National Performance Review led by Vice President Gore.

The third goal recognizes that the flow of scientific knowledge and the development of scientific and technical personnel help underpin our nation's ability to achieve technological innovation and the economic growth that flows from it. The Administration's goals and policies for basic science, mathematics, and engineering are detailed in the August 1994 statement *Science in the National Interest*.

The *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. 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.

Taken together, these NSTC documents reflect the Clinton Administration's commitment to carrying forward America's great legacy of scientific advancement and technological progress for economic growth, national security, and a better quality of life.

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With the end of the Cold War, we Americans and our leaders are turning greater attention to U.S. economic growth. Technical progress is the single most important factor in generating sustained economic growth, estimated to account for as much as half the Nation's long-term growth over the past 50 years. Technology underpins our fastest growing industries and high-wage jobs, provides the tools needed to compete in every business today, and drives growth in every major industrialized nation.

Technological advance plays a large role in improving our quality of life through new drugs and medical therapies that promise new hope for the sick and a healthier life for all. Environmental research promises cleaner air, water, and soil. Rapid technological advances are making enhanced communications, better food, and cleaner, safer, more fuel-efficient transportation possible.

The United States has an unmatched capability for technological innovation—an unparalleled R&D enterprise; a world-class cadre of scientists and engineers; the world's most diverse and productive manufacturing base; a broad and technologically sophisticated service sector; the world's most productive workforce; and a climate and culture that encourage competition, risk-taking, and entrepreneurship. These assets have positioned the United States for global technological leadership in the 21st century.

A TRADITION OF FEDERAL SUPPORT FOR SCIENCE AND TECHNOLOGY

For more than 200 years, the Federal government has played a vital role in establishing a scientific and technological infrastructure that has contributed substantially to U.S. economic growth and the competitive success of American industry. This long-standing tradition of support for science and technology has paid handsome dividends to the Nation. Federal research has given birth to new industries, such as computers and biotechnology, and propelled U.S. firms into a leadership position in other industries, including aerospace, telecommunications, and pharmaceuticals. Federal research has also made possible many smaller contributions to American life–from better tasting frozen orange juice and highly absorbent disposable diapers to vaccines for malaria and closed-captioned television for the deaf.

CLINTON ADMINISTRATION TECHNOLOGY POLICY

The Clinton Administration came to office at a time of increasing concern about the state of American technology and competitiveness. The Administration has sought to address these concerns by building a technology policy on the firm foundation of past success, an awareness of the new global competitive environment, and an eye to the future. The technology policy set forth by President Clinton and Vice President Gore is guided by five goals:

- The primary role of the Federal government in technology policy is to create a business environment in which the innovative and competitive efforts of the private sector can flourish.
- The Federal government must encourage the development, commercialization, and use of civilian technology.
- The Federal government must invest in a world-class infrastructure for the 21st century to support U.S. industry and promote commerce.
- U.S. policy must seek to integrate the military and commercial industrial bases so they can meet both defense and civilian technology requirements cost efficiently and effectively.
- The United States must develop a world-class workforce capable of participating in a rapidly changing, knowledge-based economy.

Carried out by departments and agencies across the Federal government, a rich portfolio of policies and programs is advancing these goals. These initiatives help ensure that technology remains our engine of economic growth, creating high-wage jobs in the United States and improving the standard of living and quality of life for our people.

CHAPTER 1

OVERVIEW

"Since the dawn of the industrial revolution, alarmists have argued that technology and automation threaten jobs. Such claims are still heard today. But history shows that they have never been right in the past and suggests that they are wrong again. Time after time, in epoch after epoch and country after country, technological advance has produced higher wages and living standards, not mass unemployment. This is exactly what we expect to happen again in the 21st century. And the government should be helping this process along—facilitating growth and change, not impeding it."

1994 Economic Report of the President

More than ever before, technological leadership is vital to the national interests of the United States. As we enter the 21st century, our ability to harness the power and promise of leading-edge advances in technology will determine, in large measure, our national prosperity, security, and global influence, and with them the standard of living and quality of life of our people.

In February 1993, President Clinton set forth his vision for a national technology policy in *Technology for America's Economic Growth: A New Direction to Build Economic Strength.* This policy—a key element of the Administration's strategy for long-term economic growth—outlines measures to ensure America's global technological leadership into the next century. During the past three years, the Administration's technology policy has evolved to respond to new conditions and to address a broader range of factors that affect the ability of the Nation to develop, diffuse, adopt, and commercialize new and existing technologies. National prosperity requires a comprehensive technology policy, integrated with the Nation's economic, trade, education and training, science, and defense policies. This document reaffirms the Administration's commitment to U.S. technological leadership, details the Nation's technology policy and its rationale, and describes the portfolio of programs established in support of this policy.

FORCES OF GLOBAL CHANGE

"Our Nation faces significant economic challenges. Markets are global, competition is fierce, technological change is swift and unabating. Meeting these challenges requires a strategy to equip American companies and workers to compete successfully in the 21st-century economy."

John H. Gibbons
Director, White House Office of Science and Technology Policy

"The United States must invest in technology and in our workforce if we are to meet the challenges of intensifying global competition. Our foreign competitors are shifting into high gear in the race for the future. They are rapidly expanding their technological capabilities and developing the skills of their people. Their governments are developing policies and programs to enhance the competitiveness of their industries and attract the engines of economic growth to their shores. America's future prosperity depends on answering these challenges loudly and clearly."

Michael Kantor
Secretary of Commerce

America's research-intensive industries—aerospace, chemicals, communications equipment, computers and office equipment, pharmaceuticals, scientific instruments, semiconductors, and software—have been growing at about twice the rate of the economy as a whole in the past two decades.

"...technical progress is by far the most important source of economic growth of the industrialized countries in our sample, accounting for half or more...."

Michael Boskin
Professor of Economics,
Stanford University, 1992
(former Chairman, President Bush's Council of Economic Advisors)

We live in an era of profound change—political, economic, and technological. Global competition has reached unprecedented levels. With the end of the Cold War and the demise of communism, new nations have emerged across the globe, building on a foundation of freedom, democracy, and free market principles. Today we compete not only with advanced industrialized nations such as Germany and Japan, but also with new competitors such as China, South Korea, Malaysia, and the states of the former Soviet Union.

A new battlefield has emerged in the form of a global marketplace, and able competitors from around the world are fighting for a share. International accords, such as GATT and NAFTA, are fostering competition, opening new markets and expanding existing ones, and bringing consumers more choices and higher quality at lower costs.

Technology is reshaping our world at a speed unimaginable just a few decades ago. Competition to meet the increasingly high expectations of the world's consumers has accelerated the rate of technological progress to a breathtaking pace, with each advancement more dazzling than the last. Technology plays an increasingly important role in the global economy, in the lives of every American, and in our national defense.

In the wake of these forces, the way we live, learn, and work is being forever transformed. Each of these changes—the emergence of a global economy, unprecedented global competition, and rapid advances in technology—would be revolutionary on its own, but together they have produced staggering results that are deeply felt by Americans in all walks of life.

TECHNOLOGY AND THE AMERICAN ECONOMY

Technology is the engine of economic growth. It underpins America's fastest growing industries and high-wage jobs, provides the tools needed to compete in every business today, and drives growth in every major industrialized nation. Today, technological leadership often means the difference between success and failure in the global marketplace—for companies and countries alike.

RELATIVE CONTRIBUTION SOURCES OF U.S. ECONOMIC GROWTH

Capital	24%
Labor	27%
Technical Progress	49%

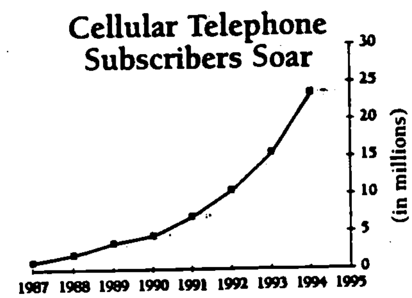
Source: Boskin and Lau

Technical progress is the single most important determining factor in sustained economic growth, estimated to account for as much as half the Nation's long-term economic growth over the past 50 years. Increases in productivity have long been recognized as one of the primary mechanisms by which technology contributes to growth. It is estimated that technology and advances in knowledge account for approximately 80 percent of total factor productivity growth. Ultimately, long-term, noninflationary growth is the only true path to real wage increases and an improved standard of living.

The performance of individual companies—the agents through which economic growth occurs—is strongly linked to their use of technology. A recent Department of Commerce analysis shows that the use of advanced technologies enhances manufacturing in virtually every important performance category. Firms that use advanced technologies are more productive and profitable, pay higher wages, and increase employment more rapidly than firms that do not. Between 1987 and 1991, employment at plants that used eight or more advanced technologies grew 14.4 percent more than plants that used no advanced technologies, and production workers' wages were more than 14 percent higher.

High-technology firms are associated with high rates of improvement in value-added manufacturing and success in foreign markets, which help support worker compensation that is 20 percent higher than the average for manufacturing.

Technology is transforming the very basis of competition—enabling small businesses to perform high-quality design and manufacturing work that previously required the resources of big business, while allowing big businesses to achieve the speed, flexibility, and closeness to customers that were once the sole domain of smaller firms.



Technology provides the tools for creating a spectacular array of new products and new services. It is creating new industries—advanced materials, mobile cellular communications, electronic commerce—and revitalizing old ones—steel, automobiles, textiles. The information industry as we know it now barely existed just decades ago. Today, however, the communications and information industries are among America's largest, constituting about 10 percent of U.S. gross domestic product and employing more than 4.5 million people in the United States. The economic importance of these technologies extends beyond the borders of the communications and information industries. By making it possible to manage vast quantities of information, these technologies are transforming every sector of our economy—manufacturing and services, transportation, health care, education, and government—and, in the process, changing forever the way people live, work, and interact with one another.

Employment in the cellular telephone industry has grown from 7,100 in 1987 to 53,900 in 1994.

In 1978, the cable television industry employed 23,500; today, the industry employs more than 112,000.

By the end of the 20th century, information will be the most important commodity in the world's economic system. The speed with which we create knowledge and our ability to put it to work for us will determine America's position in the international marketplace of the next century. Advances in information technology—software, semiconductors, microprocessors, telecommunications—are essential for managing this information explosion, putting a world of knowledge, global commerce, and communications at our fingertips.

In 1985, there were only 300,000 registered e-mail users. In 1993, an estimated 12 million Americans regularly used e-mail and related on-line services. Today, the number of e-mail users is estimated to exceed 27 million.

America is leading the world into the Information Age. The United States is laying the foundation for a National Information Infrastructure (NII) that will link schools and homes, offices and factories, hospitals and clinics, and a myriad of other business, academic, and social institutions. This network will enable a colossal leap in knowledge sharing, propelling scientific inquiry and discovery, business productivity, transportation system performance, and the education of our citizenry.

It has been estimated that accelerated deployment of the NII would increase U.S. GDP by $100 to $300 billion over the next decade.

The NII—and its international corollary the Global Information Infrastructure—will spur the growth and creation of American companies and jobs, facilitate the conduct of business worldwide, and accelerate the development of new products, services, and capabilities in the United States. American companies, large and small alike, will be able to respond quickly and flexibly to ever-changing global market demands with high-quality, customized goods and services at competitive prices.

"We are not the only nation with competence in defense technology. To sustain the lead which brought us victory during Desert Storm,...recognizing that over time other nations will develop comparable capabilities, we must...invest in the next generation of defense technologies."

William J. Perry
Secretary of Defense

The top 15 U.S. pharmaceutical companies employed more than 350,000 people and earned profits of $13.3 billion on sales of $84.8 billion in 1994.

TECHNOLOGY AND THE NATIONAL DEFENSE

On the battlefield, technology can be the decisive edge. America's technological superiority has provided our men and women in uniform the wherewithal to protect the freedom, democracy, and security of the United States. Beyond our own borders, U.S. military strength—built on a foundation of high-technology—has enabled the United States to stand in defense of our allies, preserve the peace, deter hostilities, repel aggression, and foster fledgling democracies across the globe.

During the Cold War, an arsenal of advanced weapons allowed the United States to field a technologically superior force to counter the numerically superior Soviet threat. Today, these high-technology weapons and the transportation and logistics systems that support their deployment provide the United States with the ability to undertake global military operations and conduct surgical strikes on strategic military targets—as in recent operations in Iraq and Bosnia—while minimizing the risk to U.S. soldiers and civilians. Continued technological leadership is essential to U.S. national security, military readiness, and global influence.

■ *Safer poultry products.*

TECHNOLOGY AND AMERICA'S QUALITY OF LIFE

New technologies are also improving the quality of life for all Americans. Medical research in pharmaceuticals, biotechnology, and medical devices promises new hope for the sick and a healthier life for all. Environmental research offers cleaner air, water, and soil through better monitoring, prevention, and remediation technologies. Advanced monitoring and forecasting technologies—from satellites to simulation—are helping save lives and minimize property damage caused by hurricanes, blizzards, microbursts, and other severe weather. Sophisticated traffic management systems for land, sea, and air transportation enable the movement of more people and goods in less time.

Agricultural research is producing a cornucopia of safer, healthier, and tastier food products. Automobile research is providing safer, cleaner, more energy efficient, and more intelligent vehicles—saving lives, preserving natural resources, and keeping our environment cleaner. Aeronautical technology is making air travel safer, less expensive, and environmentally compatible. Energy research is helping to deliver cleaner and less expensive fuels, reduce American dependence on foreign resources, and tap alternative sources of energy—solar, nuclear, geothermal, biomass, and hydroelectric. Information and telecommunications technologies have enabled instantaneous communications across the globe. And the ability to telecommute allows many American workers to spend more time with their families.

By 2001, there will be an estimated 15 million American telecommuters.

A GOLDEN AGE OF U.S. TECHNOLOGICAL LEADERSHIP

"We are, in a way, a whole Nation of inventors and explorers... We believe in technology and we are determined to pursue it in all of its manifestations...I do believe that the 21st century can be a Golden Age for all Americans."

President William J. Clinton
1995 National Medal of Technology Ceremony

■ *Magnetic Resonance Imaging Spectrometer.*

With the increasing importance of technology to our prosperity, national security, and quality of life, America stands poised to lead the world into an exciting new era filled with opportunity. This new era—this "Golden Age"—is tailor-made for Americans.

The vision, commitment, and investment of those who have come before us have provided the United States with the most powerful economic engine in the world—an unparalleled R&D enterprise that spans industry, academia, and government; a world-class cadre of scientists and engineers; the world's most diverse and productive manufacturing base; a broad and technologically sophisticated service sector; the world's most productive workforce; and a climate and culture that encourage competition, risk-taking, and entrepreneurship. These assets provide America with a competitive advantage in today's global economy.

We must plan for the future and invest as wisely as the generations before us if America is to retain these assets in the future.

"Americans also understand that in a global economy the only way to maintain America's competitive edge is to lead the world in innovation and new technologies. Investments in science and technology mean better jobs, higher wages, and a growing economy—not to mention new cures for diseases and new products that enrich our lives."

Vice President Albert Gore, Jr.

BEST COPY AVAILABLE

NIH RESEARCH YIELDS TECHNOLOGIES THAT IMPROVE HEALTH AND QUALITY OF LIFE AND STRENGTHEN THE NATION'S ECONOMY

Medical research supported by the National Institutes of Health (NIH) has led to many discoveries that have improved both the health and the quality of life of the American people. This is NIH's foremost goal, but medical research also yields technological and economic benefits.

■ **Biotechnology—Harnessing the Power of a Scientific Revolution.** NIH support of laboratory research in fields such as microbiology, molecular biology, and genetics during the 1950s and 1960s led to revolutionary discoveries about the structure and functioning of cells, genes, and proteins. In the 1960s, for example, scientists discovered two classes of proteins, one called restriction enzymes, which cut DNA strands, and the other called ligases, which join the cut DNA strands together. In the early 1970s, scientists built upon these discoveries and developed DNA cloning techniques. They took advantage of another class of naturally occurring molecules—bacterial plasmids, which are circular pieces of DNA that replicate autonomously. Researchers discovered how to isolate plasmids from bacteria, cut them open at specific sites with restriction enzymes, splice in fragments of foreign DNA—such as the human gene for insulin—and seal the plasmids back together with ligase. Then the hybrid plasmids containing the foreign DNA were transferred back into bacteria, where they replicated along with the bacteria and began producing the protein coded for by the foreign DNA. These techniques and subsequent advances such as DNA sequencing methods have been pivotal to the further advancement of basic research, and they provided a revolutionary new way of developing and mass-producing large quantities of valuable proteins, drugs, and vaccines. The industrial application of this new approach harnesses living cells to treat a variety of diseases and conditions and for other useful purposes such as agriculture and environmental remediation. Today, 40 approved biotechnology drugs are on the market, and 494 others have reached clinical testing stages. Some of the drug products developed through biotechnology include the following:

■ **Human Insulin.** The first drug produced through biotechnology was human insulin in 1982. About 500,000 Americans with diabetes must take insulin daily to control their blood sugar levels. Before 1982, insulin was manufactured from the pancreas of cows and pigs. The production process was costly, supplies were affected by the vagaries of the cattle and hog markets, and the animal-derived product caused immune reactions in some people. A recombinant form of human insulin was developed by splicing the human gene that produces insulin into the common intestinal bacteria called E. coli. Fermentation vats grow huge quantities of the human insulin-producing bacteria. The resulting insulin is then purified for human use. This whole process has allowed human insulin to be mass-produced.

■ **Human Growth Hormone.** Beginning in the late 1950s, children with growth hormone deficiency were treated with injections of growth hormone extracted from the pituitary glands of deceased organ donors. Tragically, some of the glands used to develop growth hormone were obtained from donors who were infected with the agent that causes Creutzfeldt-Jakob disease, which slowly destroys the brain. About 15 people contracted the disease from growth hormone injections. Biotechnology made it possible to develop a synthetic version of the hormone. Following FDA approval of the drug in 1985, children could be treated safely for growth hormone deficiency.

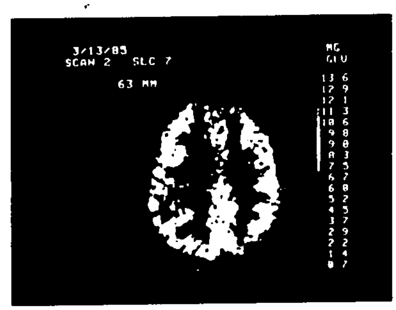
■ **Erythropoietin.** Each day, thousands of people with kidney failure must undergo kidney dialysis in order to live. Dialysis cleanses their blood of impurities that are normally filtered by the kidneys. It also tends to deplete essential red blood cells from the body, causing severe anemia in many patients. In 1989, a recombinant form of a natural human hormone that stimulates red blood cell production was produced through biotechnology. Today, this drug, called erythropoietin, helps kidney dialysis patients and others avoid the debilitating effects of chronic anemia.

■ **Hepatitis B Vaccine.** Hepatitis B virus attacks the liver, causing a chronic infection that sometimes leads to life-threatening liver disease. It is transmitted through contact with blood and other body fluids. About 1 million Americans suffer from the serious effects of this virus. In 1982, NIH scientists developed a vaccine for hepatitis B virus. Four years later, a safer, cheaper vaccine developed through biotechnology was approved. Vaccination is now routine for health care workers and is recommended for others at risk of infection and all infants and adolescents. Widespread use of the hepatitis B vaccine will help reduce the transmission of this viral infection.

■ On the AIDS Front, Basic Research Pays Off. A long-term investment by NIH in studies of the molecular composition of viruses, especially a subtype of viruses called a retrovirus, is directly responsible for recent successes in the production of drugs effective against HIV, the cause of AIDS. The most potent of these drugs are inhibitors of an essential viral enzyme called a "protease," an enzyme that cuts proteins into their working components. Retroviral proteases were first discovered in viruses found in chickens and mice. Later research revealed that retroviruses cannot replicate—or reproduce themselves—without proteases. Because HIV is also a retrovirus, scientists theorized that inhibiting HIV protease might block replication of the virus and could lead to a new treatment for AIDS. The pharmaceutical industry subsequently identified and developed agents that would inhibit HIV protease. These therapeutic agents appear to be the most effective and least toxic drugs now available to combat HIV.

■ Will Structural Biology Cure the Common Cold? One of the greatest challenges in finding a cure for the common cold is that the "common cold" is actually caused by more than 100 varieties of a certain type of virus called a rhinovirus. The development of a vaccine, the usual approach to the prevention of a viral infection, is impractical against cold viruses because more than 100 different vaccines would need to be designed, each one tailored to a different rhinovirus variety. Structural biology, a technology-based science developed in part by NIH-supported scientists, deciphers the atomic structure of biological molecules. Understanding the structure of viral molecules may one day help overcome the rhinovirus diversity problem. In 1985, a team of NIH-supported scientists discovered the atomic structure of one cold virus variety known as rhinovirus #14. The structure of #14 revealed tantalizing clues about how viruses infect people and how they might be prevented from doing so. One specific finding was that there are repeated deep clefts on #14's surface. These deep clefts are a common feature of rhinoviruses and are suspected to be the sites on the virus that attack human cells. The pharmaceutical industry has capitalized on this work by synthesizing drugs that can enter the clefts and interfere with the cold virus's ability to infect cells and reproduce. The drugs should be able to block infection of all varieties of cold virus, including new ones that arise in the future through mutations. After years of refinement and further studies, these drugs have been shown to be effective and safe in mice. Testing in humans is now under way.

■ Exploring the Brain Through PET. NIH research on imaging and analytical instrumentation was applied to the commercialization of an advanced imaging technology called Positron Emission Tomography (PET). PET scanning enables the function of organs to be studied through the mapping of metabolic activities that are normal chemical reactions that take place in the body. In PET scanning, substances used in metabolic processes are tagged with short-lived radioactive markers and injected into the blood stream. They are then taken up by metabolically active tissues or organs such as the brain. Sophisticated sensors are used to detect the location of the radioactive substance, and a computer generates a three-dimensional image of the organ being studied. Researchers have used PET scans to study changes in brain activity that occur when a person is experiencing behavioral or emotional disorders or performing specific tasks. These studies have helped advance understanding of brain activity in patients suffering from depression, schizophrenia, and drug addiction. PET technology is also used clinically in the diagnosis of disease.



■ Brain scan.

■ The Visible Human Project. The Visible Human Project is an unprecedented information resource that is revolutionizing education and research on the human body. Two people who willed their bodies to science a few years ago have become the world's first digitized humans. NIH-supported research combined powerful computer and imaging technologies to create digitized images of a 59-year-old woman and a 39-year-old man. First, the donated bodies were embedded in a special gelatin and frozen to -160°F. After computer tomography and magnetic resonance imaging technologies were used to make images of the bodies, very thin crosswise sections were cut and photographed at high resolution. The images were compiled into complete, anatomically detailed, three-dimensional representations of the human male and female bodies. The entire data set of images can be licensed through NIH's National Library of Medicine.

■ An Implantable Device Can Bring Sound to the Deaf. Thirty years ago, medicine could do very little about deafness. Decades of NIH research led to the development of the cochlear implant, a dramatic advancement that enables deaf people to hear sounds they have never heard before, sounds that dramatically enhance communication. The cochlear implant works by changing sound into electrical impulses that stimulate auditory nerve fibers. Today, more than 12,000 American children and adults are using cochlear implants. NIH had a pivotal role in the development of the initial technology and continues to support refinement efforts. Recent progress was made on the device's speech processor component, giving speech sounds greater clarity.

CHAPTER 2

A TRADITION OF FEDERAL SUPPORT FOR SCIENCE AND TECHNOLOGY

Throughout our history, the United States has led the world into the future—ever at the leading edge of discovery, creating new visions, blazing new technological trails, and expanding human horizons. And for more than 200 years, the Federal government has played a vital role in establishing a national scientific and technological infrastructure that has contributed substantially to U.S. economic growth and the competitive success of American industry.

Evolution of Technology Policy

1787–1941	Patents, agriculture, infrastructure, education, and standards
1941–1945	Manhattan Project, science, and manufacturing
1945–1980	Defense, space, energy, environment, health, and science
1980–1988	Partnerships for commercialization of government research, cooperative research, development and diffusion of civilian technology
1988–present	Partnership programs and policies

1787-1941

ORIGINS OF U.S. SCIENCE AND TECHNOLOGY POLICY

Our Founding Fathers envisioned a country of perpetual innovation and saw a need to encourage the champions of technological progress. Thus the Nation's first technology policy was written directly into the Constitution of the United States, establishing Federal responsibilities to "promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors exclusive Right to their respective Writings and Discoveries" and to "fix the Standard of Weights and Measures."

