Discovery, Education, and Innovation

An Overview Of The Federal Investment In Science & Technology

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About the National Science

and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive Order 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 (S&T). The President chairs the NSTC. Membership consists of the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant S&T responsibilities, and other White House officials.

Through the NSTC, Federal departments and agencies work cooperatively to ensure that Federal science and technology investments support national goals. NSTC Committees prepare Research and Development strategies that are coordinated across the Federal government to form a comprehensive investment package.

Call 202-456-6100 to obtain additional information regarding the NSTC.

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 S&T are important elements; articulating the President’s S&T policies and programs; and fostering strong partnerships among Federal, state and local governments, and the scientific communities in industry and academe. The Director of OSTP also serves as Assistant to the President for Science and Technology and manages the NSTC for the President.

Call 202-456-7116 to obtain additional information regarding the OSTP, or see our web site at: http://www.ostp.gov.

The White House

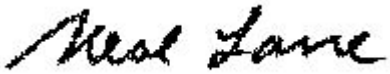
Washington

Dear Colleague:

I am pleased to transmit Discovery, Education, and Innovation: An Overview of the Federal Investment in Science and Technology. This report of the National Science and Technology Council highlights the Federal research and development portfolio, which covers a remarkable spectrum of activities. Investments in science and technology help the Federal Departments and Agencies fulfill their missions—from exploring the universe, to curing diseases, to educating the workforce of the 21st century, to defending against terrorism, to protecting our environment. Advances stemming from these Federal investments also drive the economy and help improve the quality of life for all Americans.

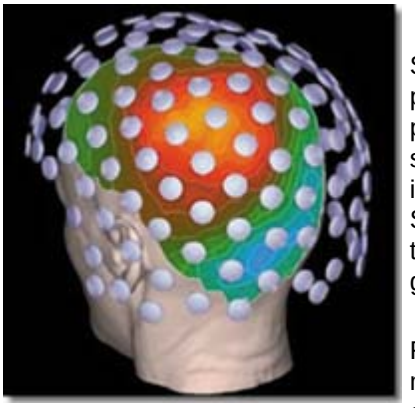
Although agencies make mission-oriented science and technology investments, the NSTC works very hard to achieve a whole greater than the sum of those individual decisions. America leads the world in science and technology, and our success is a product of strong research partnerships—among the Federal agencies, between government and academia, between the public and private sectors—and of bipartisan cooperation between Congress and the Executive Branch to put this Nation on an optimum science and technology investment trajectory.

This report summarizes just a few of our accomplishments. Through careful investment and continued cooperation, we can ensure continuing prosperity in the new millennium.



Neal Lane
Assistant to the President for Science and Technology

Introduction

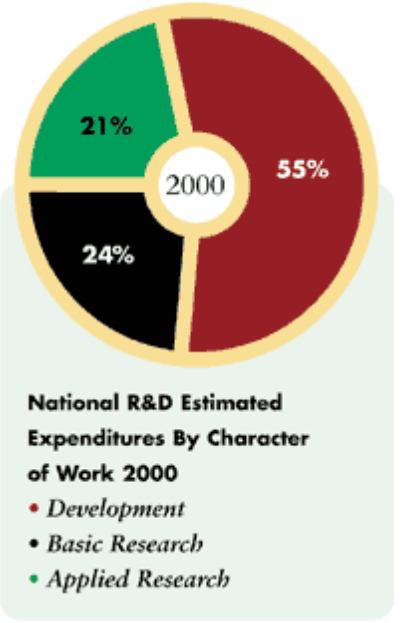


Federal support of research allows scientists to explore fundamental questions such as how the human brain enables learning, thinking, moving, and communication.

Los Alamos National Laboratory/ Department of Energy

Science and technology (S&T) have been among the principal determinants of change and the catalysts for progress in the 20th century. In the knowledge-based society of the 21st century, research, human capital, and innovation will sustain America's prosperity. The nation's S&T enterprise, the foundation of wealth and security in the new millennium, draws its strength from many partners at all levels of government, industry, and academia.

Federal investments in research and development (R&D) compose a major portion of the national S&T enterprise and enhance our capacity to capture the gains made possible by scientific and technological advances. The diversified Federal R&D portfolio serves the many missions for which Federal departments and agencies are responsible. This portfolio covers a remarkable spectrum of activities, from exploring the universe to curing disease, from defending against terrorism to protecting fragile ecosystems. This report provides an overview of how Federal departments and agencies use S&T—including R&D investments and applications of various technologies—to fulfill their missions. It highlights the impressive records and accomplishments of the agencies that contribute to and stimulate the U.S. S&T enterprise. In Fiscal Year (FY) 1999, the Federal investment in R&D totaled approximately $79.3 billion. Specific weapons systems constitute nearly half of that investment, leaving about $45 billion annually to generate new knowledge, new technologies, and new scientists and engineers. The continuing centerpiece of the Adminis-tration's commitment to S&T is the 21st Century Research Fund, which provides stability and growth for the highest priority research programs. Investments in R&D yield an extraordinary rate of return—half of our economic productivity in the last century is attributable to technological innovation and the science that supported the innovations. For the United States to stay on the leading edge of discovery and innovation, we must make a national commitment to sustain or even increase this level of investment. Several fundamental principles guide Federal investments in S&T government-wide. To ensure maximum efficacy of each taxpayer dollar, departments and agencies use their funds to:



- Sustain and nurture America's world-leading S&T enterprise, through pursuit of specific agency missions and through stewardship of critical research fields and scientific facilities.
- Strengthen science, mathematics, and engineering education, ensure their broad availability, and contribute to preparing the next generation of scientists and engineers.
- Focus on activities that require a Federal presence to attain national goals, including national security, environmental quality, economic growth and prosperity, and human health and well being.
- Promote international cooperation in S&T to strengthen the advance of science and achievement of national goals.

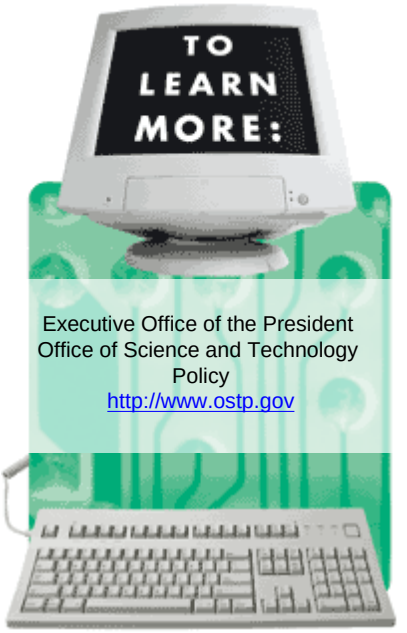
The distributed system of research funding in the United States provides strong linkages between research and the core agency missions. This system places a premium on coordination of agency programs. Many of the accomplishments cited in this report are the result of cooperative efforts among Federal agencies. For example, the Depart-ment of the Interior's ability to map landslide areas, the Department of Commerce's progress in forecasting hurricanes and El Niño, and the National Science Foundation's exploration of polar regions contribute to a greater understanding of global change mechanisms and impacts.

The President's National Science and Technology Council guides and

coordinates the Federal investment in science and technology. Cooperation among Federal departments and agencies has led to the National Nanotechnology Initiative, which is likely to change the way all things from computers to automobiles are designed and manufactured. The nanoscale image is made of carbon monoxide molecules on a copper surface. It would take 20,000 of these nanoletters to span a typical human hair.

IBM Corporation, Research Division, Alameda Research Center

The Department of Health and Human Services, the Department of Energy, and the National Science Foundation have complementary research programs that promise knowledge of human, microbial, and plant genomics. Our national success in aviation is a result of the efforts of the Department of Defense, the Department of Transportation, and the National Aeronautics and Space Administration. Interagency efforts yield some of the most impressive accomplishments in federal S&T programs. The National Science and Technology Council (NSTC) plays a vital role in coordinating Federal R&D efforts to help ensure the whole of the S&T investment at the Federal level is greater than the sum of its parts. Established by President Clinton in 1993, the NSTC is a cabinet-level Council that coordinates science, space, and technology budgets and policies across the Federal departments and agencies. The NSTC prepares interagency R&D strategies in areas ranging from information technologies to food safety, from improving transportation systems to supporting national defense. The 21st Century Research Fund, which incorporates the President's science and tech-nology initiatives, stems directly from the collaborative work of the NSTC member agencies. This report provides an agency-by-agency snapshot of the Federal investment in science and technology.



Executive Office of the President
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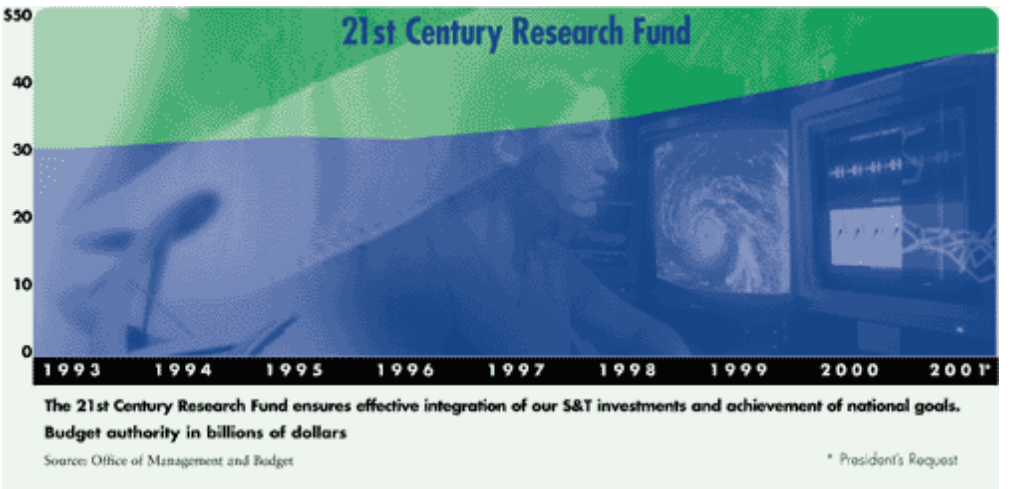

Department Of Defense

MISSION

The Department of Defense (DoD) provides the military forces needed to deter war and protect our country. DoD established an S&T program to ensure our armed forces have superior and affordable technology to support their missions and to provide our troops with the tools they need to prevail in war. The DoD S&T program, which closely coordinates its efforts with those of other Federal departments and agencies and with the overall national research community, engages regularly in joint and collaborative research.

The department carries out its R&D activities through partnerships among the military service laboratories, defense agencies, universities, industry, and international participants. Each component of DoD's S&T equation brings different capabilities and strengths to the conduct of mission-oriented research.

he Office of the Secretary of Defense directly manages approximately 11 percent of the S&T program. In particular, it leads the Multidisciplinary University Research Initiative, which supports strong teams of university personnel that conduct research in areas of importance to DoD. The Secretary's Office also supervises the Advanced Concepts Demonstration Program, which exploits more mature and maturing technologies to solve important military problems.

The Defense Advanced Research Projects Agency (DARPA) conducts high-risk research with the potential for substantial long-term payoffs. DARPA focuses on applied research and generic systems development that can provide paradigm-changing capabilities, rather than broad-based or basic research. Both the Internet and stealth technology (the F-117 Fighter and B-2 Bomber) can be traced back to initial investments made by DARPA as early as 1968.

Cutting edge research and development at DARPA yields military technology, such as this B-2 "Stealth" Bomber, and civilian spin-offs, such as the Internet.

Department of Defense

The Defense Threat Reduction Agency and the Ballistic Missile Defense Organization focus on emerging threats such as chemical and biological weapons and on theater and intercontinental missile delivery systems. The Military Department S&T offices and Armed Services Labora-tories fund and manage the research necessary to support their individual services and to support their mutual interests. Advances such as night vision systems from the Army, underwater acoustics from the Navy, and high performance turbine engines from the Air Force are typical results of this research.

In FY 1999, DoD invested approximately $37.2 billion in R&D. This funding supported the conception, development, and testing of all DoD weapons systems and subsystems. Approximately 21 percent of this investment supported in-house R&D; 65 percent supported research, development, and testing in industry; 4 percent overall (and most of the basic research funding) supported academic institutions; and the remaining 10 percent supported other researchers at national laboratories and nonprofit organizations. Within this overall budget, $7.2 billion was appropriated for S&T, which constitutes the department's investment in enhancing the armed forces' warfighting capabilities beyond the next generation of weapons systems. DoD's S&T investment helps ensure the health of a number of critical research fields. For example, DoD funds a high percentage of university-based engineering research, including 76

Department of Defense:
http://www.defenselink.mil/

Defense Research and Technology:
http://www.dtic.mil/ddre/

Defense Science and Technology:
http://www.dtic.mil/dusdst/

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Ballistic Missile Defense Organization:
http://www.acq.osd.mil/bmdo/bmdolink/html/bmdolink.html

Defense Threat Reduction Agency:
http://www.dtra.mil/

Strategic Environmental Research and Development Program:
http://www.serdp.org/

Department of the Army:
http://www.dtic.mil/armylink/

Department of the Army, Assistant Secretary of the Army for Acquisition, Logistics, and Technology:
http://www.sarda.army.mil/default.htm

Department of the Navy:
http://www.navy.mil/

percent of electrical engineering, 72 percent of mechanical engi-neering, 15 percent each of aeronautical and astronomical engineering, and 24 percent of astronautical engineering. DoD also supports other university research, including 47 percent of metallurgy and materials, 41 percent of computer sciences, 36 percent of oceanography, and approximately 15 percent each in chemistry and mathematics.

Since World War II, DoD's stewardship of these fields contri-buted to the general research of more than 65 Nobel Prize winners. In addition, many of the DoD S&T achievements have directly benefited the civilian economy. For example, the Global Positioning System (GPS) evolved from DoD's basic research investments in satellite navigation, atomic clocks, and communications. GPS technology is not only revolutionizing warfare, it is also changing air traffic control and thousands of other civilian activities. The Internet—another early DoD investment—has revolutionized society by enabling instant communications, providing information access, and promoting commerce.

Examples of Recent DOD S&T Achievements

Integrated High Performance Turbine Engine Technology (IHPTET)
The IHPTET program is a cooperative effort among the military services, DARPA, the National Aeronautics and Space Admini-stration, and private industry. Research is underway to develop more efficient and effective engines for fighters, bombers, helicopters, and transport aircraft, and to design expendable engines for cruise missiles and unmanned air vehicles. The program has demonstrated a 30 percent increase in engine thrust-to-weight ratio, which translates to a 30 percent payload increase and potential savings of $16 billion per year in operating costs. The program has also demonstrated a 20 percent reduction in fuel burned for fighter-attack and rotary-wing aircraft engines that promises to save approximately $1 billion per year in fuel costs. The technologies developed as a result of this program are also being employed in commercial aircraft engines, making air travel more efficient and reliable.