Nearly a century later, during the administration of Abraham Lincoln, the Federal and state governments embarked on a bold initiative to support America's farming industry and the Nation's emerging industrial sector. The Land-Grant Act of 1862, the Morill Act, offered tracts of Federal land to states as an incentive to create college programs in agricultural, scientific, and industrial studies. As a result, many states established Land-Grant colleges to support agriculture and the industrial arts. Today, many of these institutions are leaders in science and engineering research and education.

In 1914, the Federal government established the U.S. Agricultural Extension Service to ensure that farmers across the Nation received the benefit of the ground-breaking knowledge generated by these institutes of higher learning. Together, the Land-Grant colleges and the Agricultural Extension Service helped establish a cadre of well-trained agricultural technologists, develop new agricultural technologies, and diffuse these advancements to American farmers. This strategy played a critical role in increasing the productivity of U.S. agriculture and making America the breadbasket of the world.

Driven in large part by the needs of the agricultural sector, the United States began in the 19th century to develop the road network that is now the longest in the world. By 1900, universities and the Federal government had established road research laboratories.

Forerunners of several of today's leading science and technology institutions were established during this period as well.

Many studies during the past 30 years have found rates of return to public investments in agricultural research of more than 35 percent.

In 1860, three out of five Americans worked in agriculture. Today, less than 3 percent of the population feeds the Nation—and many others throughout the world.

"Effective research is fundamental to agriculture: solving problems from food safety to sustainability, increasing efficiency and competitiveness, and opening new economic opportunities."

Dan Glickman
Secretary of Agriculture

Attention frozen food shoppers:
You won't find the Agricultural Research Service in your grocery store's frozen food aisle, but the products of its basic thermodynamic and enzymologic research—the foundation of frozen food technology—can be found there.

AGRICULTURAL TECHNOLOGIES SPREAD GROWTH TO RURAL AMERICA

More than half of the Agricultural Research Service's CRADAs and patent licenses involve small businesses located in rural areas. These partnerships with companies, agricultural producers, universities, and state economic development programs help put new agricultural technologies to work for our economy. These technologies have stimulated new businesses that manufacture products from renewable resources grown on farms and enabled new uses for raw and waste feed stocks. A partnership between USDA and the State of Florida focuses on transferring food- and fiber-production technologies to businesses, which will increase exports of citrus fruits and stimulate job growth in rural areas.

Long-Term Partnerships in Agriculture Yield Plentiful Harvest

For more than 100 years, America has harvested the fruits of its investment in agricultural research—from the impressive productivity of American farmlands to the variety, safety, and convenience of foods and other products we enjoy today. This national investment has yielded important contributions to America's economy and continues to pay handsome dividends today.

■ **Flavorful Frozen Orange Juice.** Year-round, fresh-tasting orange juice is the result of a public-private partnership between U.S. Department of Agriculture (USDA) laboratories and the Florida Citrus Commission. For many years, growth in the frozen food industry was restrained by consumer distaste for the loss of flavor and color in frozen foods. In 1946, researchers found a method for restoring the flavor and aroma lost during vacuum evaporation of orange concentrate and developed new ways to freeze it for longer preservation, opening new markets across the world.

■ *Fresh tasting orange juice.*

■ **Wash-and-Wear Cotton.** Government-industry partnerships have been invaluable to the U.S. cotton industry. USDA research contributed to the first wash-and-wear cotton shirts in 1958 and continues to improve the worldwide marketability of cotton fabric. Research conducted by USDA's Agricultural Research Service (ARS) has given cotton stretchability and resistance to flame, heat, rotting, and weather. Other ARS contributions include a process that gave textile mills the ability to dye cotton in bright, color-fast shades; a formaldehyde-free textile finishing technique that keeps cotton fabrics wrinkle-free for more than 100 washings; and the discovery that use of advanced open weaves can make all-cotton outdoor fabrics—used, for example, in tents and awnings—more durable and tear resistant.

■ **A Shot in the Arm.** During World War II, ARS scientists learned to make huge quantities of stable, potent penicillin by growing mold number 1951 B25 in a drum of corn-processing water. This innovation helped launch the modern pharmaceutical industry by delivering inexpensive penicillin shots that cured millions of infections.

■ **Engineering Fresher Tomatoes.** USDA is also fueling the growth of emerging industries, such as biotechnology. As much as half of all fresh produce—fruits, vegetables, cut flowers—is currently lost to spoilage. But ARS scientists developed a gene that blocked 99.5 percent of the production of ethylene, a natural ripening gas, in greenhouse-grown tomatoes. The gene could enable produce to be harvested, shipped, then injected with ethylene closer to the time it is delivered to consumers, preventing loss caused by premature ripening. Calgene, Inc., DNA Plant Technology, and Monsanto have obtained licenses to use the gene to genetically engineer tomatoes and other produce.

■ **Safer Poultry Products.** Two new treatments for animal diseases, developed in part by ARS, promise to improve the safety and reduce the costs of poultry products. In 1987, ARS and Embrex, Inc. developed a method for vaccinating hatching poultry eggs against coccidiosis, a chicken disease that costs the industry $300 million annually. ARS has also developed a method to combat Salmonella, a potentially lethal bacterium, by injecting "good bacteria" into incubating eggs, as well as new tests to detect spoilage in liquid eggs used to produce bakery goods.

■ **Painless, Early Detection of Colon Cancer.** ARS scientists have developed a non-invasive method for detecting colon cancer. By isolating as few as 20 million colon cells from a stool sample, doctors will be able to diagnose early stages of colon cancer and gauge colon inflammation while avoiding the patient discomfort and hospitalization associated with invasive colonoscopy.

■ **Drier Baby Bottoms.** Babies owe their dry bottoms to the "superslurper" developed by ARS scientists, a cornstarch derivative capable of absorbing hundreds of times its weight in water. "Superslurper" has been put to dozens of uses, from diapers and baby powder to batteries and fuel filters.

■ **Mooolicious.** ARS development of lactose-modified milk enables millions of lactose-intolerant people to enjoy milk and milk products.

■ **Gobble, Gobble.** The Beltsville Small White Turkey—the small turkey with enough white breast meat to go around—was bred by ARS scientists.

■ **From the Vineyards.** California vineyards are producing an average of 30 million pounds per year of the Flame grape—a seedless red grape developed by ARS—a harvest valued by growers at $130 million.

In 1842, the Federal government appropriated $30,000 for Samuel Morse to build his original telegraph line from Washington to Baltimore to demonstrate the feasibility of the technology.

In 1887, the Marine Hospital Service established the Laboratory of Hygiene—a one-room, one-person attic laboratory—to assist in the clinical diagnosis of infectious diseases, such as cholera, among immigrants arriving on ships. After the Spanish-American War, Congress formally recognized the laboratory, authorized $35,000 for a new building, and charged it with investigating "infectious and contagious diseases and matters pertaining to the public health." In the ensuing years, the laboratory acquired increasingly broader responsibilities, evolving from its humble origins into the world's foremost biomedical research agency, the National Institutes of Health.

At the turn of the century, the lack of effective standards became a national issue. While a block of butter might weigh a pound at the shop on the corner, it might weigh more than a pound at the shop in the middle of the block. Inaccuracies in railroad scales caused disputes about taxes and charges. Scientists looked abroad for precise instruments, because most precision measuring instruments were foreign-made in 1900. Even those produced domestically had to be calibrated abroad.

Many industries lacked acceptable standards. For example, in the late 19th century, the infant electrical industry could not measure the volt, ampere, ohm, watt, or candle with sufficient accuracy. The confusion that reigned at home and abroad is illustrated by the fact that a lamp drawing 10 amperes at 45 volts was called 2,000 candlepower in the United States, 400 candlepower in Britain, and 500 candlepower in Germany. Despite the Federal government's constitutional responsibility to set standards, it did not have the technical competence to do so.

These conditions convinced Congress that the United States needed a Federal science laboratory to maintain and develop standards for commerce, science, and industry. So in 1901, President McKinley signed the act that created the National Bureau of Standards. Within a decade, this new agency began to bring harmony to measurement practices in commerce through uniform, legal weights and measures.

Since then, the National Bureau of Standards—and its successor, the National Institute of Standards and Technology—has laid the groundwork for undreamed-of advances in electricity, aviation, automotive engineering, and materials such as plastics and building materials, as well as conducting pioneering work in aeronautics, radio, and cryogenics.

In 1915, Congress established the National Advisory Committee on Aeronautics (NACA) to promote this fledgling technology for both civilian and military purposes. NACA—predecessor to NASA—built the world's first full-scale wind tunnels and promoted the cooperative government-industry R&D that enabled the Nation's aircraft industry to keep pace with foreign competitors through the peacetime years of the 1920s and 1930s. When war came again in 1941, the United States had the technology and industrial base that enabled the production of tens of thousands of warplanes a year.

SCIENCE AND TECHNOLOGY POLICY DURING WORLD WAR II

1941-1945

During World War II, the United States turned to science and technology to provide a battlefield advantage. Substantial Federal expenditures on research and development led to technological breakthroughs that helped bring about a decisive victory for the Allies in the European and Pacific theaters.

Perhaps no war effort characterizes the power and challenges of modern technology more than the Manhattan Project. In the course of developing the world's first atomic weapon, America's leading scientists and engineers faced daunting technological challenges spanning a wide array of disciplines—from basic physics to manufacturing—as well as demanding time constraints. This project established the national laboratories in Los Alamos, New Mexico, and Oak Ridge, Tennessee.

■ *The world's first general-purpose electronic digital computer ENIAC (Electronic Numerical Integrator and Computer.)*

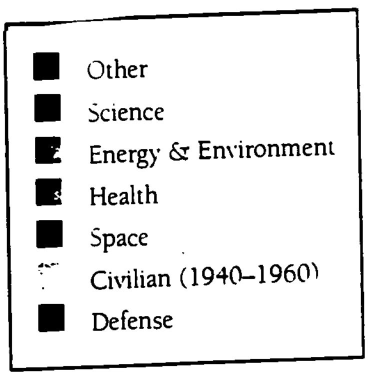
1945-1980

AN EXPANDING ROLE FOR GOVERNMENT

The end of World War II marked the beginning of a new era in which the government role in science and technology expanded dramatically. Emerging from World War II as the world's first superpowers, both the United States and Soviet Union recognized that a leading-edge scientific and technological capability was essential to projecting national military and economic might. As a result, the two nations engaged in a heated technological race throughout the Cold War.

The United States invested in a massive expansion of the military-industrial complex and established an unprecedented research and development base for defense technologies, fueling expansion of the U.S. national laboratory system—to this day a scientific and technological asset unique in the world.

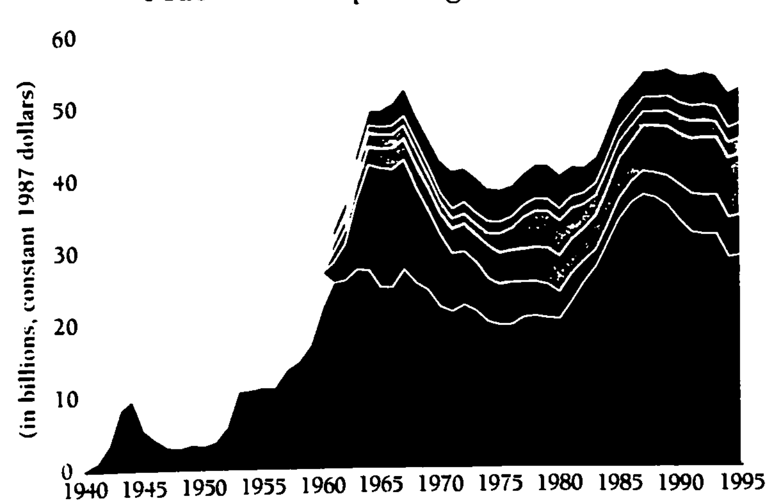
In the years following World War II, the U.S. government added significantly to the world's science and technology base through a two-part strategy: support for basic scientific research and pursuit of the science and technology agendas of Federal departments and agencies. After 1960, Federal spending on civilian technology rose dramatically as the Nation undertook a range of new civilian missions to accompany its efforts in basic research and defense.



NATIONAL SECURITY

Cold War concerns drove unprecedented Federal investments in the development of defense technologies and weapons platforms based on those technologies. These investments not only provided the United States with the world's most technologically advanced Armed Forces, but contributed significantly to advances in a wide range of commercial applications, from civil aviation and advanced materials to computers and communications. Sustained technology investments and purchases of early prototypes by the Department of Defense contributed greatly to the maturation of these technologies for commercial markets. Traditional representations of Federal R&D include the test and evaluation (T&E) components of defense RDT&E as in the figure. Defense RDT&E increased sharply in the early 1980s and has since declined after the end of the Cold War. The R&D component of those expenditures remained relatively constant throughout this period and, when compared with data in the figure for other agencies, presently accounts for about 15 percent ($7.8 billion in fiscal year 1996) of Federal R&D expenditures. Sustaining this investment is critical to ensuring the technological superiority of the Nation's Armed Forces in future conflicts.

Federal R&D Spending, 1940–1994



Defense R&D Delivers Diverse Benefits

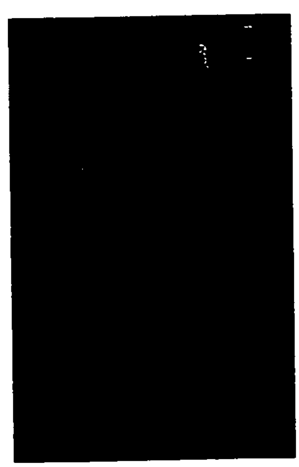
While many applications of defense-funded technology are self-evident—such as aircraft, radar, and satellite communications—the defense origins of a myriad of other technologies in commercial use today are not so obvious.

■ **Global Positioning System—A Modern Navigational Miracle.** While the Department of Defense developed the Global Positioning System (GPS) for uses such as precision weapon targeting, it has become indispensable in ship navigation and numerous civilian applications, such as emergency rescue, early earthquake prediction through precise measurement of fault line movement, and airport landing systems that perform flawlessly even in the most severe weather conditions. GPS consists of a network of earth-orbiting satellites sending radio waves that contain precise timing signals. When signals are received from three or more satellites, precise locations on earth can be determined in latitude, longitude, and elevation. Today, manufacturers are developing GPS-based systems worldwide for a new multibillion-dollar market.

■ **Defense Against Disease.** In the past, mosquito-borne malaria parasites quickly developed resistance to each new vaccine. A major breakthrough occurred in the 1970s, when defense researchers identified two new compounds—mefloquine and halofantrine—that were found effective in fighting drug-resistant parasites. Other key advances include finding innovative ways to stimulate production of malaria-fighting antibodies, distribute antimalarial drugs within the body, and produce the first genetically engineered malaria vaccine. Defense research has made similar contributions with flu virus vaccines, originally developed to protect recruits, but now used worldwide.

■ **Own the Night.** Defense night vision research eliminated darkness as mankind's adversary. Early infrared searchlights and bulky viewers were followed in the 1960s by the first generation of passive night vision devices, image intensifiers capable of amplifying even overcast starlight 20,000 times. As they became lighter and cheaper, television, law enforcement, and rescue agencies started using them. Thermal imaging, the ability to see objects by minute differences in the heat they emit, matured in the 1980s and now makes it possible to see through smoke, fog, and dust at long ranges in day or night. Civilian applications of thermal imaging enable us to monitor earth resources from space, detect cancer, make homes more comfortable, and gaze with greater clarity into space. Declassified infrared sensors are an automotive option. By the turn of the century, infrared systems might be sold in consumer appliance stores for the price of a camcorder. They could be used in night vision systems for automobiles, home security monitors, and devices that ferret out insulation leaks and faulty electrical wiring.

■ **Lasers—The Power of Light.** A defense-sponsored microwave research program at Columbia University—which uncovered the basic concepts that led to the development of the laser—has yielded economic and social benefits far beyond any imagined at the time of the work. While Charles Townes received the Nobel Prize for Physics in 1964 for his pioneering work in laser technology, the Nation has reaped enormous economic benefits from the widespread development of laser applications—fiber-optic communications, compact disc players, laser printers, new cancer surgeries—and the establishment of whole industries, such as the fiber optics industry that resulted from the marriage of lasers and transistors. Laser techniques developed for the military have also been applied to ophthalmic surgery. Combining low-energy, blue-green lasers with a computer workstation, surgeons are able to alter the shape of the cornea to repair vision impairments, including near- and farsightedness and glaucoma.



■ *Using the power of light.*

■ **Adaptive Testing.** Students, employers, and prospective employees are benefitting from defense research that established a strong mathematical theory for the construction of tests. Called Item Response Theory (IRT), it is coupled with actual test performance to reliably predict the difficulty of the test, as well as the test taker's ability. Most professionally constructed tests are based on IRT. One million students taking the Scholastic Assessment Test, thousands of young people seeking to enter military service, and civil service applicants in Michigan will soon be using computerized adaptive testing. The evolution of these tests has led to restructuring the Graduate Record Examination into a computerized form. This restructuring allows more frequent and convenient administration of the test and immediate feedback to some 400,000 graduate school hopefuls annually.

"I believe that this Nation should commit itself to achieving the goal, before [the] decade is out, of landing a man on the moon and returning him safely to earth."
President John F. Kennedy

SPACE RESEARCH

In 1957, the Soviet Union launched the first artificial satellite, and with it, a major U.S. mission in science and technology—the Space Race. President Eisenhower and Congress responded with the 1958 National Aeronautics and Space Act, establishing NASA and its role in ensuring U.S. leadership in aeronautics and space science and technology. This act laid the foundation for public-private partnerships on which U.S. leadership in aeronautics and space technology has been built. Throughout the 1960s, the United States committed financial, human, and industrial resources to achieve President Kennedy's bold objective of landing a man on the moon and returning him safely home by the end of the decade. In 1969, the United States achieved this historic accomplishment and, in the process, contributed enormous advances in scientific and technological knowledge that have helped underpin America's competitive strength in aerospace, satellite communications, computers, telecommunications, and other industries. Since 1958, NASA has annually spent roughly 90 percent of its R&D dollars in the industrial sector, thus ensuring the transfer of government-funded technologies to American industry. Also, the National Defense Education Act of 1958 brought, for the first time, Federal funding to elementary and secondary schools to improve mathematics and science education in support of the national initiatives in space and science.

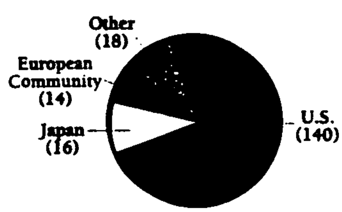
NASA BOOSTS COMMUNICATIONS SATELLITE

NASA played an instrumental role in the creation of the communication satellite business. Starting in the early 1960s, NASA was charged by act of Congress to stimulate space communication in partnership with U.S. industry. That partnership generated technology—starting with the ECHO and SYNCOM family of satellites—that formed the basis for today's $5 billion communication satellite industry. The United States dominates this industry, holding about 70 percent of the international satellite supplier market, which is expected to grow to $30 billion by the year 2000.

To ensure U.S. leadership in satellite communications into the next century, NASA is forming a partnership with the industry to address the role of satellites in the National/Global Information Infrastructure (NII/GII). Among the issues to be addressed is the investigation and development of standards and data protocols that will ensure seamless interoperability of satellite and terrestrial telecommunications in the NII/GII.

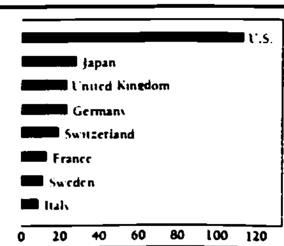
U.S. Leads in Gene Engineering Patents

1992



American Pharmaceutical Companies Produce More World-Class Drugs

1970–1992



MEDICAL RESEARCH

In the 1950s, the development of antibiotics and other medical miracles—such as the Salk and Sabin vaccines that eradicated the scourge of polio—spawned a Federal government commitment to advance the state of medical science. Federal funding for health sciences led to the establishment of an unparalleled national health research infrastructure centered around the National Institutes of Health and medical research universities. Federal investments through the Atomic Energy Commission, the Energy Research and Development Administration, and now, the Department of Energy have provided the basis for most of the nuclear medicine techniques used today, ranging from imaging technology to the use of radioisotopes as powerful diagnostic and therapy tools. These investments have produced a flow of blockbuster drugs, therapies, and medical technologies; propelled America's phar-

A World of Benefits From Space

The Space Race has yielded a wide array of technologies with powerful commercial benefits.

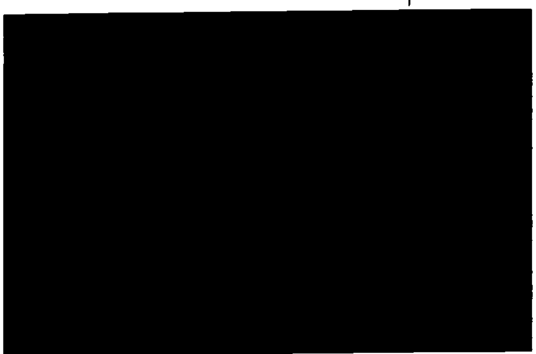
■ **Steeling for Foreign Competition.** In the 1970s, America lost its dominant position in the global steel market to strong foreign competitors employing leading-edge technology. In 1988, Gladwin Corporation partnered with NASA to convert the space agency's knowledge of coating technology into improvements in the company's continuous casting equipment that would reduce the cost of steel production. The effort led to a breakthrough involving application of materials in the continuous casting process. Within months of introducing the improved components, Gladwin posted large sales increases and potential savings to the steel industry of about $20 million per year. This improved technology has helped Gladwin keep its share of the continuous casting equipment and maintenance market despite intense foreign competition. The company expects that ongoing research with NASA will yield further improvements.

■ **Affairs of the Heart.** Each year 225,000 Americans undergo coronary artery bypass surgery to replace clogged blood vessels, a procedure that costs $25–50,000 and requires a 10- to 15-day hospital stay. Now, thanks to a system of magnetic switches developed by NASA, one in eight of these patients can be treated using excimer laser angioplasty: a $10,000 procedure requiring only a two-day hospital stay. Medical researchers seeking an alternative to coronary bypass surgery and its primary non-surgical alternative, balloon angioplasty—which is not suitable for some patients—developed excimer laser angioplasty. This procedure offers extraordinarily precise, non-surgical cleansing of clogged arteries without causing damage to blood vessel walls. The excimer laser uses pulses of ultraviolet light to break chemical bonds and disintegrate the plaque blocking the arteries. Precise control of the laser's pulse width, a key system requirement, was made possible by magnetic switches developed by NASA's Jet Propulsion Laboratory (JPL) to measure atmospheric gases. Advanced International Systems, Inc. (AIS) was formed in 1988 to develop and market an excimer laser angioplasty system. In 1990, the success rate for opening clogged coronary arteries using excimer laser angioplasty was 85 percent. AIS received FDA approval for the angioplasty system in 1992 and has already sold more than $20 million worth of this new technology. In addition to the direct surgical cost savings achieved by excimer laser angioplasty, patients and the national economy benefit from enhanced worker productivity due to reduced recovery time.

■ **Clearly Profitable.** An optical coating technology developed in 1963 for NASA's Gemini program has found a home in the commercial marketplace. High Efficiency Antireflection (HEA) technology was developed by Optical Coating Laboratory, Inc. (OCLI) to improve visible-light transmission in aerospace vehicles. The company subsequently found the computer industry a ready customer for HEA technology for use in cathode ray tube (CRT) systems. At the time, 95 percent of CRT users complained of screen glare, and 65 percent cited specific medical problems such as blurred vision and headaches. OCLI sold HEA-coated panels to the computer industry to alleviate these problems. HEA technology is also used in invisiglass, a product employed in multi-element optical systems; readout panels for medical diagnostic and test equipment; and energy-efficient lens systems for projectors, copiers, and large-screen video systems. Sales for these products exceed $100 million.

■ *Healthier computing.*

■ **Doctors Catch an Earful of Information.** For more than a century, doctors have used mercury thermometers to gauge patients' health. With the help of NASA technology, the two-minute wait for the mercury to warm up could be a thing of the past. Diatek Corporation worked with JPL to develop an infrared clinical thermometer that determines a patient's temperature in two seconds or less by measuring the infrared radiation emitted from the bottom of a patient's ear canal. This fast response permits temperature measurement of patients who are critically ill, incapacitated, or new-born, as well as saving valuable medical personnel time. Diatek worked with JPL to refine the design of the infrared sensor optics in the thermometer. The collaboration resulted in a thermometer capable of making rapid measurements of a patient's temperature within ±0.5°F. JPL attained extensive knowledge of infrared technology during 30 years of instrument development, including the $1.2 billion Infrared Astronomy Satellite telescope capable of determining the temperature of a planet or star by measuring its emitted infrared radiation.



■ *Capturing energy from the wind.*

maceutical industry to global leadership; and given birth to the biotechnology industry, viewed by many as one of the major technological opportunities of this century. Health research has grown steadily, accounting for one-third of the total Federal investment in civilian R&D today.

ENERGY AND ENVIRONMENTAL RESEARCH

In the 1970s, long lines at the gas pumps, dependence on foreign sources of energy, and environmental disasters such as Love Canal, smog-choked cities, and polluted rivers led to expanded efforts in energy research and a new mission in environmental R&D.

In 1974, the Federal government established the Energy Research and Development Agency (ERDA) to conduct energy-related R&D in oil, coal, solar, geothermal and nuclear energy. In 1977, ERDA became the Department of Energy and was elevated to full cabinet status. Energy R&D funding peaked in the late 1970s.

More than 1 million Americans are employed by more than 60,000 environmental technology businesses nationwide.

Federal funding for environmental research—provided primarily through the Department of Energy, Environmental Protection Agency, Department of the Interior, and the National Oceanic and Atmospheric Administration of the Department of Commerce—has paralleled the Nation's investment in energy. These R&D efforts have led to more fuel-efficient vehicles, better insulated homes, increased awareness of energy conservation, improved weather forecasts, and a myriad of technologies designed to prevent or repair environmental damage.

GENOME RESEARCH CONTRIBUTES TO INDUSTRIAL COMPETITIVENESS

The U.S. Human Genome Project (HGP) is managed jointly by the Department of Energy (DOE) and the National Institutes of Health (NIH). It was initiated at DOE in 1986 and at NIH in 1987. The goal of the project is to develop the technology that will allow for complete sequencing of human DNA by 2005. The DOE program is focused on the development and application of improved and cost effective technologies for mapping, sequencing, and informatics. The NIH program is focused on generating comprehensive genetic and physical maps of the human genome and sequencing human DNA as well as the DNA of several model organisms. The technologies, databases, and biological resources being developed by the HGP are being rapidly shared with the scientific community. This is having an enormous impact on a wide variety of biotechnology-related industries and research including medicine and health care, agriculture, energy production, waste control, and environmental clean-up. Examples of current spin-offs from the technologies and resources developed in the HGP include the founding of numerous companies to exploit the medical applications of genome research, as well as the initiation of genome projects for several economically important plants, animals and microbes. The economic impact of the HGP is reflected in the worldwide sales of biotechnology products that are expected to increase from less than $5 billion in 1992 to more than $50 billion in 2000.

SPIN-OFF: COMMERCIAL BENEFITS OF FEDERAL R&D

It is no accident that many of the industries in which U.S. firms lead the world grew from Federal technology investments. America's unflinching commitment to a strong science and technology base to support national defense, space exploration, and other missions has yielded substantial commercial benefits.

Technology spin-off—in which technology developed to meet Federal mission requirements is adapted for commercial markets—was particularly successful in the period following World War II through the mid-1970s. During this period, Federal R&D expenditures grew dramatically, exceeding the total civilian, defense, and industrial R&D of all other developed countries in 1964. As a result of their technological sophistication, U.S. companies were uniquely able to capitalize on the results of Federally funded basic research and mission R&D, expanding their global commercial dominance in technology-based industries.

Spin-off, or technology transfer, worked well as long as military systems represented the leading-edge applications of new industrial technologies, and as long as foreign competitors did not pose a significant competitive challenge. But the circumstances that allowed the United States to gain world leadership in commercial markets through reliance on spin-offs from Federal R&D—primarily through a defense-led technology model—have changed.

MICROWAVE OVENS EMERGE FROM DEFENSE TECHNOLOGY

Raytheon became a leading producer of military radars during World War II. In 1945, Raytheon engineer Percy Spencer observed that a microwave device from a military radar set had melted a chocolate bar in his pocket. Deciding to test his theory, Spencer placed a bag of popcorn kernels in front of the equipment and the kernels began popping. The next day, Spencer demonstrated the effect before a group of interested observers using an egg instead of popcorn. Though the egg exploded, it did not leave Spencer with "egg on his face."

By 1947, Raytheon had produced a microwave oven for use in restaurants. Nearly two decades later, the company began development of a microwave oven for the home. In 1967, Raytheon introduced the "Radarange," and sales quickly exceeded the company's expectations. Based on the commercial potential of a military technology, Raytheon made substantial investments and carried out much technical development to bring these ovens to market.

Defense materials research—designed to produce better armor, lighter equipment, less maintenance, and more durability—has moved from battlefield applications to artificial limbs, golf clubs, and construction of a 450-foot cable-stayed bridge in San Diego.

FRUITS OF AMERICAN HIGH-TECH LEADERSHIP

Much of America's technological leadership since 1945 was stimulated by Federal R&D expenditures. Some spin-offs of government research include:

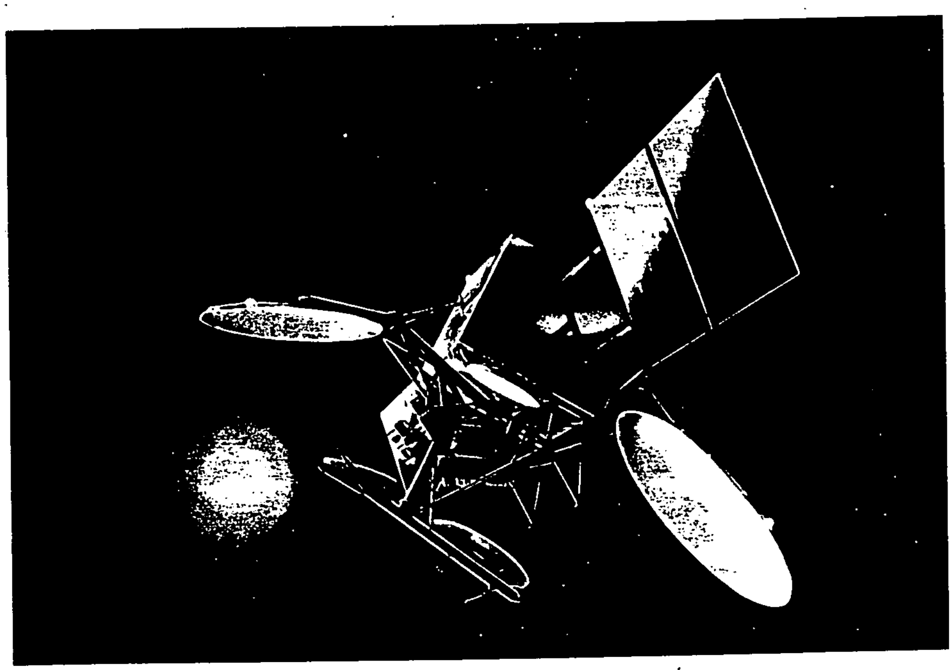
- Automated air traffic control
- The biotechnology industry
- Commercial satellite communications
- Integrated circuitry
- The Internet
- Jet aircraft
- Microwave ovens
- Satellite-based global navigation and communications
- Supercomputers

BEST COPY AVAILABLE

In just the past ten years, American employment in the computer and software industries—born of Federal investments in R&D—has almost tripled. By 2005, the number of jobs for computer systems analysts and programmers is expected to more than double.

American companies now face intense international competition from increasingly capable foreign firms—accelerating the pace of technological innovation and shortening product life cycles. Thus, traditional technology transfer, development, and diffusion—in which technology developed for a Federal mission finds its way to the private sector, and is eventually adapted to meet the demands of the commercial marketplace—often take too long to be effective. In addition, the end of the Cold War has decreased demand for—and investments in—new defense systems. This reduction has diminished the influence of defense spending on technology development paths. Whereas in the past, defense technology generally represented the leading edge of innovation, today developments in commercial technology often lead those in defense. As a result, U.S. defense programs are becoming increasingly reliant on technology "spin-on," in which commercial technology is adapted for use in military applications.

While the United States still gains substantial commercial benefits from its mission-related R&D, commercial product spin-offs have diminished from their heyday of the 1950s and 1960s as a result of the changing innovation environment.



Existing commercial space communications systems evolved from high-risk technology developed by NASA in the late 1960s and 1970s. Right, the Advanced Communications Technology Satellite.

Government-Industry Partnerships for Technology Development, Diffusion, and Commercialization

1980-1988

In the late 1970s, increasing challenges to U.S. competitiveness resulted in plant closings, job losses, and an eroding tax base. Federal, state, and local governments responded with a wide array of partnership programs with the private sector to foster economic growth and job creation. As these competitive challenges reached into U.S. high-technology industries, these partnerships incorporated efforts in technology development and deployment—bringing together sources of new technology, insights into new markets, and the funding and management needed to achieve success in those markets.

In 1980, Congress began a new era in Federal technology policy with the enactment of legislation to exploit the commercial potential of Federal R&D. By enabling firms to secure patent rights to Federally developed technologies, promoting the role of small business in innovation, bringing industry into the technology development process sooner, and coordinating policies across agencies, Congress and successive Presidents sought to more fully leverage the value to society of tax dollars spent on Federal mission-related R&D.

MAJOR FEDERAL TECHNOLOGY LEGISLATION

1980	Stevenson-Wydler Technology Innovation Act
1980	Bayh-Dole University and Small Business Patent Procedures Act
1982	Small Business Innovation Development Act
1984	National Cooperative Research Act
1984	Trademark Clarification Act
1986	Japanese Technical Literature Act
1986	Federal Technology Transfer Act
1987	Malcolm Baldrige National Quality Improvement Act
1988	Omnibus Trade and Competitiveness Act
1989	National Institute of Standards and Technology Authorization Act
1989	National Competitiveness Technology Transfer Act
1991	American Technology Preeminence Act
1992	Defense Conversion, Reinvestment and Transition Assistance Act
1992	Small Business Technology Transfer Act
1993	Cooperative Production Amendment to the National Cooperative Research Act
1996	Telecommunications Reform Act

Two landmark pieces of legislation—the University and Small Business Patent Procedures Act of 1980 (the Bayh-Dole Act) and the Technology Innovation Act of 1980 (the Stevenson-Wydler Act)—sought to establish public-private partnerships built on the mutual objective of fostering the competitiveness of American firms.

The Bayh-Dole Act created a uniform Federal patent policy that permits most Federal laboratories to grant exclusive licenses on Federal patents to U.S. businesses and universities. Private firms had been reluctant to invest substantial time and resources in the commercialization of a Federally developed technology under a non-exclusive government license that competitors could secure as well. The Bayh-Dole Act eliminated this barrier to innovation.

The cost of bringing a new invention to market in the 1990s can run 10 to 100 times more than the cost of research and development.

The Stevenson-Wydler Act found that "No comprehensive national policy exists to enhance technological innovation for commercial and public purposes. There is a need for such a policy, including a strong national policy supporting domestic technology transfer and utilization of the science and technology resources of the Federal government." The Stevenson-Wydler Act articulated a broader role for government in promoting commercial innovation and established the first major initiative to proactively transfer technology from Federal labs

■ *A potential use of the MIR–a back-up warning system on the tail-light of an automobile.*

PERSONAL RADAR, WAVE OF THE FUTURE

Nicknamed the "radar on a chip," the micropower impulse radar (MIR) will soon be available in dozens of products. Developed by an electronics engineer working in Lawrence Livermore National Laboratory's Laser Fusion Program, the MIR harnesses the speed of light for measurements in daily life—all for about $10, doing what used to require equipment costing $40,000. Computer chip-sized radar units will detect cars in blind spots; serve as automobile back-up warning systems; detect burglars; locate studs in walls; monitor a baby's breathing; perform search and rescue; monitor heart contractions; measure fluid levels; and turn lights, tools, and appliances on and off. And that is only the beginning; this exciting technology is expected to perform scores of other tasks. To date, the MIR has been licensed to 15 companies.

to industry. The act made technology transfer an explicit mission of the Federal labs, establishing an office within each lab charged with identifying technologies with commercial potential and transferring that knowledge to U.S. industry.

In 1986, the Federal Technology Transfer Act (FTTA) further leveraged investments in mission-related R&D. The FTTA authorized Federal agencies to enter into cooperative research and development agreements (CRADAs) with companies, universities, and non-profit institutions for the purpose of conducting research of benefit to both the Federal government and the CRADA partner. Since its inception in 1986, the CRADA mechanism has been strongly embraced by industry.

SPURRING COOPERATIVE RESEARCH IN THE PRIVATE SECTOR

In addition to efforts aimed at stimulating the commercial use of mission-related research, the Federal government enacted legislation in the 1980s to improve the economic, tax, and regulatory environment for the development of commercial technologies by U.S. firms.

In 1984, the National Cooperative Research Act (NCRA) reduced antitrust barriers to joint industry research. As technology development became more costly, complex, and interdisciplinary, it became increasingly difficult for a single firm to assume the cost and risk of developing new technologies. Cooperative research and development among firms with similar technology requirements offered a means to share cost and risk. Antitrust laws, however, acted as a significant barrier to such joint efforts.

Today, there are 630 cooperative research efforts registered under the NCRA.

The NCRA eliminated two key antitrust barriers to cooperative research. First, it eliminated the treble damages provision for consortia that registered their cooperative, pre-competitive R&D efforts with the Justice Department, limiting any successful legal action to recovery of actual damages. Second, it replaced the "per se rule"—in which such cooperative efforts were deemed at face value to be anti-competitive—with the "rule of reason," in which the court must weigh the benefits of such collaboration against any potential anti-competitive effects. This legislation spurred the formation of hundreds of R&D consortia.

1988-THE PRESENT

FOCUS ON COMPETITIVENESS: PARTNERSHIP PROGRAMS AND POLICIES SUPPORT U.S. INDUSTRY AND WORKERS

In 1988, the partnership between the Federal government and American industry grew closer with passage of the Omnibus Trade and Competitiveness Act. This legislation established two innovative experimental programs at the National Institute of Standards and Technology (NIST)—one directed at fostering the development of high-risk enabling technologies, the other aimed at providing technical and management assistance to small and mid-size manufacturers.

The Advanced Technology Program (ATP) is an industry-government partnership that is sowing the seeds of future economic growth and job creation. First implemented in 1990, ATP competitively awards funds, matched by industry, for developing technologies with large economic potential that would not otherwise be pursued in a competitive time frame (if at all) owing to their high cost, high risk, and delayed returns on investment. These characteristics make such research an unattractive investment for venture capitalists and for individual firms that must address more immediate business concerns and stockholder demands.

The application of holographic technology to fiber-optic communications.

The Manufacturing Extension Partnership (MEP) provides critical aid to the 381,000 small and medium-size manufacturers that form the backbone of the U.S. industrial base, provide millions of jobs for American workers, and serve as hubs for many local and regional economies. Under intensifying foreign competition, the very existence of many of these companies is threatened by a failure to modernize their operations. The MEP helps these firms become more competitive by providing technical assistance with new manufacturing technologies and approaches that lead to improvements in product quality, cost, and time-to-market.

The ATP and MEP were first implemented as pilot programs by the Department of Commerce under the Bush Administration. After their effectiveness was proved during this trial period, the Clinton Administration executed a plan of scale-up, securing substantial increases in funding for both programs in the interest of fostering U.S. competitiveness and economic growth.

Federal Investments Help Aerospace Industry Soar

Government and industry have a history of partnership in technology development that dates back to the earliest days of aviation. This technology partnership has contributed tremendously to the United States' commanding share of the global market for both military and commercial aircraft. America's investment in military aircraft technology and the establishment of the National Advisory Committee on Aeronautics (NACA) in 1915 catapulted the U.S. aerospace industry to global leadership. Through the 1920s and 1930s, NACA promoted cooperative efforts between industry and government that advanced the U.S. aircraft industry and later enabled the United States to churn out military aircraft during World War II. Following the war, U.S. industry applied military-led advancements in areas such as aerodynamics, materials, fuels, and navigation systems to the design and production of commercial aircraft, propelling American aerospace companies to global leadership.

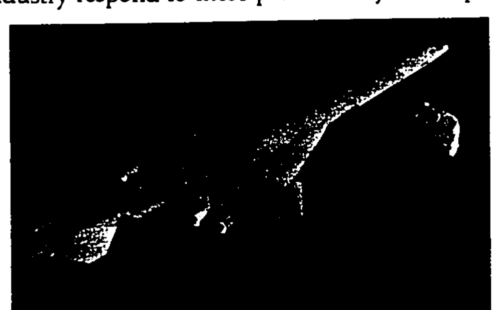
■ **Military-Commercial Aircraft Synergy**. The close relationship between military and commercial aircraft technology is highlighted by Boeing's development of a jet refueler to replace the propeller-driven KC-97. The acquisition of large numbers of intercontinental jet bombers by the Strategic Air Command in the 1950s drove the need for a jet refueler. In anticipation of this requirement, Boeing funded development of the Dash-80—a four-engine, swept-wing jet aircraft. Boeing modified the Dash-80 to meet Air Force refueling requirements, delivering the KC-135 Stratotanker within two years of the Air Force's order. The Dash-80 ultimately led to the highly successful 707 Stratoliner passenger jet.

In another project, Boeing failed to secure the government contract for the C-5, but built upon its design work to develop the 747 wide-body passenger jet.

■ **Safety, Efficiency, and Affordability in the Air.** Government research has contributed to many innovations that have made aviation among the safest and most affordable modes of transportation available today. Funding from several Federal agencies for research in computational fluid dynamics is increasing fuel efficiency while reducing design time, the need for costly wind tunnel experiments, and drag in aircraft and automobiles. Federally funded "fly-by-wire" and computational fluid dynamics technologies provide greater stability and maneuverability for military aircraft, as well as smoother rides through turbulent air and greater fuel efficiency for commercial aircraft. Other recent applications of Federally funded research include supercritical wing technologies in use on the B-757 and B-767 aircraft, winglets for the MD-11 and the B-747-400 aircraft, active turbine cooling to improve the performance of the Pratt and Whitney JT9D engine on the B-747, and wind shear detectors for commercial transports. Today, satellite-based navigation and communications are enabling a new generation of air traffic control and management to meet the needs of the 21st century.

■ **Technology for Jobs and Economic Growth.** Today the U.S. aerospace industry leads the world and is America's leading net exporter of manufactured goods, generating the largest trade surplus of any U.S. manufacturing industry. While American companies still dominate the aerospace marketplace, new challenges from foreign competitors threaten to erode their competitive position. Today's government-industry technology partnerships are helping the industry respond to these pressures by developing new jet transports and safety systems for the 21st century.

Investments in NASA's High-Speed Research and Advanced Subsonic Technologies programs are designed to advance U.S. aviation leadership through technology development. These programs are developing and validating technologies that will enable commercial development of a new generation of safe, subsonic, and high-speed civil transport aircraft that outperform current aircraft in affordability, efficiency, and environmental compatibility. Development of high-speed jets that reduce flight times by more than half is expected to generate a $200 billion market and 140,000 jobs. To ensure that the United States captures a substantial share of these economic benefits, NASA is working with the private sector to develop technologies essential to high-speed transport aircraft, including ceramic materials capable of withstanding high temperatures, "high lift" devices for wings, and advanced engines.



■ *The High-Speed Research program is being conducted as a national team effort with shared government-industry funding and responsibilities.*

CHAPTER 3

NATIONAL TECHNOLOGY POLICY IN AN ERA OF GLOBAL ECONOMIC COMPETITION

The Clinton Administration came to office at a time of increasing concern about the state of American technology and competitiveness. The Administration has sought to address these concerns by building a technology policy on the firm foundation of past success, with an awareness of the new global competitive environment and an eye to the future.

For more than 50 years, Americans have demonstrated an unwavering bipartisan commitment to U.S. technological leadership. Presidents from Harry Truman to George Bush have unequivocally supported a strong role for the Federal government in building the Nation's scientific and technical capabilities. This strong commitment, backed by investments in R&D, has created a technology base that is the envy of the world and has paid rich dividends—generating new industries, millions of jobs, and higher living standards.

The Clinton Administration is building on this legacy of success by seeking expanded Federal support for basic research and to commercialize more effectively the results of Federal mission research using the licensing and cooperative R&D tools provided by the legislative initiatives of the 1980s.

While these efforts form an essential element of this Administration's technology policy, the competitive realities of today's global economy require the Federal government to pursue new approaches that directly address economic growth and competitiveness.

Forging Government-Industry Partnerships

Government-industry partnerships rely on the private sector as the agent through which economic growth will be achieved. Industry transforms technology into the products and services that generate the wealth and jobs that improve the Nation's standard of living. Government must be a strong partner in enabling the private sector to fulfill this role more effectively.

The Administration has identified several overarching principles to guide its partnerships with the private sector. These principles seek to develop partnership programs that are aligned with private sector needs and build on U.S. academic strengths while maintaining strong government stewardship over the public's interests and investments.

■ *Assembling miniaturized electronic circuit boards.*

SHARED RESPONSIBILITIES AND MUTUAL BENEFITS

During the past 50 years, the Federal government has been the customer for most technology programs it carried out jointly with industry. Agencies initiated programs to meet their mission needs, established goals, and were responsible for using program results. Government's needs were the sole consideration, and relatively little attention was given to the challenges faced by private participants in developing commercial applications for their work. By contrast, the ultimate success of the technology partnership programs rests on meeting the objectives of both government and industry partners.

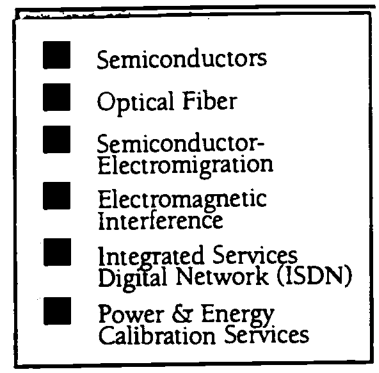
Government can achieve its economic objectives only if technologies that emerge from partnership programs are put to work in the commercial marketplace. That requires technologies that meet private sector needs. Industry should play a larger role in establishing priorities for partnerships in Federal civilian research. In the design and management of Federal civilian industrial research and technology development projects conducted by the private sector, the industry partner should, where possible, specify the research direction, control project spending, and own the intellectual property to the extent necessary to encourage its commercial development. Federal agencies are strengthening the linkages with industry in these areas.

Cost-sharing arrangements should be undertaken wherever possible. The private sector's willingness to share costs and put assets at risk demonstrates that partnership programs reflect the real needs of American business as well as a commitment to commercialize program results. Industry must be able to count on government as a reliable partner; uncertainties about government's commitment to promising projects should be minimized.

TOOLS TO COMPETE

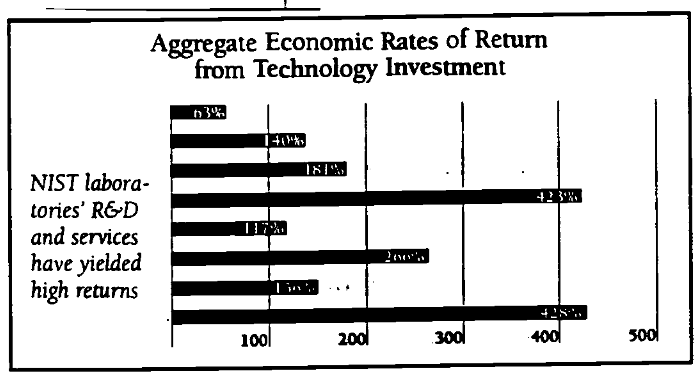
In addition to technology development programs, industry has identified a wide range of government policies—including incentives for capital formation, regulatory reform, and product liability reform—that significantly affect its ability to turn technology into products and services and bring them to market. Government must recognize and address the many factors that affect the private sector's ability to compete.

The diversity of industries in the United States is a significant strength that allows our country to pursue multiple paths to growth and job creation. However, it also presents complex challenges to government policy-makers. Different industries have different concerns, face different competitive challenges, and seek different types of policy solutions. For example, incentives for capital formation are a priority for the biotechnology industry, which is populated by many cash-poor start-ups and small firms. The pharmaceutical industry has identified product liability costs and regulatory delays in gaining approval for new products as key challenges. Telecommunications companies are eager to capitalize on the rapidly unfolding opportunities of the Information Age and see the reform of telecommunications regulations as essential to their global competitiveness. There is no "one size fits all" formula for ensuring that our companies lead the world in innovation; a portfolio of policies will best serve the national interest.