Hepatitis A Vaccine
The Hepatitis A virus is spread through water or food, including raw shellfish, which has been contaminated by feces. Hepatitis A has caused casualties in all major military campaigns and remains a threat to those living or traveling in less-developed countries. To reduce the threat to Armed Forces personnel and civilians, the Walter Reed Army Institute of Research developed a Hepatitis A vaccine. The U.S. Armed Forces Research Institute of Medical Sciences and the government of Thailand conducted clinical trials of the vaccine on 19,000 children in that hepatitis-plagued country. The vaccine proved to be at least 94 percent effective in preventing Hepatitis A. The U.S. Food and Drug Administration licensed the vaccine in 1995, and SmithKline Beecham now produces the vaccine commercially, generating over $300 million in sales in 1998 alone.

Airbase and Port Biological Detection (Portal Shield)
The Portal Shield sensor system was developed to provide early and

Office of Naval Research:
http://www.onr.navy.mil/

The United States Marine Corps:
http://www.usmc.mil/

Department of the Air Force:
http://www.af.mil/

Air Force Research Laboratory:
http://www.afrl.af.mil/

definitive warning of biological threats for high-value, fixed-site assets, such as air bases and port facilities. By warning of and identifying agents, the system allows the military to better protect against biological attacks. The system is the product of a government-industry collaboration that is part of the Advanced Concept Technology Demonstration Program. This sensor system consists of a variable number of biological sensors under the command and control of a centralized command post computer. This network, which is housed in a desk-sized shelter, can detect and identify up to eight biological war-fare agents simultaneously within fifteen to twenty-five minutes. DoD has deployed a prototype system in support of several military and civilian operations: Operation Desert Thunder in 1998, the G-7 Summit meetings in Denver in June 1997, the 1996 Olympics in Atlanta, and the 1999 NATO anniversary celebration in Washington, DC. The Portal Shield is now available to protect civilians in highly populated cities and during large events.

Lead-Based Paint Abatement

Exposure to lead is associated with adverse health effects, with young children at greatest risk. Lead exposure can result from ingesting paint chips, from breathing the dust emitted by deteriorating house paints, or from improper paint removal. Current removal methods for lead-based paint rely on chemical stripping, abrasive blasting, vacuum assisted power tools, and high intensity xenon lamps. These methods either employ hazardous chemicals or generate large quantities of hazardous waste. The DoD-led Strategic Environmental Research and Development Program has developed two methods for the safe removal of lead-based paint. The first is a molten specialty glass that, when sprayed, strips the paint from fire-resistant surfaces and encapsulates the lead. The resulting glass fragments totally immobilize the lead and are considered a non-hazardous waste. A second, similar technology can strip flammable surfaces such as wood. This technique involves coating the paint to be stripped with a slurry of glass particles and additives. This slurry is then sub-jected to high power microwave energy, melting the glass particles and encapsulating the lead. The coating is so thin and the microwave application so short that the substrate never heats to combustion temperatures. These techniques produce a non-hazardous waste stream, eliminate worker exposure to lead dust, reduce the cost of paint removal by more than 50 percent, and can be used safely in the estimated 57 million American homes that contain lead-based paint.

DoD-funded research led to the development of the Portal Shield sensor system, which detects biological threats. It has already proven its value in military operations, and is also available for civilian use, such as at the 1996 Olympics in Atlanta.

Department of Defense

Department of the Interior

MISSION

The mission of the Department of the Interior (DOI) is to protect and provide access to America's natural and cultural heritage and to honor the nation's responsibilities to Native Americans. To support several of its objectives, DOI uses S&T to:

- **Make resource management decisions based on accurate, reliable, and impartial scientific data;**
- **Monitor natural disasters to protect against loss of life and property and making available scientific information on hazards;**
- **Provide national databases of natural resource information to Federal, state, and local governments and the private sector; and**
- **Deliver Earth science results to the public.**

The U.S. Geological Survey (USGS) is the science bureau of DOI. USGS studies natural, physical, chemical, and biological processes and the results of human actions upon them. The agency conducts long-term assessments and ecosystem analyses, and also monitors and forecasts changes in the environment. USGS programs are essential to effective management of the nation's cultural and natural resources, including 500 million acres of Federally owned lands (about one-fifth of the total U.S. landmass). USGS also provides a wide variety of scientific and information services to other Federal agencies and state and local governments. For example, USGS:

- Provides maps of landslide hazard areas and real-time warnings of increased landslide risks.
- Developed a series of DNA probes and other techniques that have increased the speed and precision of the diagnosis of viral hemorrhagic septicemia virus, the most pathogenic of salmon and trout worldwide.
- Created, through the Bureau of Reclamation, computer-based programs that can improve the efficiency of hydroelectric power generation by up to 7 percent.

In FY 1999, DOI invested $517 million in R&D. Approxi-mately 89 percent of this investment supported in-house R&D, 3 percent funded research conducted by DOI industry partners, and 8 percent supported research at academic institutions. Of USGS's total R&D funding, 10 percent was allocated to basic research, 85 percent was applied research, and 5 percent went to fund development. Environmental research accounted for 72 percent of the USGS R&D effort; life sciences for 27 percent; math, computer sciences, and engineering for the remaining 1 percent.

Acid mine drainage costs more than $1 billion each year, but USGS scientists have developed a new technology to treat contaminated water.

Chuck Meyers, Office of Surface Mining

Examples of Recent DOI S&T Achievements The Florida Ecosystem Study

USGS resources and programs are crucial to the effort to restore the fragile and human-altered ecosystems of South Florida, including the Everglades. Geologists collect sediment cores that establish the history of the natural ecosystem. This history enables other scientists to differentiate human influences from natural change. Hydrologists model the almost imperceptible flow of water across the flat terrain. Biologists map and monitor the distribution of plants and animals, including invasive species, which serve as indicators of ecosystem conditions. Remote sensing images created over time provide an objective record of ecosystem change. This research helps with design and evaluation of the restoration efforts in the South Florida ecosystem.

Department of the Interior:
http://www.doi.gov/

Related Sites
United States Geological Survey:
http://www.usgs.gov/

Community-Federal Information Partnerships

Through its leadership of six community-based demonstration projects across the country, USGS advances the use of Geographic Information Systems (GIS) as a tool for building and sustaining livable communities. A GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information. The benefits of GIS are clearly visible in Dane County, Wisconsin. Real estate development there is replacing agricultural land at an alarming rate. Using GIS and data provided in part from USGS, the county government successfully championed a referendum for the purchase of $30 million of land to be preserved for parks and open space. A key factor in the county's success was the ability to show the public models of the landscape under different development scenarios. These visual models created by GIS helped the citizens "see" how their county could be affected by continuing development.