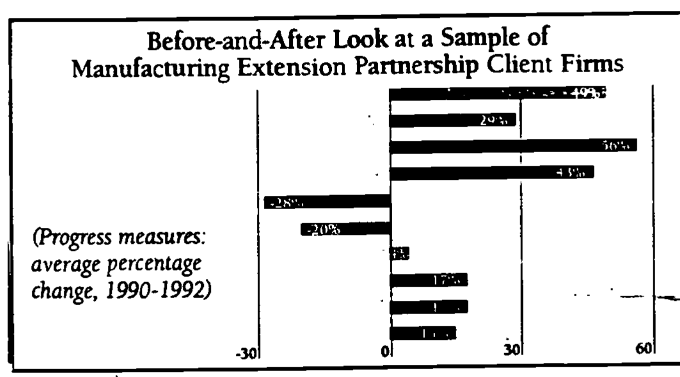


FOCUS ON WHAT WORKS

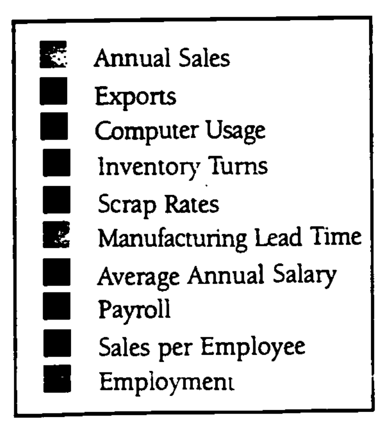
Evaluation is the cornerstone of effective program management and a key tool for government in carrying out its role as steward of the public interest. Evaluation is especially important when new and innovative approaches are pursued, such as the Administration's partnership programs.



Where government is partnering with industry to meet its own needs, program success is ultimately measured by the cost and timeliness of project completion by the contractor and by the project's contribution to the agency's mission. However, in the Federal technology partnership programs, the ultimate measures of success are business measures that relate to effective technology diffusion, adoption, and commercialization, as well as economic measures such as productivity growth and job creation.



The Federal government must focus on developing and refining methodologies for assessing the economic benefits attributable to its investments in technology partnerships with the private sector. For example, measures of success for technology development partnerships may focus on new technical capabilities, reduced time-to-market, new commercial opportunities, and business growth. Deployment programs, such as the Manufacturing Extension Partnership (MEP), can be assessed by improvements in areas such as company sales, exports, computer use, and quality. For example, MEP client firms were asked to estimate the benefits they expect to realize from changes and improvements made on the basis of the assistance they received. Based on surveys returned by 610 companies served by 13 centers in 1994, firms reported anticipated benefits of $167 million resulting from sales increases and cost savings attributable to actions undertaken with assistance from the MEP. Based on Federal funding for the centers totaling $20 million, these results translate into an $8 return on each dollar that the Federal government invested in the MEP. Bottom-line economic impacts—such as jobs created or saved—are powerful evidence of a program's value to the country.



As government and industry together confront the challenges of the new global economy, these principles will help bring this budding partnership to full flower. In the process, a vision we all share will be realized—a secure Nation, a growing economy, high-paying high-quality jobs, and a rising standard of living for our people.

CHAPTER 4

MEETING THE GLOBAL COMPETITIVE CHALLENGE: A NATIONAL TECHNOLOGY POLICY FOR THE 21ST CENTURY

FIVE GOALS OF THE PRESIDENT'S TECHNOLOGY POLICY FOR ECONOMIC GROWTH

- Create a business environment in which the innovative and competitive efforts of the private sector can flourish.
- Encourage technology development, commercialization, and use.
- Invest in a world-class infrastructure to support U.S. industry and facilitate commerce.
- Promote integration of the military and civilian industrial bases.
- Ensure that America has a world-class workforce capable of participating in a rapidly changing, knowledge-based economy.

Five Goals

■ *Improving oral drug administration by providing rate-controlled delivery that can reduce side effects, increase efficacy and decrease dosing frequency.*

Recognizing that U.S. global leadership in technology is vital to the national interest, President Clinton set forth a clear and simple vision: "Technology is the engine of economic growth." To fulfill this vision, the Administration established a policy that will maximize technology's contribution to sustained economic growth, job creation, improved quality of life, and the national defense. The policy recognizes that only the private sector has the skills and abilities to manage the complex process of developing new technologies and bringing them to market, while acknowledging that government plays a vital role in enabling the private sector's efforts.

Governments everywhere are working to build competitive and technological capabilities that remain within their national borders. Assets such as a strong science and technology base, a modern infrastructure, a skilled workforce, and a healthy business climate enable domestically based companies to grow and compete, and attract the engines of wealth creation and economic growth to a nation's shores. An effective technology policy must encompass a broad and balanced approach that invests in and cultivates these competitive assets. The Clinton Administration's technology policy is guided by five goals that address each of these important elements of technology and economic growth.

■ **The primary role of the Federal government in technology policy is to create a business environment in which the innovative and competitive efforts of the private sector can flourish.** This includes eliminating unnecessary legal, regulatory, and economic barriers to the development and commercialization of new technologies; assessing the impact of proposed laws and regulations on U.S. competitiveness; and developing new policies that foster innovation.

■ **The Federal government must encourage the development, commercialization, and use of technology.** First, the Federal government must invest in the pre-commercial development of technologies that offer large economic and social returns to the Nation. Rising costs and high risk are discouraging U.S. firms from pursuing the development of the emerging and enabling technologies that will form the basis for new products, services, and industries in the 21st century.

Second, the annual Federal investment in R&D exceeds $71 billion. A substantial portion of these funds is devoted to the development of technologies to meet government mission requirements. While a significant portion of these funds fall outside the traditional definition of R&D—for example, the Department of Defense invests $26 billion of this $71 billion on short-term developments unique to specific weapons systems—the remaining Federal R&D investment provides robust support to many technologies with strong commercial potential. This investment stands as a barometer of the health of the Nation's R&D enterprise today and a leading indicator for the vitality of the Nation's technology-based industries decades hence. If Americans are to receive the largest return on their tax dollars, Federal policy must aim to ensure that the fruits of this research extend beyond government to help U.S. firms and industries create high-wage jobs and national economic growth.

Third, the Federal government—in partnership with state and local governments, the academic community, and the private sector—should establish a range of mechanisms that encourage widespread deployment and use of technology.

■ **The Federal government must invest in a world-class infrastructure for the 21st century to support U.S. industry and promote commerce just as it has for more than a century in canals, rail transportation, aviation, and the national highway system.** Today and in the future, infrastructure remains essential to the Nation's ability to develop and deploy new technologies. We must continue to ensure the availability of efficient, high-performance transportation infrastructure, and continue our commitment to a national standards research, test, and measurement capability that keeps pace with technological innovations. Also, the knowledge-based economy of the 21st century demands that the Federal government encourage the adoption of new information technologies that will help government deliver services and meet responsibilities in transportation, public health, education, libraries, and other fields.

■ **U.S. policy must seek to integrate the military and commercial industrial bases into a single base capable of meeting both defense and civilian technology requirements cost-efficiently and effectively.** With the end of the Cold War and the growing role of civilian technology in meeting military needs, the United States can no longer afford to maintain two separate industrial bases—one solely to meet defense requirements, the other to address the opportunities of the global marketplace.

■ **We must develop a world-class workforce capable of participating in a rapidly changing, knowledge-based economy.** America's greatest asset is our people. In an era in which it is expected that most Americans will change careers several times during their lives, education will often continue past the formal training provided in elementary school, high school, and college.

"Transportation is the lifeblood of an economy—national or global. The incredible ease of movement of people and products from one place to another is what makes our vast U.S. economy possible. Increasing the speed and decreasing the cost of transportation is a key foundation to economic growth and spreads prosperity over a broader geographic area."

Daniel S. Goldin
NASA Administrator

■ *Bringing enthusiasm for technology and science to classrooms.*

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BUILDING COMPETITIVE ASSETS FOR NATIONAL ECONOMIC GROWTH

■ Technology

National Science and Technology Council
Advanced Technology Program
Partnership for a New Generation of Vehicles
Dual-Use Applications Program
Environmental Technologies
DOE's Industry of the Future Program
Energy Research
Intelligent Transportation Systems
Aeronautics Enterprise
Space Enterprise
Goals for a National Partnership in Aeronautics Research and Technology
Reusable Launch Vehicle Program
Small Spacecraft Technology (New Millennium Spacecraft)
Commercial Remote Sensing
Commercial Development of Space
NASA Commercial Technology Program
Biotechnology
Medical Research
Agricultural Research
Public-Private Technology Partnerships
Federal Patent Licensing
Cooperative Research and Development Agreements
Manufacturing Extension Partnership
National Technical Information Service
Malcolm Baldrige National Quality Award

■ Business Climate

Balanced Budget
Deficit Reduction
Research and Experimentation Tax Credit
Joint Production Amendment to the National Cooperative Research Act
National Institutes of Health Reasonable Pricing Clause
Telecommunications Reform
NAFTA
GATT
Summit of the Americas
Aisa Pacific Economic Cooperation
Export Control Reductions

■ Infrastructure

National Information Infrastructure
Global Information Infrastructure
Telecommunications Information Infrastructure Assistance Program
High-Performance Computing and Communications Initiative
Standards
Patents and Trademarks
Intelligent Transportation Systems

■ People

Goals 2000
School-to-Work
Direct Loans
Education Tax Deduction
Reemployment System
Skill Grants
Undergraduate and Graduate Education
Skill Standards
Education Technology

Business Environment

Goal 1

Create a business environment in which the innovative and competitive efforts of the private sector can flourish.

Perhaps the most important factor in the equation for national growth and prosperity is a healthy business environment. Government economic, regulatory, and trade policies are instrumental in creating a climate that enhances the private sector's ability to develop technology, turn it into products and services, and bring them to global markets rapidly.

ECONOMIC POLICY

Economic policies affect the cost and availability of capital that firms need to invest in technology, product development, and manufacturing. By cutting the deficit and balancing the budget, government borrows less, freeing capital for these private sector investments. The Clinton Administration has made great strides in reducing the Federal budget deficit and has proposed a viable plan to balance the budget while maintaining our investments for the future in areas such as technology, training, and modern infrastructure. The Administration proposed permanently extending the research and experimentation tax credit in 1993 to provide an incentive for American firms to invest in the new technologies that will underpin tomorrow's products and services. While Congress ultimately extended the credit only through June 1995, the Administration continues to support the credit and has proposed working with Congress to extend it.

REGULATORY POLICY

Regulations often play a major role in the time and capital required to develop a new product and bring it to market. This is especially true for biotechnology, environmental technology, and pharmaceutical products. The Clinton Administration seeks to meet public safety, consumer protection, and health goals in a manner that is least burdensome to business by identifying and eliminating unnecessary legal and regulatory barriers that inhibit R&D and domestic production.

Using low-level electrical energy to facilitate drug transport through the skin.

In 1993, President Clinton signed legislation amending the 1984 National Cooperative Research Act to reduce antitrust barriers to joint production ventures, offering U.S. firms a new way to cope with the escalating cost of establishing production facilities.

In April 1995, the National Institutes of Health dropped the "reasonable pricing" clause from its cooperative research and development agreements, a provision seen by industry as a significant barrier to partnership with NIH.

With the recent passage of the Telecommunications Act of 1996, the United States took a bold step into the future. These reforms will unleash a tidal wave of investment, creativity, and new technology that will spur growth, create jobs, and revolutionize our lives in ways we cannot imagine today.

In March 1995, the President and Vice President launched the "Reinventing Environmental Regulation" initiative to make environmental protection work better and cost less. The initiative contains 25 priority actions to both improve the existing environmental protection system and build the foundation for a fundamentally new performance-based system.

TRADE POLICY

Trade policies affect the playing field on which American firms must compete, but too often the playing field has been tilted by other nations to give their companies an unfair advantage. Access to global markets is a necessity in many high-technology industries. The costs of R&D and production facilities in such industries are prohibitive unless markets are captured globally to generate a sufficient return on those investments. Yet, too often, other countries' trade policies, and even those of the United States, have acted as troublesome barriers for otherwise able and successful American exporters.

The Clinton Administration is fighting to open markets worldwide. The Administration brought the NAFTA and GATT negotiations to conclusion, then secured their ratification in Congress. GATT is expected to boost the U.S. economy by $100–$200 billion in just ten years. At the Summit of the Americas, the Administration set the stage for open markets throughout the Western Hemisphere. The Administration has also taken the lead in promoting free trade in the Asia Pacific region, the world's fastest growing economy, through bilateral agreements and its leadership in the Asia Pacific Economic Cooperation (APEC) forum. President Clinton convened the first summit of leaders of the 18 APEC economies in 1993. U.S. exports to these economies totaled $320 billion in 1994, supporting over 2.7 million American jobs.

At home, certain export controls have hurt some of America's most innovative and rapidly growing industries. By reducing outdated export controls on U.S. computer, supercomputer, and telecommunications products, the Clinton Administration has freed high-technology exports worth billions of dollars annually.

NAFTA and GATT also addressed other issues critical to ensuring fair competition in the technology-driven global marketplace. NAFTA established the highest standard of protection for intellectual property, such as patents, of any international accord. The Trade Related Aspects of Intellectual Property, an accord reached in the GATT Uruguay Round, raised the standard of protection accorded copyrights, trademarks, patents, industrial designs, and trade secrets in each of the countries that are members of the World Trade Organization.

National governments increasingly are making investments in R&D to promote economic growth. Some nations, however, have used these investments to directly subsidize late-stage technology development in favored companies, providing these companies with a competitive edge over companies from nations that adhere to the principles of market-based competition. GATT protects from action government support of industrial R&D only through the pre-competitive stage of a non-manufacturable prototype. By discouraging industrial subsidies at the competitive stage of technology development, GATT will help to level the international playing field in technology.

The National Environmental Technology Strategy

"If our environmental technology industry is to remain competitive in the global marketplace, we must implement actions today that will be responsive to tomorrow's problems and needs. Meeting future challenges will require our regulatory system to adapt to a changing world by promoting the innovation that will ensure protection of our environment in a cost-effective manner. We want a government that offers opportunity, rewards innovation, and demands responsibility."

President William J. Clinton and Vice President Al Gore, Jr.
Bridge to a Sustainable Future: National Environmental Technology Strategy, April 1995

The environmental technology sector of our economy has grown to $170 billion and now provides over 1 million Americans with high-skilled and high-paying jobs in over 60,000 businesses nationwide. Global environmental revenues are estimated at $408 billion and expected to increase by $135 billion by the year 2000—more than a 33 percent gain in five years and a dollar figure comparable to Sweden's and Indonesia's combined annual gross domestic product.

Over the past three years, the Administration has worked closely with industry, non-governmental organizations, communities, academia, and state and local governments to advance the development and deployment of environmentally sound technologies, products, and practices both here and abroad.

Several initiatives are designed to identify and reform regulations that inhibit innovation and private sector investment in environmental technologies.

- Project XL (Excellence and Leadership) provides an alternative performance-based approach to environmental management that will encourage companies and communities to use cheaper, faster, and safer solutions to public health and environmental problems.

- The Common Sense Initiative (CSI) replaces a pollutant-by-pollutant approach to environmental protection with an industry-by-industry approach for the future. CSI participants in six sectors—automobile manufacturing, computers and electronics, iron and steel, metal finishing, petroleum refining, and printing—are working on more than 40 projects.

- The President's Environmental Technology Initiative (ETI) has invested $104 million in support of 274 projects with public and private sector partners to help identify and reduce regulatory and permitting barriers to environmental technology development and commercialization, address financing barriers, and encourage the deployment of environmental technologies at home and abroad.

continued on page 48

The Federal government is working with industry to help demonstrate and verify critical environmental technologies.

- The interagency Rapid Commercialization Initiative helps move promising environmental technologies into the marketplace by providing businesses with assistance in demonstrating, verifying, and permitting their technologies.

- The $7 million, 3-year Environmental Technology Verification Program tests different approaches to verifying the performance and cost of drinking water treatment, monitoring, pollution prevention, and indoor air technologies. ETI-funded third-party verification programs provide technology users with the information they need to make informed buying decisions and permitting officials with the data necessary to approve the use of new technologies.

Efforts are underway to support U.S. businesses seeking to capture rapidly expanding global markets for environmental technologies.

- An Environmental Technology Export Strategy provides strategic market analyses of large emerging environmental technology markets and supports U.S. businesses interested in moving into these markets.

- The Initiative for Environmental Technologies (through USAID) focuses development assistance on critical environmental challenges in developing countries.

- A new Environmental Directorate at the Export-Import Bank assists U.S. businesses with loans for environmental projects overseas.

- The America Desk at the State Department is tasked with helping to solve problems U.S. businesses overseas have and bringing business concerns to the forefront of the foreign policy process.

Two services help connect businesses with these environmental technology programs as well as technologies and markets. A CD-ROM provides quick access to information on Federal environmental technology programs, and the Global Network for Environment and Technology (GNET) offers an electronic marketplace and information exchange network for environmental technologies on the World Wide Web. GNET was recently given the Golden Tiger Award as the most promising new business networking site on the Internet (address:http://www.gnet.org).

(See page 54 for Environmental Technology Initiative)

TECHNOLOGY DEVELOPMENT AND DIFFUSION

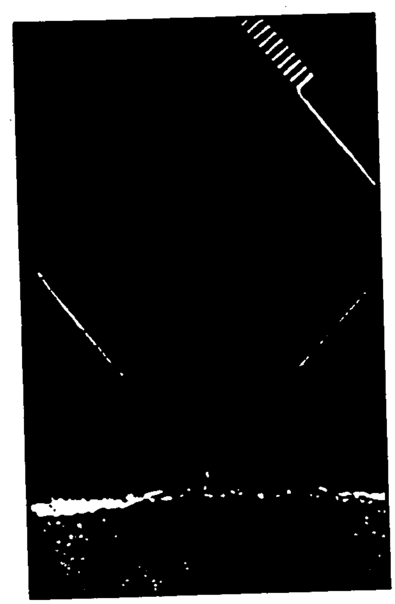
Goal 2

Encourage technology development, commercialization, and use.

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

Careful planning to meet national needs, elimination of duplicative efforts, and program evaluation are essential for effectively managing the Federal government's portfolio of research. In November 1993, President Clinton established by Executive Order a cabinet-level National Science and Technology Council (NSTC) to coordinate science and technology policies throughout the Federal government. Chaired by the President, the Council 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.

The NSTC establishes clear national goals for Federal science and technology investments and ensures that science, space, and technology policies and programs are developed and implemented to maximize their contribution to national goals. Key activities include conducting across-the-board reviews of Federal investments in R&D and coordinating R&D budget recommendations. This work is accomplished through nine committees with jurisdiction in civilian industrial technology; information and communications; fundamental science; transportation; natural resources and the environment; national security; health, safety, and food research; international science, engineering, and technology; and education and training.



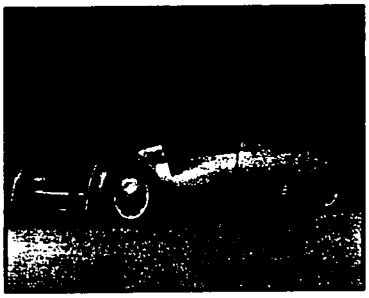
■ *New fluids are replacing CFCs in cleaning printed circuit boards during manufacturing and in many other applications.*

TECHNOLOGY PARTNERSHIPS

Today, the development of new enabling technologies and emerging technologies that promise large economic and social benefits to the Nation is at risk. New enabling technologies would support advances across a wide range of industries, while emerging technologies promise to drive the development of entirely new industries and classes of products and services. While such technologies are the fundamental building blocks for future economic growth and competitiveness, individual companies may be unable to develop them in a competitive time frame (if at all) due to their high cost, high risk, and delayed returns on investment. These characteristics make such research an unattractive investment for venture capitalists and for individual firms that must address more immediate business concerns and stockholder demands.

In the past, American companies were able to pursue exploratory research with little regard to its near-term impact on the bottom line. Today, however, U.S. industry's R&D activities have shifted away from long-term exploratory research toward the pursuit of shorter term business goals. This shift is driven by competitive pressures to downsize and streamline, move R&D closer to the customer, reduce costs, and improve quality. While a rational response to today's competitive realities, these trends threaten to dry up the wells of new technology from which our nation must draw to remain competitive.

The Federal government's technology initiatives are designed to help replenish these wells. By forming partnerships with industry, government can help ensure that U.S. companies and American workers develop the technological tools needed to compete in tomorrow's global markets.



■ *A Partnership for a New Generation of Vehicles (PNGV) experimental concept car.*

■ **Advanced Technology Program.** The Commerce Department's Advanced Technology Program (ATP) addresses the problem of developing enabling and emerging technologies by sharing the cost and risk with the private sector. ATP forms partnerships with companies and joint ventures that have the greatest potential for meeting the primary objective of the program: developing technologies to achieve broad-based economic benefits with high rates of social return for the Nation.

While government provides the catalyst, industry conceives, co-funds, and executes ATP projects. Specific R&D projects are selected from proposals submitted by industry, and all awards are made through a competitive merit-based selection process that evaluates technical and business merit. Industry is also the source of ideas for particular technology areas that offer important opportunities for economic growth. These are multi-year efforts aimed at specific, well-defined technology and business goals. By managing groups of projects that complement each other, ATP reaps the benefits of synergy and, in the long run, can have a stronger impact on the U.S. technology base and the economy.

PARTNERING FOR MUTUAL BENEFIT

While industry and government may have different goals for their technology investments, cooperation can create synergy that allows each to achieve those goals in a more efficient and effective way. Several Clinton Administration initiatives exemplify this approach.

NATIONAL ELECTRONICS MANUFACTURING INITIATIVE

The National Electronics Manufacturing Initiative (NEMI) was created to ensure the sustained growth and competitiveness of electronics manufacturing in the United States. Originated by the National Science and Technology Council's Electronics Subcommittee, NEMI was formally launched in 1996 as an industry-led initiative focused on bringing together the largest electronic equipment manufacturers, their key suppliers, and government agencies to foster development of the world's best electronics manufacturing supply chain.

To advance the U.S. electronics manufacturing infrastructure quickly, NEMI first identified key R&D activities that would require the coordination of its members and outside organizations. NEMI created technology roadmaps defining members' expectations for the evolution of these technologies during the next five-year period in terms of performance and related characteristics. Through this process, technology gaps were uncovered in the U.S. electronics manufacturing infrastructure. Accordingly, initial NEMI projects are focusing on the five areas of greatest deficiency: interconnection substrates, board assembly, final assembly, flip-chip packaging, and energy storage systems.

NEMI expects to help maintain a strong U.S. economy by improving the U.S. balance of trade in electronics, by enhancing the commercialization and effectiveness of U.S. R&D programs in electronics, and by improving the business environment for electronics manufacturing. By using product-driven technology roadmapping to improve the communication between government and industry, NEMI plans to focus national efforts on priority areas and increase the return on investment of declining R&D budgets through collaboration in precompetitive areas. NEMI also envisions a corresponding increase in national security by ensuring affordable access to critical military electronics components needed to maintain the superiority of U.S. defense systems.

NIST Advanced Technology Program: Emerging and Enabling Technologies for the 21st Century

■ **Freeing Diabetic Patients from Expensive, Unpleasant Daily Insulin Shots.** A new technology being developed with support from the Advanced Technology Program would provide a better treatment for those suffering from diabetes. Researchers are developing a way to encapsulate insulin-producing cells in microscopic polymeric spheres. These tiny spheres would allow the cells to release insulin through custom-designed pores that would allow nutrients from the bloodstream to enter the cells and metabolic wastes to leave the spheres. This would keep the cells alive while preventing the large proteins that comprise the body's immune system from entering the spheres and rejecting the foreign cells. Such a technology would allow a diabetic patient to receive a single injection of these cells, perhaps once a year. The cells would regulate the body's insulin level just as a properly functioning pancreas does. Though the process is technically challenging, preliminary results are encouraging. If successful, the United States could capture world markets for this revolutionary treatment and significantly reduce health care costs. The same technology might eventually be used to treat other chronic diseases, such as Parkinson's disease.

■ **Lighter Weight, Fuel-Efficient Automobiles.** Automobiles are now manufactured from hundreds of steel parts that are welded together during assembly. For years, people have suggested that lighter weight advanced composite materials would enhance fuel economy and allow for substantial parts integration in the primary automobile manufacturing stages. But today, the cost of manufacturing suitable composites is too high to permit their widespread use in automobiles and other vehicles. A portfolio of ATP projects seeks to reduce these costs dramatically by addressing the manufacturing processes compatible with producing large, high-performance commercial composite structures. The result could be cost-competitive vehicles that are lighter and can be mass-produced in factories that are substantially less expensive to set up and reconfigure for producing a variety of parts.

■ **Error Avoidance and Compensation to Boost U.S. Machine Tool Competitiveness.** ATP support for several projects promises to rejuvenate the competitiveness of the American machine tool industry. Under one project, a radically new architecture—octahedral hexapod design—is being explored and could lead to machine tools that are both less expensive and more accurate. In another project, advanced techniques for error compensation—which involve modeling and quantifying errors, then compensating for them in software—are also beginning to pay dividends. Such efforts would allow the Nation's machine tool makers to increase their world market share, while discrete parts manufacturers who employ the new technology would be able to produce higher quality goods at lower prices.

■ **Virtually Human.** A patient undergoes experimental surgery, comforted by the knowledge that the doctor has performed the procedure countless times. An ATP-supported project is developing a "virtual human"—a three-dimensional geometric database of the body using leading-edge computer modeling and visualization technology. Users would be able to display portions of the body using a computer graphics workstation; remove layers of tissue to reveal underlying structures; display the motion of joints, tendons, and surrounding tissues; and "walk through" cross-sections from any viewpoint. This technology serves as a powerful tool for medical education and training—surgeons will be able to simulate medical procedures repeatedly to ensure proficiency.

■ **Tools for Faster, Less Expensive Software Development.** Software developers have two choices: develop custom software line-by-line or learn the complex interface requirements of modular software libraries. The latter might reduce the need to write custom code, but both are expensive, time-consuming options that require highly skilled programmers to translate business requirements—with which they are not likely to be familiar—into software. This results in high initial and maintenance costs for complex software systems used, for example. for financial services, chemical processing, and manufacturing. By fostering innovative methods for automatic software generation and modular assembly, the portfolio of projects funded under ATP's Component-Based Software (CBS) focused program promises to change the way software is produced. With the CBS approach. software that meets business requirements could be produced much faster. Such tools would allow companies to spend more time solving business problems and less time struggling with the details of getting software to operate properly. Because software is ubiquitous. CBS success in reducing the cost of developing complex software would produce significant economic benefits throughout the U.S. economy.

APPLYING ADVANCED CONCEPTS AND TECHNOLOGIES TO IMPROVE U.S. SHIPBUILDING PRODUCTIVITY

Federal agencies are working with industry to improve shipyard productivity by identifying cost-saving ship design features and production techniques; to implement advanced management and production technologies, such as computer-aided design and flexible automation; and to establish Shipbuilding Extension Centers to assist shipbuilders in applying new technologies, improving business practices, and training their workforce.

ENERGY AND AGRICULTURE TEAM UP FOR TECHNOLOGY INITIATIVE TO BENEFIT U.S. FARMING, FORESTRY, AND FIBER INDUSTRIES

Satellites monitoring crops and rainfall. High-tech insects that destroy nuisance bugs. Biomass research that turns crop waste into fuel. These are just a few of the potential programs that will result from a November 1995 agriculture initiative launched by the Secretaries of the Departments of Energy and Agriculture. The Memorandum of Understanding builds on working relationships already in place in specific areas and generally authorizes research collaboration and joint partnerships with the food, forestry, and fiber industries.

This effort will open the doors of laboratories in both agencies, matching and leveraging the Department of Energy's unique engineering, computational, environmental, and physical sciences skills and resources with those of the Department of Agriculture in the fields of biological and social sciences, as well as knowledge of the industries. These public-private partnerships will lead to new jobs and industries, especially in rural areas; reduced air, water, and soil pollution; decreased reliance on imported oil; and improved quality and safety of America's food. Agriculture and Energy scientists are already working together to develop biofuels and bioproducts, electronic means to detect plant materials during airport baggage inspection, mass-produced beneficial insects to control crop pests, and technology to apply agrichemicals more precisely to minimize environmental impacts.

■ **Partnership for a New Generation of Vehicles.** In the Partnership for a New Generation of Vehicles (PNGV), seven Federal agencies and the Nation's automobile manufacturers and suppliers have teamed up to achieve R&D goals in three areas: advanced manufacturing methods; technologies that can lead to near-term improvements in automobile efficiency, safety, and emissions; and research that could lead to vehicle prototypes with a threefold improvement in fuel efficiency. These super-fuel-efficient family sedan-size vehicles should cost no more to own or operate than today's cars; offer comparable performance, roominess, and utility; and meet or exceed all safety and emissions standards.

PNGV has the potential to boost economic growth by strengthening one of America's most important industries. The motor vehicles and equipment industry is the largest of all U.S. manufacturing sectors. U.S. automakers, dealers, and suppliers directly provide more than 2 million jobs, and more than 13 million people work in related industries. In total, the U.S. auto industry provides one in seven American jobs. However, the tremendous success of the automotive industry has not come without a price. Fuel for ground transportation accounts for 43 percent of our petroleum-based energy demand, contributes to U.S. dependency on foreign sources of oil, and adds to the Nation's trade deficit. Moreover, the nearly 200 million registered trucks, buses, and automobiles in the United States account for a third of the Nation's air pollution.

PNGV will benefit the U.S. automotive industry by establishing manufacturing processes that are less costly and produce higher quality and by developing technologies for the future. At the same time, PNGV can help the Federal government achieve its goals of fuel economy and pollution control.

ENERGY AND ENVIRONMENTAL TECHNOLOGIES: STEWARDSHIP FOR AMERICA'S FUTURE

■ **Remediation Technologies.** The Department of Energy manages the largest environmental stewardship program across the agencies with over 140 sites and facilities in over 30 states and territories. The science and technology to address these major environmental restoration and waste management needs are managed as an aggressive national program of targeted basic science and applied research and development, demonstration, testing, and evaluation of innovation solutions to reduce the cost of remediation; to make otherwise impossible or impractical remediation possible; to provide viable alternatives to unacceptable baseline strategies; and to reduce risk to workers, local populations, and the environment. Examples of innovative technologies that have resulted include: minimum additive waste stabilization; expedited site characterization: horizontal wells; pipe explorer as a radiological and video survey system; and a combination of electro-osmosis with treatment zones for in-situ remediation of soils.

■ **Renewable Energy Sources.** During the past 15 years, the Department of Energy working in partnership with the private sector, has significantly reduced the cost of electricity generated from high-potential renewable energy sources such as biomass, wind, and photovoltaics. Soon these inexhaustible energy resources should lead to a green revolution in the way that energy is produced in the United States. Biomass, for example, already produces eight gigawatts of power in the United States. and advances in biomass gasification and turbine technology could bring biomass power to 4.5 cents per kilowatt-hour within a decade. Similarly, wind power, which is projected to be a $50 billion industry by the year 2020, has decreased in cost by 10 percent a year and many utilities are now receiving long-term bids for electricity from wind at 4.5 cents per kilowatt-hour. The Department has invested heavily in new thin-film technologies for photovoltaic cells, which has lowered the cost of those cells to less than one tenth of what they cost in 1975. Photovoltaics now produce 80 gigawatts of power worldwide and hold the promise of becoming a $100 billion industry by the year 2030.

■ **Environmental Technology Partnership (ETP).** Dramatically reduced energy consumption and pollution from energy and pollution-intensive industries—those are the goals of ETP, which was launched by the Department of Energy in February 1996. Seven industries (chemicals, petroleum refining, forest products, steel, aluminum, glass and metal casting) that consume about 80 percent of the energy and produce over 90 percent of the wastes in the U.S. manufacturing sector were targeted for an integrated program of basic and applied research. ETP will provide the critical data needed to make effective choices in the 21st century to achieve a balance between industrial activity and environmental stewardship. The prudent use of energy will be driving those choices. The response to a call for proposals has been overwhelming. Nearly 750 ideas were suggested by researchers at universities, industrial laboratories and the Department's national laboratories. Approximately 125 of the most promising proposals are undergoing a detailed evaluation, including peer review to judge scientific merit. Awards are scheduled to be made in July 1996. First research results could be reported as early as 1997.

"The Department of Energy's technology partnerships program strengthens the U.S. economy and enhances U.S. economic competitiveness in world markets by leveraging the expertise in the department's laboratories with the dynamism and commercial know-how of the private sector."

Hazel R. O'Leary
Secretary of Energy

Environmental Technology Initiative

The Environmental Technology Initiative (ETI) was announced by President Clinton in his first State of the Union address on February 17, 1993. The ETI promotes technology innovation as a means to better, more reliable, cleaner, and lower cost ways to protect the environment and public health. During 1994 and 1995, the ETI, an interagency effort led by the Environmental Protection Agency (EPA), invested $104 million in 274 projects and partnerships nationwide.

WAYS THAT ETI INVESTMENTS ARE MAKING A DIFFERENCE

Making Technologies "Approvable" by Federal and State Regulators. Many technology companies complain that they can't get customers to buy or use their new technologies based on their own, self-generated data. ETI-funded third party verification programs provide officials with the data necessary to approve the use of new technologies and give technology users the information they need to make informed buying decisions.

Under the ETI-funded Environmental Technology Verification Program, EPA is partnering with public and private organizations to verify the performance of many types of new technologies. Small drinking water systems are evaluated by NSF International, a private sector testing and standards firm. The California Environmental Protection Agency is expanding the country's first state-run technology verification program from a focus on waste clean-up technologies to pollution prevention and waste treatment technologies for the electronics, metal finishing, petroleum refining, and printing industries. Contaminated site characterization and monitoring technologies are being tested by Sandia National Labs, and indoor air products are being tested by the University of Illinois. The Environmental Technology Verification Program is also piloting an independent approach that will proceed without EPA involvement, to assess the effectiveness of a solely private sector-led technology verification program.

Making Cleaner Cars. With ETI funding, the Saturn Corporation in Tennessee is working with the University of Tennessee's Clean Technology center to develop new analytical tools—computer models and software that will help the company identify pollution prevention opportunities, and energy and cost savings throughout its automobile manufacturing processes.

Harnessing the Power of New Information Networks: California's Environmental Technology Leveraging Network Exchange (E-LYNX). EPA, the California Trade and Commerce Agency's Office of Strategic Technology, the Community Environmental Council, the California Small Business Development Centers, the Hoopa Valley Tribe, the California Regional Technology Alliances, members of the California Environmental Business Council, the Rural Community Assistance Corporation, the California Environmental Protection Agency, and the U.S. Department of Energy California Environmental Enterprise are building an on-line/off-line communications and information service for technology developers, users, policy-makers, service providers, regulators, and researchers to consolidate and distribute environmental technology resources for the electronics industry.

Constructed as a user-driven information system, E-LYNX will provide environmental technology companies with information on sources of funding, opportunities to share experiences with other companies, and information on business assistance services available from private and public sources. It will also deliver up-to-date information on where innovative technologies are being used, tested, verified, and certified, and on potential buyers' needs. It will provide a forum where regulators and permit writers can identify targets of opportunity to eliminate policy and regulatory barriers and then move "better, cleaner, cheaper" technologies into the marketplace. E-LYNX will be on-line at a World Wide Web site this year. Systems similar to E-LYNX are being developed in the Northwest and Northeast by other ETI stakeholders.

Creating Jobs at Home Through Environmental Technology Exports. With ETI funding, EPA-New England, the Environmental Business Council, and NALCO Fuel Tech and their partners were able to market $50 million in air quality management technologies and services to the Polish government and several Central European industries. Environmental technology export sales will generate jobs in the United States as NALCO Fuel Tech and their partners serve export market needs.

Keeping Our Air Clean. With ETI funding, EPA is exploring flexible operating permits that meet air quality standards to protect public health while accommodating companies' needs to use new technologies and processes. For example, EPA is working with the State of Connecticut to give CYTEC Industries the ability to meet air quality standards using innovative pollution prevention and control technologies at its specialty chemicals plant in Wallingford, Connecticut—without the cost and delay of having to modify permits with each equipment or manufacturing process change. CYTEC's Wallingford plant employs 600 people, and is the town's fourth- largest employer and second-largest taxpayer. EPA is also working with G.D. Searle Pharmaceutical in Georgia; Lasco Bathware in Washington state; and Rio Grande Portland Cement in New Mexico to advance this approach in other industries.

Promoting Technology Innovation Through Public-Private Partnerships. With ETI funding, EPA's Design for the Environment Program is assisting the Professional Wet Cleaning Partnership (PWCP) in promoting the use of wet cleaning fabric care technology as an alternative to the use of perchloroethylene, the chemical currently used in the dry cleaning industry. The PWCP is a newly formed partnership of industry, union, and environmental groups. Partners include the International Fabricare Institute, the Neighborhood Cleaners Association, the Federation of Korean Drycleaning Associations, the Fabricare Legislative and Regulatory Education Council (FLARE), Greenpeace, the Center for Neighborhood Technology, the Massachusetts Toxics Use Reduction Institute, and the Union of Needletrades, Industrial and Textile Employees (UNITE).

These diverse groups have voluntarily joined forces to encourage the development of professional wet cleaning methods to reduce, to the extent technically feasible, the use of perchloroethylene. This effort will reduce exposures to this hazardous air pollutant among workers and thousands of Americans who live near the Nation's more than 34,000 dry cleaning facilities.

Common Sense Approaches. With ETI funding, EPA, the Department of Energy, and a consortium of metal finishers are working together to reduce toxic emissions in more than 3,000 metal finishing facilities nationwide. One project is working to reduce the uses of chromium, which has long been known to cause lung cancer in occupationally exposed humans. ETI also includes a project with chemical manufacturers to reduce a range of harmful chemical exposures that Americans face in their places of work.

TECHNOLOGY ROADMAP CHARTS CLEANER, CHEAPER, ENERGY-EFFICIENT FUTURE FOR PULP AND PAPER INDUSTRY

The pulp and paper industry's "Agenda 2020" has set out a research vision that is contributing to deliberations with the EPA targeted at meeting environmental goals. This research agenda provides for energy-efficient technologies that will achieve enhanced environmental protection at significantly reduced compliance costs. The industry estimates it may reduce its compliance costs from about $11 billion per year to $3 billion—while competitively producing paper and forest products for the global marketplace.

AMTEX: PARTNERING TO REVITALIZE U.S. TEXTILES

A second "Industrial Revolution" for the U.S. textile industry started with the approval in October 1993 of a cooperative research and development agreement establishing a partnership between the Department of Energy, its National Laboratory system, and the vertically integrated U.S. textile industry. This partnership, called AMTEX, was approved for the benefit of an industry that faces severe global competition. The Department of Energy National Laboratory system, having proven its value at enhancing national energy security and national defense in technology areas such as high-speed computers, communications, and manufacturing automation, was identified as the appropriate partner for technology R&D needed to rebuild a world-class textile industry.

AMTEX covers all phases of fiber, textile, and textile product manufacturing, and integrates best business practices into the fiber and textile economy. Now in the third year of partnership, emphasis is placed upon the development of tools and techniques needed to create an "electronic marketplace" for the textile industry so that U.S. textile businesses can identify and meet customer needs faster and more economically than other suppliers. Emphasis is also placed on technology for energy efficiency and pollution prevention, which will maintain industrial competitiveness, business growth, and job security. AMTEX is the largest partnership between a single industry sector and the Department of Energy, and its demonstrated success provides a model for future R&D partnerships between the public and private sectors.

■ **DOE's Industry of the Future Program.** Sustainable economic growth and environmental improvements are the targets of DOE's Industry of the Future Program. DOE is working in close partnership with America's energy-intensive industries—steel, chemicals, forest and paper products, metal casting, glass, petroleum, aluminum, and textiles—to develop advanced manufacturing technologies for improved process and materials efficiency that will reduce the consumption of energy and resources used in production. These technologies will foster economic growth by improving manufacturing productivity while achieving environmental benefits such as pollution prevention through greater process efficiency. This approach offers large potential economic benefits—manufacturers currently spend about $100 billion on energy and $50 billion on pollution abatement annually. By partnering with industry in the development of industry visions and co-funding the development of energy-efficient technologies, the Industry of the Future Program is helping to reshape the way industry sees itself and its future.

PNGV, the National Environmental Technology Initiative, and the Industry of the Future Program demonstrate an important tenet of the Clinton Administration's technology policy: competitiveness, economic growth, and environmental quality can go hand-in-hand.

FEDERAL MISSION RESEARCH

In the pursuit of its missions, the Federal government is one of the Nation's largest generators of scientific knowledge and technological advancements. The Federal government invests more than $71 billion annually to advance science and develop technologies through government laboratories, universities, and private companies. The results of these government efforts often have significant potential for applications in the commercial sector. At a time of constrained Federal spending and unprecedented global competition in high technology, the United States must take steps to ensure the greatest returns on its public R&D investments.

■ **Technology Transfer.** The 1986 Federal Technology Transfer Act established the framework for partnerships between Federal laboratories and the private sector. Since passage of the act, Federal agencies and their laboratories have worked hard to make technology transfer to the private sector an integral part of their laboratory functions. These efforts have paid off. Between 1992 and 1994, the number of licenses on Federal patents granted to industry nearly doubled, and licensing royalties paid to the Federal government jumped 77 percent to a record $24.5 million annually. Even more important, Federal laboratories have reached out aggressively to the private sector, forming partnerships that allow industry and government to bring complementary assets to bear on research in areas of mutual interest. As a result of these efforts, cooperative research and development agreements between Federal laboratories and industry have soared.

Today, 13 Federal agencies are engaged in more than 3,500 CRADAs with the private sector, an increase of 177 percent since 1992.

■ **NASA's Aeronautics Enterprise.** Aeronautical research and technology play a vital role in promoting U.S. economic growth and national security through safe, superior, and environmentally compatible civilian and military aircraft, and through a safe, efficient national aviation system. However, factors such as growth in air traffic, demanding environmental standards, an aging aircraft fleet, and foreign competition present formidable challenges. The continued safety and productivity of the Nation's air transportation system and future U.S. competitiveness in aeronautics depend on a coordinated and effective national investment in aeronautical research and technology.

■ *Designing faster and more efficient aircraft.*

To help meet these challenges, NASA's Aeronautics Enterprise identifies, develops, verifies, transfers, and encourages the application and commercialization of high-payoff aeronautics technologies. This enterprise works closely with U.S. industry, universities, the Department of Defense, and the Federal Aviation Administration to coordinate R&D investments and ensure that NASA's technology products and services add value, are timely, and have been developed to the level at which customers can confidently make decisions regarding the applications of those technologies. The Aeronautics Enterprise focuses on several goals:

NUCLEAR RESEARCH CONTRIBUTES TO MEDICAL PROGRESS

Major advances in medical research—a legacy of the Department of Energy's work in nuclear energy—include the discovery of most of today's biomedical radioactive tracers (technetium 99m, ionic thallium 201, etc.) and the instrumentation needed to detect the tracers.

In 1992, nearly 11 million nuclear medicine procedures were performed in the United States, and 1991 world sales of medical imaging equipment reached $610 million. Current research programs that hold great promise include accelerator targetry, radiochemistry, radiotracer development, the development of imaging agents, the biochemistry of brain and heart muscle and tissue, substance abuse, and neutron capture therapy.

GOALS FOR A NATIONAL PARTNERSHIP IN AERONAUTICS RESEARCH AND TECHNOLOGY

American firms and workers lead the world in manufacturing aircraft, engines, avionics, and air transportation systems equipment. In the process, they make a major contribution to our nation's security and economy. Today, however, the aeronautics industry faces a number of difficult challenges. The end of the Cold War has permitted a reduction in defense expenditures, including cutbacks in the development of new aircraft and engines. Also, foreign governments have strongly supported their own aeronautics industries through major investments in technology development. We must meet these challenges and maintain leadership in this global industry if we are to retain the national security and economic benefits that derive from aeronautics.

Goals for a National Partnership in Aerospace Research and Technology provides a framework for partnership among the Federal agencies, industry, and academia in aeronautics research and technology development. Three goals define this partnership and will help the U.S. aeronautics industry maintain its global competitiveness:

- Maintain the superiority of U.S. aircraft and engines by pursuing the development of subsonic and high-speed aircraft, improving aircraft design and manufacturing, and maintaining an adequate aeronautics R&D infrastructure.
- Improve the safety, efficiency, and cost effectiveness of the global air transportation system by increasing the air traffic management system's capacity and efficiency, and developing and deploying new technologies that enhance aviation safety and security.
- Ensure the environmental compatibility of aviation by developing and applying technologies that reduce aircraft noise and engine emissions.

- Develop high-payoff technologies for a new generation of environmentally compatible, cost-effective subsonic aircraft and a safe, highly productive global air transportation system.
- Ready the technology base for an economically viable and environmentally friendly high-speed civil transport.
- Ready the technology options for new capabilities in high-performance aircraft.
- Develop and demonstrate technologies for air-breathing hypersonic flight.
- Perform basic aeronautical research, develop advanced concepts, and develop theoretical, experimental, and computational tools—including high-performance computing and information technologies— for advanced aerospace systems.
- Develop, maintain, and operate critical national facilities for aeronautical research that support industry, the Federal Aviation Administration, the Department of Defense, and NASA programs.

To help achieve these goals, the Aeronautics Enterprise is working to forge stronger partnerships with its customers (for example, in program planning and execution). An emphasis on low-cost experimental aircraft will increase flight opportunities. NASA Centers of Excellence focus in-house research, provide single points of contact for management and external customers, and ensure maximum cost effectiveness.

Under the 1958 Space Act, NASA has established more than 3,500 partnerships with industry.

■ **NASA's Space Technology Enterprise.** The National Aeronautics and Space Act of 1958, designed to ensure U.S. preeminence in space, laid a foundation for the excellence that characterizes the U.S. space program today. The act directs NASA to provide leading-edge technologies by improving the usefulness, performance, safety, and efficiency of space vehicles; conducting research and technology development for space-related manufacturing processes; promoting the commercial use of space; and applying NASA's unique competence in scientific and engineering systems. In addition, NASA emphasizes the transfer of space-related technologies from government laboratories to the commercial sector to spur U.S. economic growth and competitiveness.

NASA's Space Technology Enterprise is working to integrate NASA's technology needs and industry's needs in a plan for exploratory research and advanced technology development that will keep the United States on the leading edge of space science and technology. The new technologies that emerge from this partnership will not only reduce the costs of NASA missions and enable new and more challenging missions, they will also enable new commercial products and services that will contribute to job creation.

■ **National Institutes of Health.** Among the many fields of R&D, medicine is one of the very few in which the results of exploratory research are often directly applicable to the development of new products. In other fields, it may take decades to translate such research results into their ultimate uses. NIH has identified five broad research areas that are especially rich in scientific opportunity. These research areas are likely to be exceptionally productive in the near future, yielding knowledge that will contribute in many ways to improved health and quality of life for the Nation.

Research on the *Biology of Brain Disorders* focuses on both the normal developments of the brain and changes that may underlie brain disorders. The studies involve the development and use of animal models, neuroimaging technology, and laboratory and patient-oriented studies. Relevant research topics include pain, addiction, mental illness, neurodegenerative disease, and neurological disorders associated with aging, such as Alzheimer's disease.

Studies of *New Approaches to Pathogenesis* focus on understanding disease mechanisms, the regulation of cell division and cell death, and how cell and tissue injuries result from infection, metabolic abnormalities, genetic deficiencies, or environmental toxins. Specific research topics include bone and connective tissue diseases, autoimmune disorders, virus-cell interactions in AIDS, and cardiomyopathy, to name a few.

PRODUCTS FROM NIH PATENT LICENSING

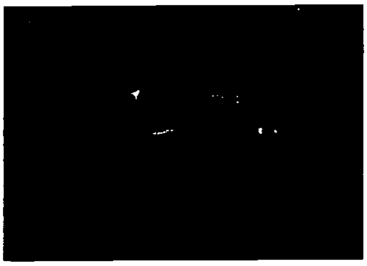
- A simple, accurate, and inexpensive screening test for HIV infection that can also be used to monitor and ensure the safety of public blood supplies.
- Two major therapeutics against HIV infection.
- Vaccines for the prevention of hepatitis A and a drug for the treatment of B-cell chronic leukemia.
- Major advances in flow-through centrifugation used to separate blood components.
- Enhancements to imaging technology.

New Preventive Strategies Against Disease addresses emerging infections, the prevention and treatment of drug and alcohol abuse and eating disorders, as well as the development of vaccines against cancer and infectious diseases such as HIV, otitis media, and herpes. Prevention research also involves the identification and assessment of behavioral, genetic, and environmental risk factors that contribute to disease.

SPACE TECHNOLOGY ENTERPRISE GOALS

- Reduce the cost of access to space.
- Provide innovative technologies to enable ambitious future space missions.
- Build capacity in the U.S. space industry through focused space technology efforts.
- Share the harvest of space endeavors with the U.S. industrial community.