USGS – Microsoft Partnership Expands Access to Map Images

With a few clicks of the mouse, scientists, planners, consumers, and school children can now use the Internet to see aerial map images that are detailed enough to distinguish buildings and cars. Microsoft and USGS are working together to modify map data so the images can be quickly and easily displayed with unprecedented clarity over the Inter-net. Users can not only download the image they see on their screen, they can also purchase a full resolution digital file from the USGS website. The Microsoft TerraServer website opened to the public in June 1998, providing more than a trillion bytes of geospatial map data through a userfriendly interface. The site averages over 12 million visitors per day. This government-industry partnership provides public access to USGS aerial map images while allowing Microsoft and other project partners to promote their techno-logical contributions.

Fighting Water Contamination

During FY 1999, USGS scientists received two patents, while thirteen USGS scientists and engineers were awarded $1.2 million in grants to develop new technologies. Examples of patented USGS technologies that have value to DOI and the private sector include:

- Acid Mine Drainage (AMD) Treatment Technology, a technology to treat water contaminated by acid mine drainage and other industrial waste. The annual cost of treating AMD-polluted water in the United States is
- $1 billion. This patented process has been field tested at contaminated sites in Pennsylvania over the past two years, and the technology is now being transferred to the private sector.
- Contaminant Sampler for Ground Water. USGS has developed a down-hole passive water sampler to assist with the identification of Volatile Organic Compounds. In the typical ground water monitoring program a large site uses 100 to 300 samplers a month (average cost $10.00 per sampler). The new technology, which costs 50 cents per unit, eliminates the need to purge and could

save $900 to nearly $3,000 a month just in monitoring costs alone. This technology is now being used by private industry (General Electric) and government agencies (Air Force and Army).

Department of Agriculture

MISSION

The mission of the U.S. Department of Agriculture (USDA) is to enhance the quality of life of the American people by:

- **Ensuring a safe, affordable, nutritious, and accessible food supply;**
- **Caring for agricultural, forest, and range lands;**
- **Supporting sound development of rural communities;**
- **Providing economic opportunities for farm and rural residents;**
- **Expanding global markets for agricultural and forest products and services; and**
- **Working to reduce hunger in America and throughout the world.**

USDA has a long and proud history of developing and disseminating cutting-edge agricultural S&T. Since 1862, when the Morrill Act established the first land-grant institutions, the U.S. agricultural research system has provided solutions to the problems facing the world's food and fiber production and processing systems. From World War II to the 1990s, public investment in agricultural research has been responsible for 75 percent of all growth in U.S. agricultural productivity. In addition to increases in profitability for farmers, these investments benefit consumers by lowering food costs.

USDA's S&T programs are primarily carried out within the research, education, and economics mission area. Research laboratories are housed in the Agricultural Research Service (ARS), with intramural research conducted primarily by the Forest Service. Extramural research is carried out by the Cooperative State Research, Education, and Extension Service, a USDA agency that provides funding in the form of formula funds and competitive grants to various land-grant universities and other state research institutions. A number of other agencies in the USDA, including the Economic Research Service, the National Agricultural Statistics Service, and the Animal and Plant Health Inspection Service, are also engaged in research activities.

USDA scientists work closely with their private sector counterparts to ensure that agricultural technologies are available to the public to enhance economic growth. Through Coopera-tive Research and Development Agreements, ARS scientists can transfer technologies directly to industry groups. In FY 1998, ARS provided training to a nationwide network of Resource Conservation and Development coordinators on methods to identify rural business opportunities based on technologies developed by agency scientists. ARS also entered into a Memorandum of Understanding with the Minority-Owned Business Technology Transfer Consortium. This collaboration resulted in two agreements with small businesses to develop patented technology on a biobased industrial product and an enhanced nutrition food product.

In FY 1999, USDA invested approximately $1.8 billion in R&D. Approximately 60 percent of this investment supported in-house research, 1 percent was allocated to industry, and 22 percent supported research at academic institutions. Partnerships among Federal and state scientists, extension experts, industry personnel, and local producers help to produce the safe, abundant, and affordable food supply that Ameri-cans enjoy today. Agricultural research, education, and outreach affects food production at all stages—the field and feedlot, processing and preparation in the home, and marketing and trading worldwide. As we move into the next century, the agricultural research system will continue to provide solutions for complex environmental questions pertaining to agriculture,

Wheat seeds treated with bacteria like those colonized in this petri dish are nearly immune to wheat take-all, a root-destroying fungal disease. USDA is

developing this and other less chemically-intensive pest control alternatives.

Agricultural Research Service/ Department of Agriculture

US Department of Agriculture:
http://www.usda.gov

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Agricultural Research Service (ARS):
http://www.ars.usda.gov

increase production to meet rising global demand, and develop new markets for American agricultural products.

Examples of Recent USDA S&T Achievements

Food Production

USDA is racing for ways to feed more people without degrading the environment. By building a gene catalog for our food supply, USDA researchers can breed for qualities such as disease and pest resistance and engineer hardier, more nutritious crops that will require fewer pesticides. In 1998 USDA produced a new variety of feed-corn that enables farm animals, such as pigs and chickens, to absorb phosphorous more easily. Better absorption reduces the amount of phosphorus in the waste of the farm animals by nearly 50 percent. This reduction in phosphorus contributes to clean water efforts and enables farmers to spend less on dietary supplements, which ultimately lowers the cost consumers pay at the grocery store.

Increasing Food Safety and Improving Nutrition

USDA researchers take advantage of many new technological developments to help identify food pathogens. Space satellites can detect insects in farm fields and provide data on how much pesticide is needed and where, saving millions of dollars in unnecessary chemical use and possible environmental damage. Scanners that identify nerve gas in the air can be modified to spot hidden pathogens like E. coli and salmonella in food that could otherwise result in human sickness. The USDA implemented a new approach to food inspection—Hazard Analysis and Critical Control Point—to reduce pathogen levels in consumer meat and poultry products. Another new approach, originally developed to assure safe food for astronauts during space flights, has lowered the prevalence of salmonella in meat and poultry by 25 to 50 percent.

While making food safe, USDA is also making it more nutritious. Agricultural researchers have developed a substance called Z-trim, which can be used to replace fat in a number of food products. Researchers have determined that Z-trim is safe and it tastes good. Z-trim is made from a variety of low-cost agricultural byproducts such as hulls of oats, soybeans, peas and rice, or bran from corn, or wheat. USDA will license the Z-trim process to private companies that can then use the process to develop commercial products. USDA also created NuSun, a vegetable oil made from new sunflower hybrids, that is designed to be healthier, make foods taste better, and stay fresh longer. NuSun is low in saturated fat and uses more oleic acid than traditional sunflower oil. Research shows that a low-fat diet with high oleic acid reduces serum cholesterol and the risk of coronary heart disease.

Controlling Emerging Threats to Crops and Animals

USDA conducts research on emerging and exotic diseases that pose major threats to crops and animals. The research focuses on identifying, detecting, and preventing the introduction of exotic pests and controlling the ones already existing in the United States. Other studies focus on

S&T partnerships among Federal and state scientists, extension experts, industry personnel, and local producers help to produce the safe, abundant, and affordable food supply that Americans enjoy today.

Bruce Fritz, Agricultural Research Service

identifying and controlling emerging diseases that infect livestock, including Bovine Spongi-form Encephalopathy, African swine fever, and avian influenza. In addition, USDA is working to develop more efficient long-term management of select invasive species, including leafy spurge, salt cedar, Brazilian pepper, and yellow starthistle.