Between 1985 and 1995, NIH was awarded 560 patents and negotiated 713 licenses to develop commercial applications based on those patents. Accumulated sales of products developed under these licenses are estimated to be $2 billion and have generated more than $100 million in royalty income. Over the same period, NIH intramural scientists negotiated 269 CRADAs with private organizations. The $100 million in royalty income plus more than $31 million in industry resources brought in through CRADA collaborations stimulate and support additional research and product development at NIH.



■ *Using a confocal light microscope in the laboratory.*

Genetic Medicine research includes, for example, the sequencing and analysis of the human genome, investigations that may lead to the development and testing of gene therapies for a variety of human disorders, and studies of the intricate and multiple genetic interactions that underlie complex disorders such as obesity and mental illnesses. This research holds great promise for new insights and approaches to treating and preventing a wide range of diseases.

Studies aimed at the development and improvement of *Advanced Instrumentation and Computers in Medicine and Research* include novel imaging technologies that will assist in disease diagnosis, treatment, and prevention. They also will assist laboratory studies in fields such as cellular and structural biology, disciplines that yield essential knowledge of basic life processes as well as more applied knowledge for drug design. Telemedicine and shared instrumentation programs are important components of this research category.

■ **Biotechnology.** Biotechnology promises to have a profound impact on health care, agriculture, energy, and environmental management. Worldwide annual sales of this burgeoning industry are projected to reach $50 billion by the year 2000. The development and production of biotechnology products will create thousands of new jobs, promote economic growth, and help address agricultural, environmental, and health concerns.

The Biotechnology Industry Organization reports that, before 1970, there were only 93 U.S. biotech companies. By 1995, there were 1,308 companies employing 108,000 people in the United States and generating $12.7 billion. Jobs in this industry are expected to reach 500,000 by the year 2000.

The United States now holds a competitive edge in biotechnology thanks to significant investment in health research. Japan and the European Union, however, have made achieving a leadership role in biotechnology by the year 2000 a priority. Each nation is effectively coordinating its public and private investments in biotechnology, establishing a strong government-supported technology transfer infrastructure in partnership with industry and the academic community.

In the United States, the Federal government has played an important role in advancing this embryonic technology. The National Institutes of Health supported the cloning of the first gene in 1973, the development of DNA sequencing, and the initial groundbreaking experiments in recombinant DNA genetics.

More than 1,000 clinical trials are currently in progress using biotechnology-derived pharmaceuticals, and over 700 biotechnology-derived diagnostic devices are currently being used in clinical practice.

Today, 13 Federal agencies are engaged in biotechnology research in a broad array of areas such as agriculture, energy, the environment, health, and manufacturing/bioprocessing. Research activities seek to meet both economic and social goals, including transferring biotechnology research discoveries to commercial applications, improving the benefits of biotechnology to the health and well-being of the population, and protecting and restoring the environment.

■ **Small Business Innovation Research Program.** The Small Business Innovation Research Program (SBIR) encourages small businesses to participate in Federal mission-related R&D and to take commercially promising technology to market. Under SBIR, now authorized until the year 2000, each government agency and Federal laboratory with more than $100 million in extramural research funds is required to set aside a percentage (now 2 percent; scheduled to rise to 2.5 percent in 1997) of those funds to be awarded competitively to small businesses.

SBIR is a three-phase program administered independently by each of 11 participating agencies. Agencies invite eligible small businesses to propose innovative ideas that meet the specific research and development needs of the Federal government. SBIR proposals are competitively selected and accepted on the basis of specific topics proposed by the participating agencies.

Phase I of the program provides funding to evaluate the scientific and technical merit and feasibility of an idea. Under Phase II, projects with the most potential are funded to further develop the proposed idea for one or two years. Phase III is the period in which an innovation is brought to market through private sector investment and support.

SBIR awards have enabled thousands of small firms to undertake research projects, create new and innovative technologies, and sell competitive products.

AN SBIR SUCCESS STORY
SAVITAGS: GLOBAL TRACKING OF MATERIAL

More than two-thirds of the intermodal containers shipped to the Persian Gulf during Operation Desert Storm had to be opened and checked to determine what was inside. But a new technology developed by Savi Technology of Mountain View, California, under a Navy Small Business Innovation Research project may go a long way toward solving this problem for the military—and for commercial transporters across the globe.

The SaviTag is a small electronic device that enables tagged items to be monitored and tracked automatically anywhere around the world. In essence, the SaviTags offer wireless computing in the shape of a tag. Each tag incorporates a miniature radio transmitter, radio receiver, and microcomputer in a compact package about the size of a deck of playing cards. The SaviTag is programmable, allowing it to be adapted for a wide variety of applications.

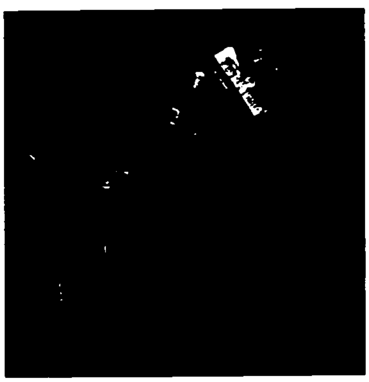
SaviTags can be located by satellite and can identify thousands of items in transit or stored over a wide area in minutes, with the location and identity of an item displayed by icon on a computer map. In addition to its defense applications in tracking hazardous material and munitions between Europe and the United States and in tracking equipment and materiel in and out of Somalia, Bosnia, Haiti, and Korea, the SaviTags have been used for automatic trailer-level receiving and sealing for one of the world's largest commercial package shippers, tracking jet engine parts in a major remanufacturing facility, and automatic tracking and invoicing of the delivery of road construction material for the Alberta, Canada, Department of Transportation. The SaviTag system can also be used for just-in-time distribution through truck, sea, and rail hubs.

DISSEMINATION OF TECHNICAL INFORMATION

Economic growth and industrial competitiveness do not stem simply or automatically from the development of new ideas. Growth occurs because advances in knowledge are put to work in the private sector. However, technology diffusion can be a slow and uncertain process in the United States, highlighting the need for more effective mechanisms for deploying scientific, technical, and other information. In today's rapidly changing business environment, it is essential that firms have the latest information on, for example, promising government research, and more competitive manufacturing and management practices. The Clinton Administration is expanding the private sector's access to this critical knowledge.

■ **Manufacturing Extension Partnership.** New manufacturing technologies and approaches are available that can lead to dramatic improvements in product quality, cost, and time-to-market. With the exception of a small number of market leaders, most U.S. firms have been slow to adopt these new technologies and approaches—especially America's 381,000 small and medium-sized manufacturers. These establishments form the backbone of the U.S. industrial base and represent about 95 percent of U.S. manufacturing plants. Millions of jobs rest on their competitive performance.

Many of these manufacturers lack awareness of changing technology, production techniques, and business management practices. Owners and managers of small companies may have difficulty in finding high-quality, unbiased information, advice, and assistance. Also, smaller firms often work in isolation and lack opportunities to learn from other companies in similar situations. Currently available public and private sources of assistance are fragmented and vary greatly in breadth, depth of service, and quality. In addition, they reach only a small fraction of the small and medium-sized manufacturers whose existence is threatened by continued reliance on outdated technology, production methods, and management practices.



■ *Manufacturing industrial gears and speed reducers.*

To accelerate and expand the adoption of manufacturing innovations, the Clinton Administration has set a goal of establishing a nationwide network of 75 manufacturing extension centers by 1997 to assist small and medium-sized manufacturers to modernize their production capability. Led by the Commerce Department's National Institute of Standards and Technology, this Manufacturing Extension Partnership is designed to help smaller firms upgrade their equipment, improve their processes, and strengthen their business performance.

■ **National Technical Information Service.** In the course of advancing R&D, the Federal government generates a tremendous array of scientific and technical information of potential value to the private sector. For more than 50 years, the National Technical Information Service (NTIS)—a self-sustaining agency of the U.S. Department of Commerce—has ensured public access to the results of taxpayer-funded R&D.

Today, more than ever, NTIS fulfills an essential role in diffusing commercially valuable technical information to researchers in firms and universities around the Nation. NTIS currently maintains more than 2.6 million documents and adds 100,000 documents to the collection each year.

NTIS FedWorld provides dial-up and Internet access to customers (more than 1 million to date) who can tap a wide range of government information services and bulletin boards, providing the public with better, more timely access to government resources through a "one-stop" electronic shopping mall.

A report from the U.S. General Accounting Office calls the Malcolm Baldrige National Quality Award criteria "the most widely accepted formal definition of what constitutes a total quality management company."

Members of the Baldrige Board of Examiners have delivered more than 10,000 presentations on quality management and the award program. Baldrige winners have given approximately 30,000 presentations, reaching thousands of organizations.

■ **Malcolm Baldrige National Quality Award.** In addition to technology, the adoption of management innovations is essential to the competitiveness of U.S. business and industry. The Malcolm Baldrige National Quality Award, developed and managed by the Commerce Department with the cooperation and financial support of the private sector, has become both the U.S. standard of quality achievement and a comprehensive guide to quality improvement. The award program recognizes those firms that have achieved the highest levels of quality management in manufacturing, service, and small business.

Equally important, the Baldrige Award guidelines—of which more than 1 million copies have been distributed to date—provide a framework for quality improvement efforts in American industry, academia, government, and non-profit organizations. The guidelines establish evaluation criteria for quality management and performance in seven key areas: leadership, information and analysis, strategic quality planning, human resource development and management, management of process quality, quality and operational results, and customer focus and satisfaction.

INFRASTRUCTURE TO SUPPORT INDUSTRY AND FACILITATE COMMERCE

Goal 3

Invest in a world-class infrastructure to support U.S. industry and facilitate commerce.

America's superior infrastructure—our roads and highways, seaports and airports, telecommunications and power systems—has provided American firms with a competitive edge throughout this century. While these are still essential elements of American commerce, new kinds of infrastructure and innovative ways of managing and using existing facilities are needed to preserve America's edge in the new knowledge-based economy and to improve our quality of life.

■ **National Information Infrastructure.** The role of information in all facets of society is growing. For business and industry, information links producers, suppliers, service providers, freight carriers, distributors, and customers in an ever-tightening network of commercial activity. Information also ties R&D, production, and marketing into a seamless innovation process, whether these functions reside within or outside the company. Advanced technologies are essential for the efficient management and use of this information.

NATIONAL INFORMATION INFRASTRUCTURE GUIDING PRINCIPLES

- Promote private sector investment.
- Extend the "universal service" concept to ensure that information resources are available to all Americans at affordable prices.
- Promote technological innovation and new applications.
- Promote seamless, interactive, user-driven operation of the NII.
- Ensure network information security and network reliability.
- Improve management of the radio frequency spectrum.
- Protect intellectual property rights.
- Coordinate with other levels of government and with other nations.
- Provide access to government information and improve government procurement.

In 1993, the Administration articulated its vision for a National Information Infrastructure (NII)—a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. Development of the NII will help unleash an information revolution that will change forever the way people live, work, and interact with one another. Turning this vision into reality will propel scientific inquiry and discovery, business productivity, and the education of our people.

Private firms are leading this revolution today through the development and deployment of the infrastructure. Nevertheless, there remain essential roles for government in this process. Carefully crafted government actions will complement and enhance the efforts of the private sector and ensure the growth of an information infrastructure available to all Americans at reasonable cost.

To help communities and non-profit organizations enter the Information Age, the Commerce Department's Telecommunications Information Infrastructure Assistance Program provides competitively awarded matching grants to school districts, libraries, state and local governments, health care providers, universities, and other non-profit organizations to connect institutions to existing networks, to enhance those networks, and to permit users to interconnect among different networks.

■ *Direct user access kiosks give the public a way to immediately and individually interact with information systems, such as government or banking systems.*

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INTELLIGENT INFRASTRUCTURE: MOVING AMERICA INTO THE 21ST CENTURY

"It's our turn to commit to building the next frontier in surface transportation. And that frontier will be in the Information Age. If tens of millions of Americans can surf the information superhighways, why can't 175 million drive on high-tech highways?"

Federico Peña
Secretary of Transportation

Under the Intelligent Transportation Initiative, the Federal government is working with state and local governments and the private sector to foster the deployment of a core information infrastructure in 75 of the Nation's largest metropolitan areas. This foundation will support traffic control centers that manage operation of all major area roads, provide real-time information to motorists and other travelers, and identify and respond to breakdowns and accidents immediately. The result is expected to be a 15 percent savings in travel time at a small fraction of the cost of new physical infrastructure that would achieve the same increase in system capacity.

The Department of Transportation Intelligent Transportation Systems Program is encouraging the application of core communications, computer, and sensing technologies to many transportation functions, including highway traffic management, in-vehicle navigation systems, nationwide management of truck fleets, paperless non-stop crossing of state and national borders, and availability of comprehensive information to travelers.

In March 1994, Vice President Gore introduced the U.S. vision for an international corollary to the NII—the Global Information Infrastructure—at a meeting of the International Telecommunication Union in Buenos Aires. Because information crosses state, regional, and national boundaries, coordination is important to avoid the establishment of unnecessary obstacles and to eliminate unfair policies that handicap U.S. industry. Like the vision for the NII, the GII is directed at promoting competition, creating flexible regulatory policies, ensuring universal service, and providing open access to the network for all information providers and users.

■ **High-Performance Computing and Communications.** The High-Performance Computing and Communications (HPCC) initiative is an essential element of the Administration's NII efforts. HPCC funds R&D into more powerful computers, faster computer networks, and more sophisticated software. The advanced technologies derived from HPCC research have broad technical, business, economic, environmental, public safety, and military applications. The program is also developing and applying HPCC networking technologies for use in the fields of health care, education, libraries, manufacturing, and the provision of government information.

■ **National Institute of Standards and Technology.** Establishing the Federal government's responsibility to "fix the standard of weights and measures" as a constitutional provision, the framers of the Constitution understood that measurements and standards are indispensable to the Nation's industrial foundation and ability to conduct commerce. The Commerce Department's National Institute of Standards and Technology (NIST) helps fulfill this responsibility through its world-class laboratory programs. NIST works with U.S. industry in areas such as manufacturing, materials, electronics, chemical processing, construction, and information technology focusing on measurement methods, standards, evaluated data, and test methods. NIST also works with national and international standards-setting organizations to stimulate U.S. commerce and help U.S. industry understand and comply with foreign standards, regulations, and procedures.

AMERICA CAN COUNT ON NIST LABORATORIES

As the ball fell in Times Square, America counted down the final seconds of 1995—and in doing so Americans literally counted on the Commerce Department's National Institute of Standards and Technology, which had calibrated the clock to ensure the New Year was celebrated on time—not too early, not too late. But, in truth, America has counted on NIST since its founding nearly a century ago as the National Bureau of Standards (NBS). American industry and the public have relied on NIST for a broad range of research and services in technology, measurements, and standards since 1901.

Today, NIST efforts help ensure fairness and efficiency in the sale of more than $2 trillion worth of goods and services. Knowing that measurements of weight, size, and volume are accurate and uniform promotes customer confidence in the sale of goods ranging from lunch meat at the deli counter to natural gas flowing through transnational pipelines to ultrapure gases purchased by semiconductor manufacturers.

American companies, small and large, depend upon NIST tools and services for hundreds of millions of measurements made daily:

- More than 350 different NIST-developed measurement tools and services are embedded in the quality control systems of the automotive industry—from small metal parts suppliers to large refiners of gas and oil.
- Virtually all U.S. semiconductor manufacturers depend on NIST-developed test methods to evaluate their raw materials, processes, and products.
- The entire U.S. steel industry relies on more than 125 NIST Standard Reference Materials in assessing the quality of raw materials and finished products.
- Billions of dollars worth of electric power are measured more accurately because NIST maintains the national watt-hour standard and conducts research to improve the accuracy of standards for calibrating watt-hour meters.

NIST has also contributed to America's economic growth, defense, safety, and quality of life in countless other ways:

- **Saving Lives.** NIST-developed smoke detector performance requirements, installation guidelines, and studies played an essential role in dramatically reducing the fire death rate in the United States, contributed to the establishment of a $100 million U.S. residential smoke detector market, and enabled U.S. manufacturers to acquire a 50 percent share of the world market.
- **Improving Television for the Deaf.** A system called TV Time, created by NIST engineers, allowed time for frequency information to be broadcast on TV channels without disturbing regular shows, leading to the closed captioning system for the deaf.
- **Fighting Crime.** NIST developed the computerized system the Federal Bureau of Investigation uses to match fingerprint evidence against 30 million records so that local police can identify and arrest suspects.
- **Lighting up the Night.** The first neon tube, which later formed the basis for a new industry, was developed at NIST in 1904.
- **Tuning in Tunes at Home.** NIST developed the first "crystal rectification filter circuit" unit, enabling radios to operate on household current.
- **Smile, This Won't Hurt...as Much.** For decades, NIST has maintained a partnership with the American Dental Association to advance the state of dentistry. This enduring relationship has produced quality dental materials and procedures. One of the most significant accomplishments was the development of the high-speed dental drill, the device that in the late 1950s replaced its slow and often torturous predecessor in dentists' offices across the Nation.
- **Supporting Industry, Defending the Nation.** Before World War I, U.S. industry had relied on precision gauge blocks imported from Europe. During the war, NBS produced the precision gauge blocks needed for the manufacture of interchangeable parts. In doing so, NBS contributed to the war effort and freed American industry from an area of foreign technical dependence.

SURFING THE NET—FROM ARPANET TO INTERNET...AND BEYOND

Thirty-five years ago, U.S. war planners undertook an effort to ensure the survivability of America's computing and communications capabilities in a nuclear first strike to preserve a credible U.S. retaliatory capability. From this initiative the first network, ARPAnet, was established, allowing geographically separated researchers to share computer resources and laying the foundation for today's Information Superhighway.

In the early 1980s, the National Science Foundation (NSF) recognized ARPAnet's tremendous potential for facilitating the exchange of ideas and information among computer science researchers and funded the connection of university research centers across the Nation to the ARPA Internet. In the mid-1980s, NSF extended Internet access to other scientific communities. In addition, NSF stimulated broader use of the network by providing limited access, via the Internet, to its supercomputer centers.

In 1988, NSF and Merit, Inc. placed a higher speed backbone into operation, fielding an advanced network called NSFNET. This backbone, together with federally supported regional networks, vastly expanded the number and type of network users, setting the stage for today's explosive growth of the Internet.

Today, the Internet serves as the core of a growing National Information Infrastructure that is reshaping our economy, our jobs, and the way we live. Millions of Americans are now "surfing the net"—exchanging thoughts, gathering information, and conducting research. And the number of users continues to rise at a meteoric pace. In 1995, the number of Internet users grew at a monthly rate of 7 percent, more than doubling in size over the course of the year. In January 1995, *Information Week* estimated the number of users at 20 million; by March, the number was 25 million according to *Inc.* magazine; and by April, *Business Week* had the count at 30 million. CompuServe and America Online alone are reportedly adding more than 2,500 new subscribers a day, and 30 to 50 percent annual membership growth is projected through the end of the decade. At this astounding pace, analysts at Ernst and Young estimate that every household in Europe will be linked to the Internet by 2005, while in America every person in the household will have a link.

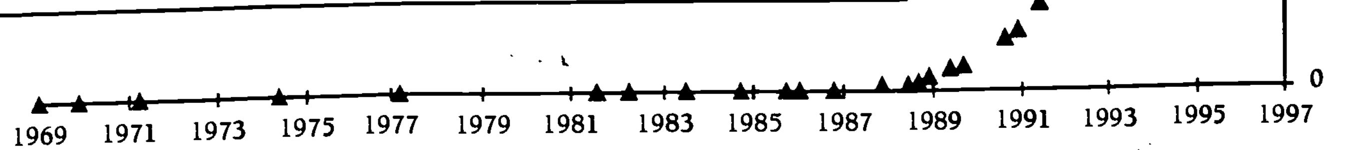
Despite its growth, however, Americans are only beginning to tap the full potential of the Information Superhighway—companies are exploring its value as a strategic business tool and for conducting electronic commerce; hospitals and doctors are experimenting with new ways of delivering health care; schools are discovering how the Internet can be used to better educate our children; Federal, state, and local governments are developing new means for delivering services more efficiently; and libraries are learning how to overcome geographic borders to make their resources available to all.

The economic impact of an accelerated deployment of the NII has been estimated to increase U.S. GDP by $100 to $300 billion by 2007.

All Americans have a stake in the evolution of the NII, a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips and forever change the way we live, work, and interact with one another.

Internet Hosts Show Explosive Growth

While the actual number of Internet users is uncertain, the number of "hosts"—computers from which information can be obtained over the Internet—serves as a measure of Internet growth. As illustrated by the graph below, the number of Internet hosts has grown exponentially since 1969.



Source: Hobbes' Internet Timeline/Network Wizards, Internet Domain Survey; data available at http://www.nw.com/

■ **U.S. Patent and Trademark Office.** For more than 200 years, the U.S. Patent and Trademark Office has promoted technological progress by issuing patents to enable inventors to secure for limited times the exclusive right to their discoveries, as envisioned by the framers of the Constitution. As a result, American industry has flourished, new products have been invented, new uses for old products discovered, and employment opportunities created for millions of Americans.

In addition to issuing patents, the U.S. Patent and Trademark Office examines existing legal regimes in the United States and determines if they are adequate to meet the needs of our inventors, creators, and businesses in the 21st century. For example, the NII has tremendous potential to enhance the quality of our lives and create new sources of economic growth and opportunity, but only if effective protection is extended to education, information, and entertainment products when these works are disseminated electronically. Owners of intellectual property will not put their investments at risk in the NII unless appropriate systems for protection are in place. Likewise, the public will not use the services available on the NII and generate the market necessary for its success unless a variety of works are available under reasonable terms and conditions, and the integrity of those works is ensured.

The U.S. Patent and Trademark Office advocates improvements to legal regimes in other countries to ensure that American inventors, creators, and businesses are adequately protected. Efforts are conducted multilaterally and bilaterally.

ADVANCED TECHNOLOGIES FOR ENVIRONMENTAL MONITORING AND TIMELY WARNING IMPROVE PUBLIC SAFETY AND REDUCE COSTS

Each year, hundreds of lives and billions of dollars are lost due to severe weather conditions that could be predicted minutes to months in advance. Significant improvements to short-term forecast and warning products—technologies that will enhance the Nation's ability to observe, understand, and model the environment and to disseminate products and services to users more effectively—are a national priority. The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) is currently developing an integrated environmental observation, assessment, and forecast service that will improve public safety, economic growth, and environmental security. For example, better hurricane-track forecasts have the potential to save lives and to reduce evacuation costs, estimated at hundreds of thousands of dollars per mile of coastline evacuated. Better seasonal forecasts will produce immediate economic benefits, especially in the agriculture and water resource management sectors. Monitoring, assessment, and research on climate change will provide the basis for long-range forecasts of ten years or more with sufficient scientific credibility to support governmental and industrial decisions.

Cooperation among Federal agencies and the private sector is reducing risks to aviation safety posed by volcanic eruptions. Volcanic ash is hazardous to modern jet aircraft; it can erode compressor blades, melt onto critical engine parts, and cause loss of engine power. Worldwide, some 80 jet aircraft in the past 15 years have accidentally entered volcanic ash, putting thousands of passengers at risk and causing at least $400 million in aircraft damage. A dramatic example of the stakes involved occurred in 1989, when a KLM Boeing 747 jet flew through volcanic ash that had erupted from Alaska's Redoubt Volcano. The plane lost power to all four engines on approach to Anchorage International Airport, and nearly crashed before landing. Aircraft repairs cost more than $80 million. To help air traffic controllers and pilots avoid ash clouds, the U.S. Geological Survey, the National Weather Service, and the Federal Aviation Administration (FAA) developed new procedures to speed eruption information to commercial and military aviation. The FAA uses eruption warnings from the Geological Survey and information on ash cloud paths tracked by satellite by the Weather Service to alert pilots and air traffic controllers. Planes can then be rerouted around ash clouds safely and efficiently. For example, timely warnings during three eruptions of Alaska's Mount Spurr Volcano in 1992 allowed planes to be rerouted to safety, kept flight cancellations at Anchorage airport to a minimum, and prevented aircraft damage.

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Leading-Edge Transportation Technologies Are Saving Lives, Time, and Money

America's transportation system comprises a growing network of highways, transit systems, railroads, waterways, airports, seaports, and pipelines that is critical to the Nation's vitality and economic well-being. In all, transportation in the United States accounts for 17 percent of GDP, or about $1 trillion a year. What's more, transportation's vast capital stock—the physical infrastructure—is worth some $2.4 trillion to the Nation.