Addressing Pesticide Concerns

USDA R&D efforts address pesticide-related concerns posed by the August 1996 enactment of the Food Quality Protection Act. The legislation challenges U.S. farmers to produce high quality, market competitive food products that also increase the margin of safety regarding pesticide residues. Building on the existing research and technology transfer programs, the department is working to enhance the availability of data that the Environmental Protection Agency uses to assess tolerances and to develop less chemically- intensive pest control alternatives.

Department of Commerce

MISSION

The Department of Commerce (DOC) promotes job creation, economic growth, sustainable development, and improved living standards for all Americans. DOC works in partnership with business, universities, and communities to:

- **Build for the future and promote U.S. competitiveness in the global marketplace by strengthening and safeguarding the nation's economic infrastructure;**
- **Keep America competitive with cutting-edge S&T and an unrivaled information base; and,**
- **Provide effective management and stewardship of our nation's resources and assets to ensure sustainable economic opportunities.**

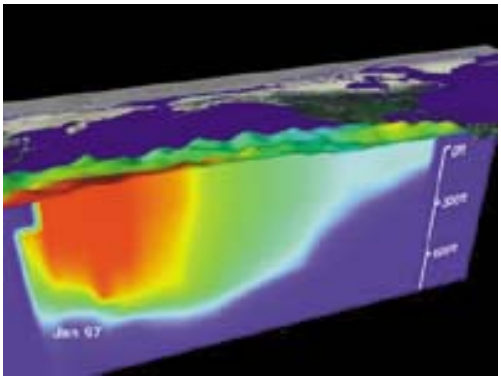
Three bureaus within DOC are directly involved with S&T activities. The National Oceanic and Atmospheric Administration (NOAA) describes and predicts changes in the Earth's environment and helps to conserve and manage the nation's coastal and marine resources. The National Institute of Standards and Technology (NIST) strengthens the U.S. economy and improves the quality of life by working with industry to develop and apply technology, measurements, and standards. The National Telecommunications and Information Administration's (NTIA) Institute for Telecommunication Sciences promotes advanced telecommunications and information infrastructure development in the United States and facilitates more efficient and effective use of the radio spectrum.

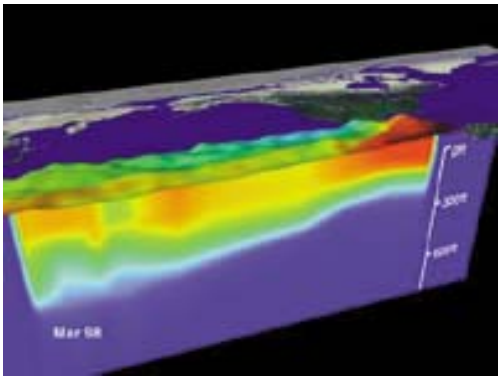
During FY 1999, DOC invested approximately $1.1 billion in R&D. Approximately 65 percent of this total supported in-house R&D, 23 percent was allocated to industry, and 7 percent funded research at academic institutions.

Examples of Recent DOC S&T Achievements

Forecasting the El Niño Southern Oscillation

NOAA provided a six-month advance forecast of the 1997-1998 El Niño—the first El Niño ever predicted. Using improved models and data from a network of buoys and satellites, NOAA correctly predicted that El Niño would cause unusually heavy rainfall in California and the Southwestern United States, and that it would make the winter milder than normal throughout the country. In a 1999 survey of 87 managers in the agribusiness, water resources, utility, and emergency sectors, 47 percent said they used the 1997 El Niño forecasts to make planning and operational decisions, and 66 percent of users reported beneficial outcomes. Utility com-panies in Michigan and Indiana alone reported savings of $250 million because of these forecasts. Climate forecasting can result in benefits to U.S. agriculture, and ultimately to the U.S. consumer, of more than $300 million annually from improved agricultural crop decisions. For example, a team of economists has forecasted a 13 to 26 percent rate of return to U.S. agriculture arising from a NOAA program that observes sea-surface temperatures in the tropical Pacific.





Improved Hurricane Tracking and Prediction System

Beginning with the 1995 hurricane season, NOAA's National Weather Service adopted the hurricane prediction and modeling system developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL). The GFDL model provides improved forecasts of a storm's path, wind intensity, and precipitation fields with lead times of 36 hours or longer. The benefits from better hurricane forecasts are substantial. For example, predicting hurricane landfall more accurately in a 24-hour forecast can save as much as $100 million in unnecessary evacuation costs. Increased storm

These computer models of water temperatures in the Pacific Ocean helped NOAA scientists predict the unusually heavy rainfall in California resulting from the 1997–1998 El Niño.

National Oceanic and Atmospheric Administration

preparedness also leads to savings. Even if only 15 percent of storm damages could be avoided with timely storm preparations, early warning could save up to $70 million per year.

NIST Measurement and Standards Laboratories

Today's leading technologies and industries rely on sophisticated and challenging measurements and standards. Producers of software, pharmaceuticals, optical fibers, flat panel displays, semiconductor microelectronics, cellular telephones, magnetic storage devices, GPS systems, and high-speed machine tools need to conform to product specifications that help make them competitive in global markets. Product standards are critical to about $150 billion in U.S. exports each year in all categories. NIST Measurement and Standards Laboratories support the development and dissemination of these standards. NIST's maintenance of accurate weights and standards of length, area, and volume ensures the fair exchange of more than $3 trillion in U.S. goods, from gallons of milk sold at the grocery store to millions of cubic meters of natural gas transported through pipelines. NIST also conducts research to develop new measurement science that anticipates the needs of technologies and industries yet to emerge.

Public-Private Partnerships — The Advanced Technology Program

NIST manages the Advanced Technology Program (ATP)—a unique partnership between government and private industry. The program is designed to accelerate the development of high-risk technologies that promise significant commercial payoffs and widespread benefits for the economy. R&D co-funded by ATP is credited with rescuing the U.S. printed wiring board industry. The United States was once the dominant producer and exporter of these thin laminated boards, which form the backbone of almost all consumer electronic products. But by 1990, U.S. global market share had fallen to a low of 26 percent and was declining steeply. This decline was alarming because printed wiring boards are ubiquitous, connecting individual electronic devices in thousands of products—from copiers, pagers, and computers, to radar, industrial sensors, and biomedical implants. The ATP-sponsored joint venture with six major U.S. electronics companies, a nonprofit research organization, and Sandia National Laboratories developed new techniques to produce printed wiring boards more economically, with less manufacturing waste, and with higher quality. By 1997, the U.S. global market share for the boards was rising by about 15 percent annually, generating $7 billion in annual sales and providing 200,000 U.S. jobs. U.S. and global consumers also benefit from lower costs and higher quality of electronic products.

Department of Commerce:
http://www.doc.gov/

Related Sites
National Institute of Standards and Technology:
http://www.nist.gov/

National Telecommunications and Information Administration
http://www.ntia.doc.gov/

Department of Health and Human Services

MISSION

The Department of Health and Human Services (HHS) is the principal agency charged with protecting the health of all Americans and providing essential services that improve the economic and social well being of individuals, families, and communities in the United States. Fostering advances in the sciences underlying medicine, public health, and social services is a crucial element of the HHS mission.

Five HHS agencies invest in fundamental and applied research and technological innovation:
The National Institutes of Health (NIH) is charged with uncovering new knowledge that will lead to better health for all. The NIH works toward its mission by:

- Supporting the research of non-Federal scientists in universities, medical schools, hospitals, and research institutions throughout the country and abroad;
- Conducting research in its own laboratories;
- Helping to train research investigators; and
- Fostering communication of biomedical information.

The Human Genome Project completed a working draft of the human genome during the year 2000.

Centers for Disease Control and Prevention

The Centers for Disease Control and Prevention (CDC) research program contributes to efforts to monitor public health, identifies and investigates public health problems, and promotes healthy behaviors.

The Food and Drug Admini-stration conducts research that helps ensure the safety and effectiveness of drugs, medical devices, biological products, food, and cosmetics.

The Agency for Healthcare Research and Quality supports research designed to improve health care quality, reduce its cost, and broaden access to essential services.

The Substance Abuse and Mental Health Services Administration funds research to improve the quality and availability of prevention, early intervention, treatment, and rehabilitation services for substance abuse and mental illness.

In FY 1999, HHS invested approximately $15.8 billion in R&D. Approximately 20 percent of this total supported in-house research, 5 percent was allocated to industry, 53 percent supported research at academic institutions, and the remaining appropriation went to other non-profit organizations and Federally Funded R&D Centers. This extramural research community includes more than 50,000 scientists located at more than 2,000 universities, research institutions, and medical centers across the United States and abroad. About 10 percent of the NIH budget supports intramural research, which is conducted by scientists employed by NIH's own laboratories. NIH's varied research portfolio encompasses basic biomedical and behavior research, clinical health studies, and prevention and health promotion research.

Examples of Recent HHS S&T Achievements
Sequencing the Human Genome

Department of Health and Human Services:
http://www.hhs.gov/

Related Sites
Department of Health and Human Services Research Page:
http://www.hhs.gov/policy/research.html

National Institutes of Health:
http://www.nih.gov/

Centers for Disease Control and Prevention:
http://www.cdc.gov/

Substance Abuse & Mental Health Services Administration:
http://www.samhsa.gov/

Agency for Healthcare Research and Quality:
http://www.ahcpr.gov/

The Human Genome Project will decipher the DNA sequences of human genes and of several other organisms used extensively in research laboratories as model systems. This project is an out-standing example of national and international collaboration. Scientists in this country, supported by private industry, NIH, and the Department of Energy, and in European organizations have already unraveled more than 20 percent of the human genome and charted the chromosomal locations of more than 30,000 human genes. They delivered a working draft of the complete sequence in 2000, and expect to have the final draft of the complete sequence available by 2003, along with a map of an additional 50,000 genes.

One of the most immediate clinical applications of genetic information is in the prevention and diagnosis of disease. Once it is established that a change, or mutation, in a gene is associated with a disease, a DNA test can be developed to determine whether individuals carry the specific gene mutation. The knowledge can inform personal medical decisions. For example, such a DNA test has been developed for hereditary non-polyposis colon cancer, and individuals who carry the gene mutation associated with this illness are encouraged to undergo more frequent screenings. Efforts are also underway to develop diagnostic screening that will identify women with breast cancer who will respond to the new Herceptin antibody treatment. A large fraction, 25-30 percent, of all breast cancer patients produce abnormally high amounts of a gene product known as HER2, which promotes growth of some cancer cells, and these women are most likely to benefit from the new treatment.

PulseNet: DNA "Fingerprinting" to Combat Food Borne Illness

PulseNet is a national network of laboratories in state health departments, CDC, and food regulatory agencies. PulseNet performs DNA "fingerprinting" on food borne bacteria. This network permits rapid comparison of "fingerprint" patterns through an electronic database at the CDC. The impetus for creating PulseNet was a large outbreak of food borne illness caused by the bacterium Escherichia coli 0157:H7 in the western United States in 1993. Scientists at CDC performed DNA "fingerprinting" on clinical samples and determined that the strain of E. coli 0157:H7 found in patients had the same fingerprint as the strain found in hamburger patties served at a large chain of regional fast food restaurants. Because this outbreak and its cause were recognized quickly, the ground beef patties were recalled, and an estimated 800 illnesses were prevented. This episode demonstrated that bacterial DNA "fingerprinting" had come of age and was ready for routine application in public health laboratories.

IDS Therapies

Although much remains to be learned about the human immunodeficiency virus (HIV) and AIDS, scientists have been able to develop effective therapies based on the findings from basic research on the nature of the virus, how it establishes infection, and how it develops in the body. This knowledge has resulted in the development of new classes of antiviral

A DNA fingerprint of this bacterium, E. coli 0157:H7, helped prevent 800 illnesses in one episode of beef contamination.

Mae Melvin, Centers for Disease Control and Prevention

drugs that can be used to treat HIV infection. These agents have been successful in extending the length and quality of life for thousands of HIV-infected people in the United States and Western Europe, and HIV/AIDS is no longer among the 15 leading causes of death in the United States. Nonetheless, the incidence of new infections has not declined in the United States, and the global pandemic continues to increase at an alarming rate. The development of an effective vaccine, as well as behavioral and biomedical interventions to prevent transmission are essential to halting the continued spread of HIV/AIDS. In addition, scientists are identifying new adverse effects of therapy, and drug-resistant strains of HIV are evolving, requiring continued efforts to develop simpler, less toxic, and less expensive drugs and drug regimens. The investment in AIDS research also has provided a new paradigm for confronting viral diseases other than HIV. And the new knowledge of the human immune system and newly developed technologies are being used in the development of vaccines and therapies for other diseases. The results of these enormous efforts by government, academic, and industrial scientists are the drug combinations that can markedly improve and extend the lives of many people infected by HIV.

Department of Transportation

MISSION

The Department of Transportation (DOT) is the Federal steward of the nation's transportation system. The Department's research and development (R&D) program supports its five broad missions, to:

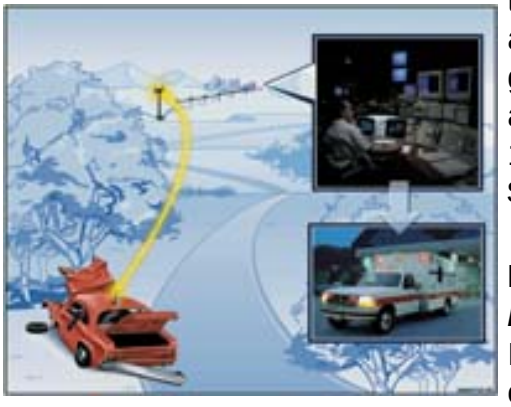
- **Operate key Federal transportation services, including the nation's airspace and waterway systems;**
- **Manage public investment in transportation, in concert with state and local governments;**
- **Regulate transportation safety by setting and enforcing standards;**
- **Work with other Federal agencies addressing broad mandates that affect transportation (e.g. clean air and national security);**
- **Promote the adequacy, efficiency, and robustness of our transportation system and industries.**

Created in 1967, DOT brought under one umbrella a myriad of transportation agencies and programs. Today's DOT comprises the Office of the Secretary; the Federal Aviation, Highway, Railroad, and Transit Administrations; the National Highway Traffic Safety Administration; the Maritime Administration; the Research and Special Programs Administration; the United States Coast Guard; the Bureau of Transportation Statistics; the Saint Lawrence Seaway Development Corporation; the Surface Transportation Board; and the Transportation Administrative Service Center.

The Department also maintains a multi-modal research facility, the Volpe National Transportation Systems Center; a national safety training center, the Transportation Safety Institute; and specialized research capabilities at the Mike Monroney Aeronautical Center and William J. Hughes Technical Center (aviation), the Transportation Technology Center (rail), and the Turner Fairbank Highway Research Center.