Technology is essential to the health of our transportation system and of our nation. Innovations in transportation contribute to America's economic growth and national security. They enhance our environment and our local communities. And, perhaps most important, they save lives and reduce the risk of accidents and injuries.

- **Saving Time, Saving Lives.** Americans lose 2 billion hours a year to gridlock. The Transportation Department's Operation TimeSaver is aimed at cutting travel times by at least 15 percent and reducing the number of highway incidents. This program challenges state and local transportation agencies to invest in an arsenal of new technological tools to keep the flow of people and goods moving more smoothly, safely, and with less impact on the environment. Many communities are already reaping benefits from these new technologies. For example, Lexington, Kentucky, computerized its traffic signals and reduced stop-and-go traffic by 40 percent. Using an adaptive freeway control system, Minneapolis increased freeway speeds by 35 percent and cut accidents by a quarter. In Baltimore automatic vehicle locators on buses have improved on-time performance by 23 percent. And thanks to new automated toll collectors, traffic on New York's Tappan Zee Bridge went from a crawl to more than 25 miles per hour.

- **Making Driving Safer.** The work of the Transportation Department's National Highway Traffic Safety Administration (NHTSA) has yielded numerous technologies that make our roads and cars safer. Among the technologies that have contributed to a 50 percent reduction in the traffic fatality rate since 1970 are antilock brakes, air bags, and improved automobile structures. Today, NHTSA is working on a "smart," affordable crash sensor that will help drivers avoid dangerous collisions. NHTSA also is ensuring the safety of the next generation of vehicles developed under the Partnership for a New Generation of Vehicles.

- **More than Fixing Potholes.** Construction and maintenance of the highway system costs the Nation about $80 billion per year. Technologies now in use have the potential to increase the useful life of our highways and bridges dramatically, reducing maintenance costs and often eliminating the need for new construction. For example, the Federal Highway Administration's (FHWA) "Smart Inspector" is a unique bridge inspection tool that enables rapid and safe inspection of bridges using the latest portable computing, voice recording, processing, and display technologies. The FHWA also is evaluating the use of recycled solid waste materials—including steel slags, rubber tires, crushed glass, roof tiles, and recycled plastics—for everything from patching potholes to controlling ice.

- **Combatting Terrorism.** The Federal Aviation Administration has worked long and hard to keep our airports and air travelers safe from terrorists and other threats. Among the technologies that have helped ensure airport security are portals that detect weapons on passengers and "bomb sniffers" that locate explosives in checked baggage. The FAA is now developing improved systems for detecting explosives, both on passengers and in baggage. The focus is on two basic technologies: trace detectors that identify trace emissions from different explosives, indicating their presence, and bulk detectors that use electromagnetic energy or nuclear radiation to penetrate and identify explosives based on their elemental or structural composition.

- **Bringing Travelers into the Space Age.** The Global Positioning System (GPS) is a satellite-based radionavigation system originally developed by the Department of Defense. Today, commercial uses of the system far outnumber military applications. GPS is now guiding everything from sailboats to supertankers. A system developed by the U.S. Coast Guard allows ships and boats with GPS receivers to navigate their way into America's harbors more accurately and more safely. The FAA is building a network of ground stations that will enable GPS-based navigation for all phases of flight, making plane trips shorter and reducing costly flight delays. Working with the railroad companies, the Federal Railroad Administration is pursuing pilot projects to incorporate GPS into advanced train control systems that would prevent railroad accidents and injuries costing approximately $35 million a year. Finally, as a critical component of the Transportation Department's Operation TimeSaver program, GPS is allowing local traffic control centers to monitor the location of transit buses, emergency vehicles, and police cruisers.

■ **Detecting Windshear.** A severe weather phenomenon known as "windshear" can wreak havoc on planes during takeoffs and landings, when they are close to their minimum flying speeds and altitudes. Windshear—sudden changes in wind speed and direction found in storms called "microbursts"—has been found responsible for more than half of all airline fatalities over a ten-year period. In the past, windshear has struck with little or no warning. But NASA has developed and tested technology to detect these invisible but extremely hazardous winds miles ahead of an aircraft. NASA developed the pilot's alerting requirements and procedures, and conducted studies to assess the potential for microwave radar, lidar (laser radar), and infrared to detect the hazard. These technologies have proven capable of detecting hazardous windshear conditions. After several years of development, NASA began flight testing the prototype windshear sensor systems in 1991. On November 30, 1994, Continental Airlines Flight 1637 departed Washington's National Airport equipped, for the first time, with an airborne detection system capable of providing the cockpit crew with up to 90 seconds advance notice of windshear activity. Several U.S. companies are commercializing these technologies.

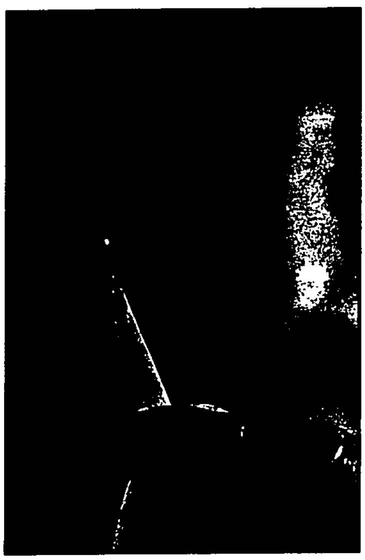
■ **Aviation Deicing.** For almost 40 years, airlines have deiced planes by spraying them with glycol. This creates excessive time delays for the airlines, and glycol runoff poses environmental problems. A new deicing system—being demonstrated under the Energy Department's National Industrial Competitiveness Through Energy, Environment, and Economics Program—could solve these problems. The Whisper Wash™, roughly analogous to a car wash, provides a portable adjustable structure that aircraft can taxi through for deicing en route to the takeoff runway. The system delivers heated compressed air for deicing along with precise amounts of glycol for anti-icing. Excess fluid is collected and stored for off-site filtering and distillation for possible use in other applications. The Whisper Wash™ is placed close to the end of the departure runway to minimize the time between treatment and takeoff, a significant improvement over current methods in which aircraft are primarily deiced at the departure gate. At many airports, the taxi time from gate to runway can exceed the safety margins for ice buildup and force a plane to return for another treatment. One Whisper Wash™ can service the same number of planes as 24 deicing trucks. The aviation and heating fuel savings and glycol reduction are estimated to reduce the annual cost of operations for a typical airport by $14 million.

■ **High-Tech Transit.** With the support of the Federal Transit Administration (FTA), new transit buses are on the horizon that are cleaner, more efficient, and more accessible than conventional buses. The FTA has already developed a prototype hybrid electric bus that runs on both diesel and electricity and has completed the initial design of a second bus, the Advanced Technology Transit Bus (ATTB). The ATTB is the first bus to meet clean air, weight, and accessibility requirements while improving performance and reducing operating costs for transit agencies. A third type of bus currently under development is an advanced battery-operated bus.

■ **Keep on Truckin'.** The American trucking industry could receive a boost in productivity from a public-private research effort designed to keep things rolling. Currently, long-haul trucking operates under an array of Federal, state, and local regulations that govern cargo weight, fuel taxes and fuel usage, vehicle safety, driver performance and working hours, and licensing and registration. As a result, trucks can be subjected to numerous inspections and stops during the course of a long-distance journey. This contributes to a reduction in efficiency and an increase in total costs and time required for freight movement. A potential solution can be found in the Commercial Vehicle Operations (CVO) segment of the Intelligent Transportation Systems Program, which applies advances in electronics, communications, and information technologies to the Nation's surface transportation system. CVO's HELP (Heavy Vehicle Electronic License Plate) program is a multistate, multinational research effort to design and test an integrated heavy vehicle monitoring system that combines automatic vehicle identification, automatic vehicle classification, and weigh-in-motion capabilities. The use of such information in intermodal freight movements is now being applied to ensure seamless movement of shipments onto trains, through ports to ships, to highway vehicles, and on to the final recipient. Conrail is now actively pursuing this technology.

Goal 4

Promote integration of the military and civilian industrial bases.



■ *A tiny experimental recording head that records 3 billion bits of information–3 gigabits–in just a square inch of a hard disk.*

INTEGRATION OF MILITARY AND CIVILIAN INDUSTRIAL BASES

Science and technology play a critical role in the national defense, allowing the U.S. Armed Forces to counter military threats, overcome advantages that adversaries may seek, and reduce collateral damage during wartime. With the end of the Cold War, defense spending is in decline. Today, commercial technology development often leads defense R&D, making the technology base that propels the economy increasingly crucial for national defense. Many leading-edge technologies that provide our military with a battlefield advantage—software, computers, semiconductors, telecommunications, and manufacturing technologies—are being driven by rapidly changing commercial markets.

In the past, it was common to think of technologies as spinning off from military development to civilian markets. Today, many technologies have dual-use applications in both military and commercial products, such as polymer matrix composites for airframe structures, optoelectronics for advanced computers, flat-panel displays, and digital wireless communications. And technologies are increasingly "spinning on," with commercial technologies being modified for military applications. While some technologies remain exclusively or near-exclusively military, many technologies originate in the commercial sector, with the Defense Department representing only a small fraction of the total world market.

For all these reasons, the United States cannot afford to maintain distinct military and civilian industrial bases. Instead, the United States must tap a dynamic commercial marketplace for new technologies, providing a more sophisticated and powerful military defense at a lower cost to the American taxpayer.

Barriers have grown between the two industrial bases as special defense requirements and business practices increasingly segregated the military sector of the industrial base from the civilian sector. Defense Department procurement regulations, accounting standards, and military specifications have acted as a wall between these two industrial bases, discouraging the sharing of human resources, facilities, technologies, and production lines that offers cost savings and efficiencies through economies of scale and scope.

The Administration's initiatives in dual-use technologies and acquisition reform are designed to remove many of these barriers and assist in the integration of the Nation's military and civilian industrial bases into an industrial base capable of meeting both defense and commercial requirements. This will allow the Department of Defense to exploit the rapid rate of innovation and market-driven efficiencies of commercial industry to meet defense needs at lower cost. Conversely, the innovation and accomplishments that originate in defense programs and laboratories will move rapidly to the commercial sector.

■ **Dual-Use Technologies.** The dual-use strategy rests on three pillars: dual-use R&D to exploit the potential of advanced commercial technologies to meet defense needs; integration of commercial and military production to enable industry to "dual produce"; and insertion of commercial products, processes, and technologies into defense systems wherever possible. This strategy is designed to improve access to leading-edge technology, reduce the cost of advanced defense technologies, and provide the ability to quickly enhance military capabilities to a higher level, if necessary.

The Technology Reinvestment Project (TRP), run by the (Defense) Advanced Research Projects Agency, was the Defense Department's first major dual-use technology program. The TRP awarded nearly $1 billion during a series of competitions held in 1993–1995. Because industry was required to pay at least half of the cost of every TRP project, the government's investment is leveraging several billion dollars of R&D. In addition to advances in composite aircraft structures and detection of chemical/biological agents, TRP-supported projects are developing promising dual-use technologies in a range of critical defense areas, including:

- **Low-Cost Night Vision.** U.S. troops will be able to "own the night" through widespread use of infrared sensors made ten times cheaper by leveraging new commercial technology.
- **High-Density Data Storage Devices.** Vast increases in portable, low-cost data storage will give our frontline soldiers access to the best information and intelligence.
- **Battlefield Casualty Treatment.** New sensors and information systems will greatly improve the ability to find and diagnose injured combatants during the critical first hour they are down in the field.

Although no further TRP competitions are planned, the Department of Defense has requested fiscal year 1997 funding of $250 million for a new Dual-use Applications Program. This program will have increased involvement by the military services both to accelerate "insertion" of specific dual-use technologies into weapon systems and to promote broader service acceptance of the dual-use approach.

In the area of dual production, the Defense Department's partnerships are already helping develop commercial applications for advanced military technologies as a way to lower costs. For example, a few years ago, the Defense Department pursued microwave monolithic integrated circuit (MIMIC) technology as a strictly military development, but the high cost prohibited widespread use of the devices. MIMICs are advanced gallium arsenide semiconductors used for military radar. Defense now encourages MIMIC contractors to pursue commercial applications—in collision avoidance systems for automobiles, satellite communications, and air traffic control signal processing. By leveraging commercial production, the payoff to defense is the world's best radar at a lower cost.

The Department of Defense has pursued the third dual-use theme—commercial insertion—in several areas. For example, civilian contractors are working with Defense Department staff to develop a process for inserting non-military parts in the Single Channel Ground and Airborne Radio System. The broader goal is to develop a corps of "smart buyers" in the military who have a detailed knowledge of relevant commercial technologies and an understanding of commercial markets and buying practices.

Computing Advances from Defense Research Add up to Commercial Success

America's national defense and space missions spurred the development of many of the key technologies that have propelled the world into the Information Age.

■ **The World's First General-Purpose Electronic Digital Computers.** The computer revolution was launched during World War II with the construction of the world's first general-purpose electronic digital computer, ENIAC (Electronic Numerical Integrator And Computer). Built by engineers at the University of Pennsylvania with funding from the Department of the Army, ENIAC weighed 30 tons and filled a 30-by-50-foot room. ENIAC was joined shortly by EDVAC (Electronic Discrete Variable Automatic Computer), the first true computer with a central processor and a memory for data and programs. These systems provided the foundation for the astounding evolution of computers.

In the late 1940s, the Department of Defense contracted with the Massachusetts Institute of Technology to develop a computing system for use in a Navy flight simulator. The result was the world's first reliable, real-time computer, the Whirlwind. Defense used the Whirlwind to process data from radar stations in the SAGE (Semi-Automatic Ground Environment) air defense system. and later for SATIN, the first automated air traffic control system. In addition to groundbreaking hardware developments, the SAGE and SATIN programs yielded the first compilers and assemblers.

■ **IBM's Defense Calculator.** With the outbreak of the Korean War in 1950, IBM invested $3 million of its own money in the development of a general-purpose scientific calculator, the Defense Calculator, which it introduced in 1952. Though defense contractors were the primary market for the Defense Calculator, its potential for the business market resulted in further technology development by IBM. Two years later, IBM marketed its Model 702, designed for business use, launching the company's commercial computer business.

■ **The Integrated Circuit.** Texas Instruments' Jack Kilby is credited with building the first functional integrated circuit in 1958, a feat that attracted Air Force funds for development. In 1959, Fairchild's Robert Noyce developed an integrated circuit using a planar approach without Defense Department funding. Though the invention of the integrated circuit and its near-term improvements were accomplished without Federal funds, the government's early adoption and use of the technology spurred the industry's growth and helped catapult both companies to global leadership in semiconductors.

■ **Early Advances in Supercomputing.** Purchases of supercomputers by the Atomic Energy Commission's Los Alamos and Livermore laboratories provided some of the early funding that enabled companies to develop advanced computing systems for commercial markets. These laboratories placed the first orders for supercomputers from IBM, Control Data Corporation, and Cray Research. By helping to underwrite initial development costs, the laboratories enabled the companies to introduce the systems into commercial markets at lower prices.

■ **Foundations for Computer Graphics.** With financial support from the CIA and a computer on loan from the Air Force, the computer graphics group at Harvard University demonstrated a prototype virtual reality system in the mid-1960s. This work and the Defense Research Projects Agency (DARPA) investment in computer graphics research at the University of Utah contributed significantly to the technical foundation of the Evans and Sutherland Corporation, which subsequently provided computer-based equipment for pilot training—equipment that is used today by the U.S. military and by commercial pilots the world over. In addition, the Department of Defense's university funding provided training for many of today's leading technologists, among them John Warnock of Adobe Systems, and Jim Clark, founder of Silicon Graphics and Netscape. When the Federal government began its support for this research, the vast implications of computer graphics—what-you-see-is-what-you-get document creation systems, scientific visualization, the entertainment industry, virtual reality—were unforeseen.

■ **DARPA's VLSI Program.** The Very Large Scale Integration (VLSI) Program conducted by DARPA has contributed in numerous ways to the Nation's strength in computing. VLSI was built on the vision of making integrated circuit technology available to system designers. To this end, VLSI funded both academic research activities and the Metal Oxide Semiconductor Implementation Service (MOSIS). The MOSIS semiconductor integrated circuit fabrication and testing facility—funded jointly by users, DARPA, and the National Science Foundation—provides industry and universities across the Nation with low-cost, fast-turnaround prototyping of integrated circuits. In addition, the VLSI program:

- Resulted in the development of the multichip wafer, allowing multiple designs to share a single silicon fabrication run. This capability—together with the tools developed to assemble the designs and services for digital submission of chip designs—made the concept of a low-cost, fast-turnaround silicon foundry a reality. Several companies based on these technologies were formed.
- Stimulated development of the Geometry Engine project, which formed the basis of Silicon Graphics, Inc. The company's simulation technologies have been instrumental in creating spectacular special effects in movies such as *Jurassic Park* and *Forrest Gump*.
- Stimulated the development of Berkeley UNIX, an operating system funded by DARPA to provide a research platform for VLSI tools, which has become the basis for the operating system of choice in workstations, servers, and multiprocessors.
- Accelerated understanding of the importance of low-cost, high-quality graphics for VLSI design, inspiring the creation of the Stanford University Network (SUN) workstation project. Together with Berkeley UNIX, this technology formed the basis for Sun Microsystems.
- Supported two key Reduced Instruction Set Computing (RISC) experiments, the Berkeley RISC project and the Stanford MIPS project. These technologies formed the basis for many RISC designs, including those of MIPS Computer Systems (now owned by Silicon Graphics, Inc.) and Sun Microsystems.
- Sponsored extensive developments in computer-aided design (CAD), leading to revolutionary improvements in CAD technology for layout, design rule checking, and simulation. The tools developed in this program have been used extensively in both academic research programs and industry.

■ **Defense Acquisition Reform.** The Defense Department is firmly committed to improving defense acquisition processes to help improve long-term military readiness by increasing access to state-of-the-art commercial technology, products, and services. In October 1993, President Clinton signed into law the Federal Acquisition Streamlining Act of 1994 (FASA), which provides for three key statutory changes. First and foremost, 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 has developed a strategic plan to ensure that reform measures are institutionalized and to create an environment for continuous improvement.

In June 1994, the Pentagon announced a reversal of its long-standing policy toward military specifications, or milspecs, the 31,000 specifications and standards that prescribe how military items are to be made and tested down to the most minute detail. The Secretary of Defense has instructed the military services to use commercial or performance-based specifications and standards in lieu of milspecs unless no practical alternative exists. Already this decision has dramatically reduced the number of required milspecs for dozens of weapons systems: the Air Force's Space Based Infrared System dropped from 150 to 2; the Navy's SLAM missile, from 104 to 6; and the Army's BCIS Phase I antifratricide digital system, from 467 to 194.

Since the 1994 FASA, there have been still other improvements in military acquisitions. For example, the Federal Acquisition Reform Act of 1995 gave the Defense Department authority to extend its pilot acquisition program to cover entire facilities. And further streamlined acquisition by authorizing, for three years, greatly simplified procedures for contract purchases below $5 million.

Together the statutory reforms embodied in the FASA, subsequent legislation, and administrative reforms such as the milspec policy further the Pentagon's ability to take advantage of the inventiveness and efficiency of today's dynamic commercial high-technology market.

A World-Class Workforce

Goal 5

Ensure that America has a world-class workforce capable of participating in a rapidly changing, knowledge-based economy.

Increasingly, our country's competitiveness and what we as individuals earn depend on what we learn. From factory floors and farms to offices and hospitals, knowledge and the ability to use information and technology are becoming the keys to employment and wealth.

Today, American workplaces are home to a vast array of advanced information, telecommunications, and manufacturing technologies. These technologies are creating a knowledge-based economy in which our workers must be adept at gathering, processing, and interpreting data and information.

Moreover, new forms of work organization being adopted by many U.S. companies require workers to possess conceptual, analytical, communication, interpersonal, and self-management skills in addition to basic academic knowledge and technical skills.

Too many Americans are ill-prepared for workplace roles in the new economy. By one count, 90 million adult Americans have limited information and quantitative skills. It is estimated that 60 percent of the new jobs in the year 2010 will require skills possessed by only 22 percent of workers today. We are already seeing growing disparities in income that are a direct result of disparities in levels of education. In 1979, full-time male workers aged 25 and over with at least a bachelor's degree earned on average 49 percent more per year than did comparable workers with only a high school diploma. By 1993, the difference in wages had nearly doubled, to 89 percent.

In our rapidly changing economy, learning must become a way of life. To sustain rapid job growth while increasing growth in wages and productivity, the Administration has undertaken an ambitious agenda of lifelong learning to help American workers respond to challenges and grasp opportunities in the new economy.

■ **Elementary and Secondary Education.** With a strong focus on K–12 education, the Goals 2000: Educate America Act of 1994 established eight ambitious national education goals, including goals designed to raise U.S. students' competence in mathematics and science and to promote adult literacy and lifelong learning.

Goals 2000 provides a framework for comprehensive state and local efforts to improve teaching and learning. The objective is to create a system in which highly skilled teachers can focus on achieving clear, widely agreed-upon goals, assisted by parents and the community, who in turn can look to a set of well-defined standards by which to hold educators and school systems accountable.

Mathematics and science education form the basis for the technological and scientific advances that fuel today's economy, and these subjects are gateways to high-wage scientific, engineering, and technical careers. Goals 2000 established an ambitious national education goal: "U.S. students will be first in the world in science and mathematics achievement." This poses a tremendous challenge to American educators. In international comparisons, U.S. students rank below students in most other developed nations in mathematics and science.

"We are moving from an Industrial Age built on gears and sweat to an Information Age demanding skills and learning and flexibility."

President William J. Clinton
State of the Union Address
January 24, 1995

In 1984, 25 percent of workers used computers on the job; by 1993, 46 percent did.

"The United States must sustain world leadership in science, mathematics, and engineering if we are to meet the challenges of today and tomorrow."

President William J. Clinton

Only 11 percent of middle school math teachers and 21 percent of science teachers majored in their fields of teaching specialization.

While much of the responsibility for achieving this goal rests with school systems at the state and local levels, the Federal government plays a role in encouraging improvements. Federal government investments for improvements in mathematics and science education at the pre-K–12 education levels focus on enhancing teacher skills, improving science and mathematics curricula, promoting systemic reforms, and other areas.

Many of America's young people are not equipped with the basic academic and technical skills businesses demand. The School to Work Opportunities Act, proposed by the Administration and passed by the Congress in 1994, provides assistance to States and localities for building systems that prepare young people for a good first job. Partnerships among businesses, labor organizations, and educators offer young people learning experiences in both school and work settings that will help provide the knowledge and skills they need to make a smooth transition into the world of work.

■ *Encouraging curiosity and innovations.*

■ **Higher Education.** The cost of higher education discourages many Americans from attending college, raising barriers to lifelong learning at a time when the economic benefits of higher education have increased dramatically for both individuals and the Nation. Under the new Federal Direct Loan Program, individuals can borrow money for college directly from the Federal government and tailor their repayments to suit their financial circumstances.

Businesses have long been allowed a tax deduction for the costs of providing education and training for employees. Yet despite the high returns and the high costs of post-secondary training and education, the current tax code provides only limited relief to individual taxpayers making such investments. The Middle Class Bill of Rights, proposed by President Clinton in 1994, includes a tax deduction of up to $10,000 for annual expenses on post-secondary training and education. This proposal provides a financial incentive for Americans to get the education and training necessary to thrive in a changing economy, recognizing that investment in human capital is a major determinant of growth in national productivity and living standards.

■ **Undergraduate and Graduate Education.** The principal resource for maintaining U.S. technological leadership is our pool of well-educated scientists and engineers. They are the wellspring of new ideas and new solutions to challenging problems.

American colleges and research universities are unmatched in their ability to provide advanced education and to enrich it through leading-edge research. Maintaining this system of excellence is becoming ever more important as society becomes increasingly dependent on scientific and technological advances and, by extension, on an adequate supply of well-trained scientists and engineers.

As students progress to higher levels of formal education, fewer of them continue their studies in science, mathematics, engineering, and technology. Too often, teaching in these fields fails to capture students' interests, as instructors rely heavily on lectures and repetitive textbook problems, especially in mathematics and physical sciences.

Our undergraduate students must have rapid access to the ever-expanding wealth of knowledge being generated, provided by faculty who can convey the excitement of discovery and its applications and are armed with knowledge of advances in technology and instrumentation, new experimental methods, and emerging pedagogical techniques. The Federal government is working as a catalyst to inject such vitality into U.S. undergraduate science, mathematics, engineering, and technology education by investing in organizational reform, faculty enhancement, curriculum improvement programs, and student support.