Although each DOT organization has its unique mission and research priorities, all operate under the department's common missions and a commitment to meeting its strategic goals: safety, mobility, economic growth, environmental protection, and national security. DOT works with all levels of government, industry, and academia to stimulate innovation through targeted research and technology development.

In FY 1999, DOT invested approximately $891 million in its research, development, and technology programs. Approximately 37 percent of that total went to support in-house R&D at DOT's laboratories, 40 percent was allocated to industry, 11 percent funded R&D by state and local governments, and 7 percent supported research by academic institutions and other groups. This funding has particularly far-reaching effects: just a 1 percent improvement in transportation efficiency can save our economy $100 billion over a decade, making this country more competitive.



In partnership with industry and state governments, the National Highway Traffic Safety Administration has developed the Automated Crash Notification System (ACNS). ACNS alerts emergency medical personnel to bring help to crash victims more quickly. This system may save hundreds of lives

Examples of Recent DOT S&T Achievements

Intelligent Vehicles and Transportation Systems

Intelligent Transportation Systems (ITS) are systems that take advantage of advances in electronics to make transportation operations more secure, effective, and reliable. DOT's ITS program has conducted over 80 operational tests throughout the United States, with a Metropolitan Model Deployment Initiative showcasing the system's infrastructure in four major cities.

Collectively, these efforts have demonstrated that ITS will improve mobility, productivity, and safety. For example, the installation of ramp

every year.

Department of Transportation

meters has increased freeway capacity in Seattle by 10 percent and reduced accident rates on freeways in Minneapolis by more than 20 percent. Automatic vehicle location technology on buses in Baltimore improved on-time performance by 23 percent, and allowed Kansas City to reduce the number of buses needed by 9 percent. Incorporating systems into new roadways can save an estimated 35 percent of the cost of providing the same capacity through traditional highway construction alone, and can reduce the number of new lane-miles needed by one-third.

Department of Transportation:
http://www.dot.gov/

Related Sites
Office of Research, Technology and Analysis:
http://www.rspa.dot.gov/dra/

NSTC Transportation Science and Technology:
http://scitech.dot.gov

Vehicle-based electronics can also contribute to safety. Automated Crash Notification (ACN) Systems can automatically alert Emergency Medical Services in the event of a serious automobile crash. In a cooperative effort with industry and state government, the National Highway Traffic Safety Admini-stration (NHTSA) designed, built, and deployed an ACN System in some 1,000 privately owned cars in western New York. A recent analysis of NHTSA fatal crash data shows that 35 percent of deaths among crash victims occurred within 10 minutes of the crash, 43 per- cent within the first half-hour, and 56 percent within one hour after injury. Based on an analysis of these percentages, it appears that ACN systems may save 400 lives per year.

Nationwide Differential Global Positioning System (NDGPS) Applications

The Nationwide Differential Global Positioning System (NDGPS) service, now being fully implemented, offers geographic position calculation across the United States. The implementation is being led by DOT with DoD and DOC as partners. The cost to implement the NDGPS service is estimated at $37 million, but benefits to the United States are approximately 140 times greater. These benefits include increased availability of service, more efficient highway inventories, and better management of existing and planned infrastructure. As an example, states use NDGPS-based techniques to improve the accuracy of land surveys. Surveyors collect data in the field, using standard surveying instruments. They then download a correction file from the Internet, process the collected data using this correction, and improve the accuracy of the position calculation to within 1 to 3 meters. The download and processing takes approximately 15 minutes per point. Improvements in efficiency resulting from NDGPS will save states approximately $20 to $30 million annually.

Innovation in Structures and Materials

DOT established the Strategic Highway Research Program (SHRP) to help meet the demands of the nation's increasing traffic levels at a reasonable cost. One particularly successful result is Superpave, Superior Performing Asphalt Pavements. Superpave consists of a new framework for asphalt binder specification and mixture design, several prototype pieces of equip-ment, first-generation performance models, and software. Implemen-tation of Superpave means that longer-lasting asphalt pavements can be installed more quickly on new or upgraded highways, with improved safety and reduced maintenance and replacement costs. More than 1,300 Superpave projects have been placed in more than 40

The Department of Transportation's Federal Railroad Administration is funding research into new high speed ground transportation technology. New trains developed under this program can safely travel at top speeds of up to 300 miles per hour.

Bombardier Transportation

states and every state highway agency now can use the system.]

SHRP research also showed that high performance concrete (HPC), which is stronger and more durable than standard concrete, would allow construction bridges with longer spans and fewer piers. To promote this technology, DOT partnered with the state of Texas to build the Louetta Road Overpass, the first HPC bridge project. Since then, 15 other bridge projects have been initiated across the country. These projects include new durability requirements for the deck, beams, and substructure, higher concrete strengths for many of the beams, and a new quality control program.

Improved Sensing and Inspection Techniques

The Federal Aviation Administration actively pursues strategies to reduce aircraft engine failures, which can result in devastating and deadly accidents. For example, on July 19, 1989, a flight crashed when the fan disk in a DC10's tail-mounted engine failed; there were 111 fatalities and 47 serious injuries among the 296 passengers and crew onboard. The ensuing investigation revealed that the fan disk hub failed as a result of a small and, at the time, undetectable flaw in the titanium billet, or slab, from which the hub was manufactured.

DOT established the Engine Titanium Consortium to improve detection of imperfections in engine materials. This initiative has significantly improved the ability to inspect titanium used in the rotating components of aircraft engines. One new technology, multi-zone inspection, divides the raw material for aircraft engine components into multiple zones, providing a more sensitive, uniform inspection. In facilities producing billets of the raw materials, the multi-zone system has performed with four times the sensitivity of traditional methods of billet inspection. The Society of Automotive Engineers approved an industry- wide specification for the multi-zone system, making this technology widely available to industry.

Department of Energy

MISSION

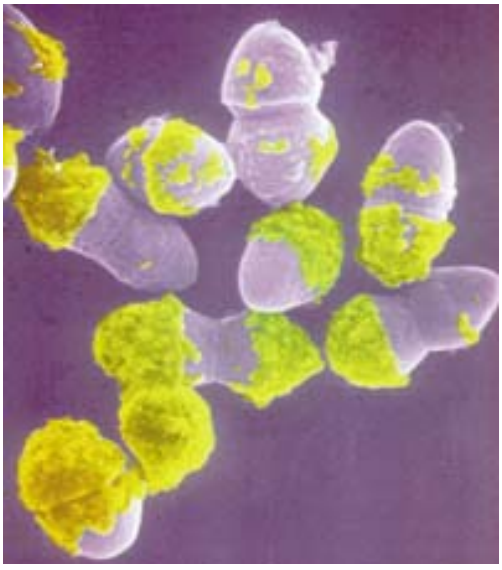
The Department of Energy (DOE) has four principal missions:

- **Foster a secure and reliable energy system that is environmentally and economically sustainable;**
- **Support continued U.S. leadership in science and technology (S&T);**
- **Be a responsible steward of the nation's nuclear weapons; and**
- **Clean up DOE facilities.**

DOE funds basic and applied research. Beginning with the Manhattan Project, DOE has funded research at universities and in its own laboratories—institutions that have evolved over 50 years to become a principal means of maintaining the nation's leadership in scientific discovery.