The Federal government plays a major role in financing graduate education in areas such as fellowships and traineeships in pre- and post-doctoral programs. Federal research grants also support graduate students by providing funds for assistantships.

Our graduate-level research universities have new opportunities to contribute to the Nation's competitiveness through the training they impart to scientists, engineers, and technologists. While the Nation will always need outstanding scientists and engineers to teach in colleges and universities; the share of Ph.D.-level scientists and engineers employed at academic institutions has been steadily declining for more than two decades. Today, roughly half of all doctorate-level scientists and engineers work outside academia.

Closer ties between universities and the private sector, through industry-university cooperative activities, would yield multiple benefits. By working directly with scientists and engineers from industry, students gain new awareness of needs and opportunities in the private sector. At the same time, the companies are given a window on leading-edge research and emerging technologies.

■ **Reemployment System.** Technological change and market forces will demand new skills in existing jobs. They may also eliminate jobs, companies, and, in some cases, even entire industries. For example, a recent Commerce Department study showed that, over the 1973–1988 period, job creation averaged 9.1 percent per year in the manufacturing sector, while job destruction averaged 10.3 percent. Job creation and destruction are observed within all manufacturing industries and require at least 11.7 percent of workers to change their job or job status each year.

In today's rapidly changing economy, new approaches are needed to help American workers keep pace. To address this challenge, the Administration is working with the states to turn the Nation's unemployment system to a reemployment system that will smooth the transition from one job to another and increase worker skills to prevent job loss. A key element of the new system is a nationwide network of one-stop career centers that provide job counseling and information on training opportunities, job openings, local employment trends, and assistance programs at all levels of government.

Unfortunately, workers who need training now face a complicated maze of dozens of government-assisted training programs, each with its own rules, regulations, and restrictions. President Clinton's Middle Class Bill of Rights has proposed replacing this complex system with a single choice-based system for adults, consolidating nearly 70 training and related programs. The Administration proposes the use of skill grants that could be used at any eligible training provider.

■ **Skill Standards.** Skill standards can play an important role in increasing the supply of highly skilled workers and smoothing their transitions between jobs. In the United States, a lack of formal mechanisms for national certification of most worker skills diminishes the portability of training and reduces the incentive for employees to invest in increasing their skills.

The Goals 2000: Educate American Act established the National Skill Standards Board to encourage voluntary development of a national system of occupational skill standards to strengthen the connection between the skills required in the workplace and those imparted through education and training.

"I believe a total national effort to make the many benefits of technology available to all of our young people can lift—in one bold stroke—the level of the American workforce and the level of public education. This is something American business leaders have been asking us to do for over a decade."

Richard W. Riley
Secretary of Education

■ **Educational Technology Initiative.** Despite dramatic advances in information and communications technologies, the way Americans teach and learn remains largely unchanged from a century ago. The textbook remains the basic unit of instruction, teachers and instructors use "chalk and talk" to convey information, school teachers work largely in isolation from their peers, and the classroom remains a technological backwater. We can do better.

New technologies have the potential to provide learners of all ages with access to multimedia electronic libraries and museums containing text, images, video, music, instructional software, and simulations. They can provide access to the world beyond the classroom, including access to the best teachers, and outside the typical nine-to-three school day. These technologies can make job training more accessible, especially for small and medium-sized firms with few resources to devote to worker training and for workers who, on their own, are attempting to improve their skills.

THE PRESIDENT'S FOUR PILLARS FOR EDUCATIONAL TECHNOLOGY

1. Provide all teachers the training and support they need to help students learn using computers and the Information Superhighway.
2. Develop effective and engaging software and on-line learning resources as an integral part of the school curriculum.
3. Provide access to modern multimedia computers for all teachers and students.
4. Connect every school and classroom in America to the Information Superhighway.

President Clinton has challenged the Nation to connect every classroom to the Information Superhighway by the year 2000 and to provide computers, good software, and well-trained teachers. The National Information Infrastructure initiative is working to promote the use of advanced information technologies for accessing the education and training required for the knowledge-based economy of the 21st century. The Commerce Department's Telecommunications and Information Infrastructure Assistance Program is providing matching grants to school districts, libraries, and universities to help them adopt new telecommunications technologies.

In 1994, there was one computer for every ten students in elementary and secondary schools.

Today, only 9 percent of all instructional rooms in public schools—classrooms, labs, and media centers—are connected to the Internet.

The President's challenge is galvanizing private initiatives. Tech Corps recruits, places, and supports volunteers from the private sector to advise and assist schools in integrating new technologies into the classroom. The American Technology Honor Society is tapping the technological expertise of students to expand and improve their schools' use of technology.

Students will be recognized and rewarded for their efforts. A new voluntary corps of technologically literate teachers, 21st Century Teachers, will help other teachers learn how to use new technology to improve teaching and learning in school and at home.

On NETDAY (March 9, 1996), President Clinton, Vice President Gore, and 20,000 volunteers laid 6 million feet of cable providing thousands of California schools with the technology required to link classrooms, libraries, and laboratories to the Information Superhighway.

The CyberEd truck—a cyber classroom on wheels—will bring model technology to every rural and urban Empowerment Zone in the Nation, providing hands-on educational technology experience.

The Department of Education's Technology Learning Challenge grant program supports partnerships of schools, colleges, and the private sector for the development and demonstration of educational technology. In 1995, the initial challenge grant competition for elementary and secondary education attracted more than 500 proposals and resulted in 19 grants totaling $10 million. The challenge grants have been matched by $70 million in private sector contributions in the first year. The President has proposed a significant expansion of this program to help keep U.S. schools on the leading edge of learning technologies.

■ *Exploring the use of technology.*

To further encourage action at the state and local levels, President Clinton has proposed the creation of a $2 billion, five-year Technology Literacy Challenge Fund to be administered by the Department of Education. States will be asked to work with local governments, private sector partners, parents, teachers, and students to develop statewide strategies to build upon the President's four pillars for technological literacy. This fund expands efforts that were initiated under Goals 2000 technology planning grants.

CHAPTER 5

CHALLENGES IN U.S. TECHNOLOGY POLICY

Since first articulating its technology policy in 1993, *Technology for America's Economic Growth—A New Direction to Build Economic Strength*, the Clinton Administration has made great strides in fulfilling this vision with a portfolio of innovative yet commonsense technology programs. Taken together, these investments in the future promise large economic benefits to the Nation. Nevertheless, stubborn problems remain, and new challenges are on the horizon that will require attention in the future.

CHALLENGES IN U.S. TECHNOLOGY POLICY

DEFINING NATIONAL INTERESTS IN A GLOBAL ECONOMY

Establishing government policies and programs to support U.S. national interests in a global economy presents many challenges. Today, the sources of economic growth—technology, capital, and labor—are increasingly global. For example, investment capital flows around the world in search of the best opportunities with the greatest returns. In technology, some 640 foreign-owned R&D facilities in the United States employ more than 105,000 R&D workers, and foreign-company R&D performed in the United States has grown to more than 15 percent of total U.S. industrial R&D. U.S. companies are taking advantage of labor overseas, tapping the skills of engineers in India, who design computer chips and transmit those designs back to the United States by satellite. In other cases, American workers enjoy the benefits of foreign investment in the United States. Half of the 1 million workers in the U.S. chemical industry are employed by U.S.-based affiliates of foreign companies.

Nations everywhere have recognized this new global competition for business activity and sources of economic growth. They have established a range of policies and programs to attract these engines of wealth creation to their shores and to help businesses grow.

Federal policy-makers increasingly need a strategic, global point of view as they pursue policies designed to strengthen the U.S. economy. Continued global economic growth remains in the interest of the United States, expanding market opportunities and increasing political stability worldwide. Nevertheless, U.S. foreign and domestic policies should seek to leverage U.S. interests in the global economy. For example, our national interests are served through market-opening initiatives and efforts to strengthen the protection of intellectual property rights worldwide. U.S. domestic policies should seek to create a business climate that puts technology to work in the United States, minimizes barriers that have the potential to drive business activity and jobs offshore, attracts global investment, and stimulates U.S. exports.

FINANCING INNOVATION

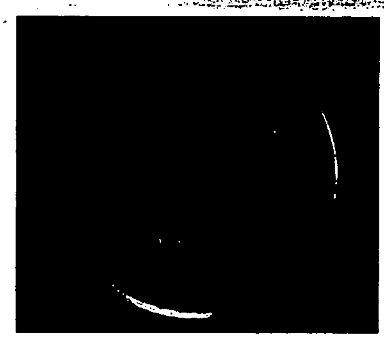
One of the most stubborn problems of innovation is ensuring the availability and affordability of capital for new technology. This age-old problem is exacerbated by the increasing costs of developing and commercializing emerging and enabling technologies. In addition, the farther downstream one goes with a technology-based project, the larger the capital requirements. Failure to secure adequate and timely financing can break a technology venture at any stage. Unfortunately, difficulty in obtaining adequate financing—a problem faced by entrepreneurs, small firms, and large companies alike—often prevents many promising technologies from reaching the market in time, if at all.

The availability of company financing for technology is closely linked to a technology's perceived cost and risk. Major business investments will not usually be made until risks have been reduced to the level needed to meet the investment criteria in use by the corporation. Many promising technological opportunities involve a combination of high risk and high cost that precludes their timely development in the private sector. Government can play a role in encouraging private companies to pursue such opportunities. For example, cost-sharing by government where there is potential for broad-based economic benefits with high rates of social return encourages private sector investment at the pre-competitive stage of technology development. By serving as a catalyst to bring together complementary expertise in consortia and alliances and by including peer review of a project's technical and business merit, the Advanced Technology Program and others like it will reduce the uncertainties associated with new ideas. The reduction of perceived risk may be sufficient to encourage the private sector to pursue technology development projects without government support.

Compared with its major foreign competitors, U.S. industry appears to invest at a lower rate and on a shorter term basis in areas such as R&D, workforce training, and the development of supplier relationships. While U.S. capital markets are highly efficient, corporate governance rules, accounting systems, (for smaller firms) barriers to access and transaction costs, and other factors tend to skew the allocation of capital away from investments that boost productivity, firm competitiveness, and sales growth, which, in turn, boost wages, employment, and economic growth. Government should explore ways to encourage longer term private investment in areas that underpin technological innovation.

PUBLIC UNDERSTANDING OF TECHNOLOGY

Americans increasingly face decisions on issues related to technology and its role in both society and our personal lives. Yet technology itself is rarely a subject of study in our schools and colleges. And although society relies heavily on technology, positive images of people who make and use technology are sorely lacking in popular culture.

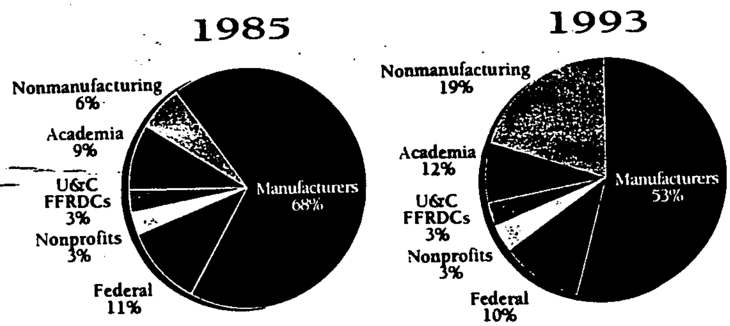


■ The National Medal of Technology is the highest honor awarded by the President of the United States of America for technological innovation. It is administered by the U.S. Department of Commerce.

No Federal programs exist for the express purpose of promoting our students' and the public's learning about the nature of technology, its increasing role in society, and the extraordinary contributions scientists and technologists have made to our standard of living, economic prosperity, and competitiveness. To provide a foundation for understanding complex economic, political, ethical, and social issues derived from an increasingly technological society, partnerships among the Federal government, the education community, industry, and the media are needed to improve the technological literacy of Americans.

At both the undergraduate and graduate levels, greater emphasis on the processes and methods of technological innovation, on how to use technology, and on the functions of technology in our society is needed in curricula designed for students who do not pursue a science, mathematics, or engineering major. Technology is pervading all aspects of society, and those who do not specialize in science, mathematics, and engineering disciplines—such as elementary school teachers, lawyers, and business managers—are increasingly confronted by technological issues and problems in their personal and work lives.

Service Sector's Share of R&D Performance Has More Than Tripled



**Service sector R&D performance is more than 95% of all nonmanufacturing R&D.*

THE SERVICE SECTOR

The U.S. service sector has emerged as a set of dynamic, technologically intensive industries that have a major impact on the U.S. economy. Services provide roughly 75 percent of American jobs and account for 70 percent of U.S. GDP. The U.S. service sector is a major consumer of high-technology products, especially information technologies. The role of the service sector in technology is growing; in 1993 this sector invested $25 billion of industry-sourced funds in R&D.

The growth of the service sector has not been reflected in U.S. technology policy. Federal agencies involved in technology policy and partnership activities with the private sector should remedy this underrepresentation by increasing service sector participation to levels more commensurate with its role in the economy.

STATE-FEDERAL TECHNOLOGY PARTNERSHIPS

During the past 15 years, state and local governments have established numerous programs to fuel technology-based economic growth and job creation at the regional level. They include new business incubators, seed capital funds, manufacturing extension programs, partnerships with Federal and university laboratories, and assistance for entrepreneurs. At the same time, the Federal government has pursued programs designed to promote technological competitiveness. In large part, these initiatives have been undertaken with little coordination. By integrating these efforts, Federal, state, and local governments could significantly boost the competitiveness of American firms.

Each level of government has unique experiences and resources to contribute to innovation in the United States. Strengths at the Federal level include basic research, mission-driven R&D, and the ability to address national technology issues. Strengths at the state level include close interaction with entrepreneurs and young companies, small and medium-sized manufacturers, regional industrial consortia, and local boards and councils that support entrepreneurship and nurture technological leadership at the grassroots level. Moreover, states play a key role in deploying transportation, environmental, and educational technologies developed by the private sector and the Federal government.

Better integration of these complementary initiatives will allow all levels of government to achieve more than they could acting alone. Building on recommendations developed by the State-Federal Technology Partnership Task Force, led by former governors Richard Celeste of Ohio and Dick Thornburgh of Pennsylvania, an intergovernmental steering group will be created to establish policy and provide strategic direction for state-Federal technology partnership activities. High-level representatives from Federal and state governments, industry, academia, and labor representing all regions of the country will participate. Initial focus areas will include building the role of states in the national science and technology system, catalyzing private sector investments in technology, and building national excellence in manufacturing.

ECONOMIC DEVELOPMENT

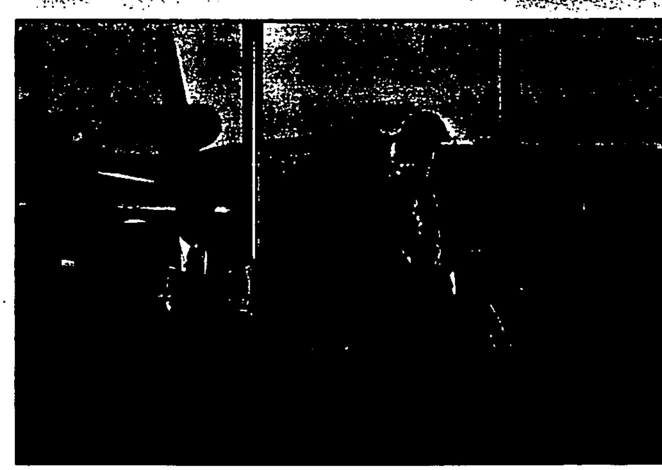
In the 1980s, governors and legislatures of several manufacturing states recognized that their traditional industrial bases were in decline and that local solutions were needed. These states looked to their native strengths in industrial and academic R&D. Each built and tested new institutions for bringing together industry, government, and academia to share the costs and benefits of the pursuit of new technology and new operating methods. These cooperative technology programs have yielded solid economic development.

Each year, Federal and state governments spend billions of dollars on economic development programs to establish wealth-generating capabilities at the regional level. In the new economy, building technology-based assets—such as linkages between creators and users of technology, technically skilled workforces, advanced telecommunications infrastructure, and technical assistance programs that focus on technology deployment—will play an increasingly important role in regional growth and job creation.

The Federal government should pursue policies and explore changes to existing laws that would allow it to allocate more of its economic development funds to encouraging regions, states, and localities to identify and develop their indigenous technology-based resources, develop ways to fully exploit them, and build new technology-based capabilities as appropriate.

MANUFACTURING ASSISTANCE

The Administration is well on its way to achieving its goal of establishing a nationwide network of manufacturing extension centers to assist America's small and medium-sized producers in adopting new technologies. These centers have helped thousands of producers update their operations and management methods. As these producers become more technologically sophisticated, so do their requirements for information and assistance.



■ *Accessing and using information through a laptop computer.*

Many national institutions—the Departments of Energy and Defense, NASA, Federal laboratories, large companies, industry and trade associations—have technical knowledge and capabilities that could propel these manufacturers even farther along the path to excellence. With an effective deployment mechanism now in place, the Federal government should serve as a catalyst to integrate these national resources into the manufacturing extension network, providing small and medium-sized firms with access to the best knowledge and skills, regardless of geographic location. Advanced telecommunications and information technologies will play a major role in achieving this goal.

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MANUFACTURING AND THE NII

The most widespread uses of advanced information technologies in manufacturing are applications within a company, such as computer-aided design and numerically controlled machines. As a whole, small and medium-sized manufacturers continue to lag behind larger firms in incorporating such technologies into their operations, but the rapidly developing manufacturing extension network is accelerating progress.

Greater competitive and economic gains could be made, however, by electronically linking groups of companies—producers, their tiers of suppliers, distributors, and customers, and even entire industries—in a tight, seamless network of commercial activity. This would allow producers and suppliers to collaborate in the development of innovations, improve the speed and efficiency of business transactions, improve materials supply and management, and allow supply chains to react swiftly to changing market demands. Yet with limited infrastructure in place to transmit data quickly and efficiently from one application to another inside or outside the company, most businesses will remain isolated and incapable of interacting with other companies, suppliers, and customers in a timely and cost-effective manner.

Some industries with large, technologically sophisticated leaders—autos, aerospace, and textiles—are rapidly moving onto the Information Superhighway. Other industries, populated with many small and medium-sized producers, remain stalled on the entry ramp. Many smaller firms simply do not have the expertise, time, or resources to proceed on their own.

While the private sector has primary responsibility for building the National Information Infrastructure, government can promote its widespread adoption and use. The manufacturing extension network should help interested small and medium-sized manufacturers and groups of suppliers to prepare for the NII in manufacturing. Federal agencies that have strong relationships with particular industries can serve as catalysts in moving those industries closer to multi-enterprise integration; government procurements can serve as incentives in this regard. Government should also provide strong technical support to the private sector in establishing standards for product and business data, network interfaces, and business and engineering practices.

POLICY INTEGRATION

Technology policy issues increasingly arise in trade, economic, regulatory, and other policy areas. For example:

- **Technology and Trade Policy.** The ability of American firms to compete in the global marketplace is enhanced by Federal government efforts to establish a level playing field to ensure that foreign firms do not gain unfair advantages. During the Uruguay Round of the GATT negotiations, government R&D subsidies and the protection of intellectual property rights were prominent issues.

■ **Technology and Economic Policy.** Technology is a principal factor in stimulating productivity growth. Policy-makers increasingly recognize technology's influence in the economy and the need to maximize its contribution. To assist in this analysis, government statistical agencies are developing ways to gauge the effect of technology at the microeconomic level.

■ **Technology and Regulatory Policy.** Regulation plays a major role in the capital and time required to bring products to market, especially in the biotechnology, environmental technology, and pharmaceutical industries. For example, environmental regulations significantly influence the development of environmental and manufacturing technologies. Banking and securities regulations heavily influence the structure of capital markets, which affects the cost, availability, and patience of capital needed for technology development and commercialization.

■ **Technology and National Security Policy.** Government must carefully balance America's national security needs and commercial interests. With the end of the Cold War, the rationale behind export controls on U.S. computer and telecommunications products changed. The Clinton Administration recognized this new reality and eased these controls, consistent with changing national security interests, in order to promote American competitiveness. In establishing defense co-production arrangements with other nations, policy-makers must consider the potential for and protect against the commercial exploitation of advanced technologies by foreign competitors. Foreign acquisition of U.S. high-technology companies and foreign dominance of commercial technologies vital to the military, such as flat panel displays, continue to raise national security concerns.

■ **Technology and Foreign Policy.** Increasingly, technology transfer is used as an incentive to advance U.S. non-commercial interests in other nations. Also, some foreign nations may demand transfers of technology in exchange for market access. Care must be taken to establish arrangements that are mutually beneficial to the United States and other nations and to ensure that one-way flows of technology do not adversely affect U.S. competitiveness or the jobs of American workers.

Traditionally, such areas of policy have been treated separately, with little coordination among policy-makers in different disciplines. Now, technology issues increasingly cut across policy lines and need to be integrated with other government policies to better promote U.S. competitiveness and economic growth, and to foster a better understanding of technology among Federal policy-makers.

ABSTRACT

Technology in the National Interest highlights the important role technology plays in the American economy and the challenges we face in an increasingly competitive, technology-based global economy. The document describes Federal technology initiatives designed to stimulate economic growth and job creation in the United States. It also traces the evolution of U.S. technology policy, identifying milestones in that evolution from the Constitution of the United States to major legislation of the past decade. This history demonstrates a long-standing tradition of bipartisan support for science and technology, and the invaluable contribution the Federal government has made to technological progress and technology-driven economic growth.

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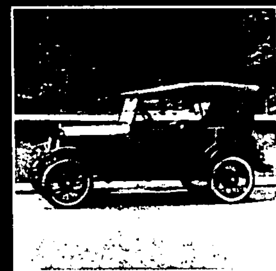

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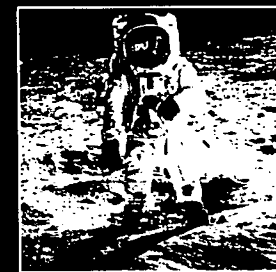

1969

197

Superintendent of Patents, U.S. Patent and Trademark Office forerunner

Improved plow (Deere)

Department of Agriculture

Land Grant Act

Radio (Marconi)

Model T (Ford)

First working jet engine

Xerography

National labs established at Los Alamos and Oak Ridge

Pola

U.S. Constitution first national technology policy

Steam powered locomotive for passengers and freight

Safety elevator (Otis)

Phonograph (Edison)

Air conditioner

First flight of liquid-fueled rocket

Color television broadcast

General purpos electronic, digital co

1787 1802 1825 1838 1852 1862 1877 1895 1902 1908 1926 1937 1940 1943 1946

1793 1807 1837 1839 1860 1876 1887 1901 1903 1914 1933 1939 1942-45 1945 19

Cotton gin (Whitney)

Telegraph (Morse)

Internal combustion engine

Laboratory of Hygiene, NIH forerunner

Wright Brothers' first flight

FM radio

Manhattan Project

Superso

Practical steamboat (Fulton)

Vulcanized rubber

Telephone (Bell)

First company research lab (General Electric)

National Bureau of Standards

Agricultural Extension Service

Helicopter (Sikorsky)

Vannevar Bush's *Science: The Endless Frontier*

HE NATIONAL INTEREST

N OGICAL INNOVATIONS AND LEGISLATION

59

1973

1977

1981

Transistor

Space Shuttle

First patent on higher life form

ie

National labs established at Los Alamos and Oak Ridge

Polaroid instant camera (Land)

Operable laser

Data transmission via fiber optics

Energy Research & Development Administration, DOE predecessor

Scanning tunneling microscope

Omnibus Trade & Competitiveness Act

Department of Energy

or television broadcast

General purpose, electronic, digital computer

USSR launches Sputnik I/Space Race

Telstar, first active communications satellite

Microprocessor

MRI scanner

National Cooperative Research Act

Telecommunications Reform Act

1940 1943 1946 1948 1957 1960 1962 1966 1971 1974 1977 1981 1984 1988 1996

9 1942-45 1945 1947 1949 1958 1961 1965 1969 1973 1975 1980 1982 1986 1993

Manhattan Project

Supersonic flight

NASA

Integrated circuit

Kevlar

Recombinant DNA

Bayh-Dole Act

Stevenson-Wydler Act

Federal Technology Transfer Act

ter ky)

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Jet airliner

USSR places first man in space

Apollo XI, first man on the moon

Laser printer

Small Business Innovation Research Act

Joint production amendments to NCRA

Operational GPS system

EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES

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