DOE is the principal supporter of the physical sciences in the Federal government and plays a major role in supporting biological and environmental sciences, mathematics and computing, and engineering. The department is also charged with the design, construction, and operation of large scientific user facilities such as particle accelerators, light sources, and neutron sources located at the DOE national laboratories. More than 15,000 scientists, including post-doctoral and graduate students, from universities, national laboratories, and industry use DOE's major facilities to conduct cutting edge scientific research. University scientists are the most frequent users of the national laboratory facility system and their undergraduate and graduate students provide the next generation of scientists and engineers. Users of DOE facilities have received every significant scientific prize and accolade, including 39 Nobel prizes. In 1997, a DOE-funded researcher received the Nobel Prize in Chemistry, and in 1998 a former DOE national laboratory employee received the Nobel Prize

in Physics. Historically, DOE laboratories have won more R&D 100 awards (sponsored by R&D Magazine) than any other organization. The award seeks out and recognizes the 100 most technologically significant new products each year. In 1998, DOE laboratories were home to 34 winners. The research performed at DOE facilities produces innovations and technological achievements that have improved the nation's security, environmental quality, knowledge base, prosperity, and overall quality of life.



DOE's Joint Genome Institute sequenced this microbe, E. forcium, in just one day. Knowledge of the complete genome sequence may help develop treatments for the infections it causes.

Lawrence Berkeley National Laboratory

In FY 1999, DOE invested approximately $7.2 billion in R&D, with $3.3 billion of the total spent on defense related matters. Approx-imately 10 percent of DOE's investment supported in-house R&D, 20 percent was allocated to industry, 8 funded research at academic institutions, and 51 percent was allocated to Federally Funded R&D Centers. About one-third of the budget supports basic research in the physical sciences. DOE also supports life sciences and environmental programs, including the Human Genome Project and the U.S. Global Change Research program.

Examples of Recent DOE S&T Achievements

Carbon Nanotube Technology

Incredibly light synthetic metals with a potential electrical conductivity 50-100 times better than copper are being made using carbon nanotubes.

Department of Energy:
http://www.doe.gov/

Related Sites
Department of Energy
Laboratories Page:
http://www.doe.gov/people/peopnl.htm

First discovered in 1991, nanotubes are a new class of materials formed from graphite-like sheets of carbon rolled into exquisitely small cylinders. The structures are about 100 times stronger than steel and about 1,000 times thinner than a human hair. Scientists are working on ways to incorporate nanotubes into new composite materials, making them much stronger than existing fiber-reinforced composites. Nanotubes encapsulated with chemicals might some day be used to deliver medication to specific parts of the body or to separate reactant chemicals. Fuel cells converting hydrocarbon fuels directly into electrical energy for use in remote locations will most likely incorporate large membranes of nanotubes. A computer based on nanotube devices would be extremely compact, fast, and powerful.

Microbial Genomics

In 1994, DOE initiated microbial genomics, one of the most exciting and high profile fields in biology. Microbial genomics studies the genetic sequence of microscopic organisms. Research in South Carolina has shown that “Conan the Bacterium”—D. radiodurans R1—is extremely resistant to genotoxic chemicals, oxidative damage, high levels of ionizing and UV radiation, and desiccation.

The ability to survive such extreme environments is attributed in part to a unique DNA repair system in combination with its structure. The remarkable capabilities of this microbe may enable scientists to engineer a form of D. radiodurans that can help DOE and other government agencies clean up some of the most troublesome waste disposal problems. The possible uses of microbial information are staggering since microbes make up about 60 percent of the Earth’s biomass and have existed on this planet for over 3.7 billion years, surviving extremes of heat, cold, radiation, pressure, salt, and acid. This rich diversity means that microbes have long ago “achieved” many scientific advances that can be brought to bear on some of our most pressing societal problems. For example, some microbes can thrive in environments that are deadly to most living things by sequestering toxic compounds. Understanding the chemistry and biology of this microbial capability would allow scientists to develop new methods to clean up our nation’s lands and waters that are contaminated with hazardous chemicals.

DOE-funded research has resulted in an exciting new technology that converts paper mill waste into levulinic acid, an important, multipurpose chemical.

National Renewable Energy Laboratory

Green Chemistry

DOE has found many ways to apply R&D to industrial energy and environmental challenges. One innovative, energy-saving project converts wastes like paper sludge into a valuable industrial chemical used to make a range of everyday products, including petrochemicals. This technology utilizes levulinic acid, a new feedstock derived inexpensively from biomass, in the manufacture of industrial chemicals. Major biomass fuels are agricultural field residues (barley and wheat), logging residues, mill residues, and municipal solid waste. Researchers are optimistic about the success of the project because levulinic acid is economical (unlike most alternative feedstocks) and can be converted to a large number of other chemicals. Levulinic acid is made with low-cost and abundant waste

feedstocks such as paper mill sludge, municipal solid waste, unrecyclable waste paper, waste wood, and agricultural residues. DOE shared the cost of this project with Biofine, the New York State Energy Research and Development Authority, Chemical Industry Services, Merichem, and Pencor Environmental Ventures. On June 28, 1999, this project received the Presidential Green Chemistry Award at the National Academy of Sciences in Washington, DC.

Bridge Inspection Technology

A 1998 bridge inventory made three major findings: 150 to 200 bridge spans suffer partial or total collapse every year; one-third of the more than 500,000 bridges in the United States require some type of strengthening or repair (total cost of $70 billion); and every public bridge of over 20 feet in length must be inspected every 2 years. DOE's Lawrence Livermore National Laboratory, under the guidance and sponsorship of the Federal Highway Administration, has developed a new bridge deck inspection system called the HERMES Bridge Inspector. HERMES uses a combination of 64 ultra-wideband radars to image and inspect a two-meter wide swath of a bridge deck in a single pass and at highway speeds. The system gener-ates a three-dimensional picture of a bridge deck interior and enables the operators to recognize concrete flaws as much as a foot under the surface. In 1998, HERMES won an R&D 100 Award by providing a tech-nology that is more reliable and efficient, thereby saving millions of dollars in bridge inspections and repairs.

Department of Education

MISSION

The U.S. Department of Education's (ED) mission is to:

- **Strengthen the Federal commit ment to ensuring access to equal educational opportunity for every individual;**
- **Supplement and complement the efforts of states, the local school systems and other instrumentalities of the states, the private sector, public and private non-profit educational research institutions, community-based organizations, parents, and students to improve the quality of education;**
- **Encourage the increased involvement of the public, parents, and students in Federal education programs;**
- **Promote improvements in the quality and usefulness of education through Federally supported research, evaluation, and sharing of information; and**
- **Increase the accountability of Federal education programs to the President, the Congress, and the public.**

ED conducts R&D and operates a number of programs that support increased access to educational technologies. In partnerships with other agencies like the National Science Foundation, ED supports the development of competencies in K-12 core subject areas, such as mathematics and science.

In FY 1999, ED invested approximately $265 million in education R&D. Approximately 4 percent supported in-house R&D, 6 percent was allocated to industry, 66 percent funded research at academic institutions, and 23 percent was allocated to other non-profit organizations. ED also receives funds for increasing and improving the effective use of educational technologies. This funding was used to support states, districts, schools, and educational partnerships between industry and community groups.

Examples of Recent ED S&T Achievements

Distance Learning

Distance learning is the acquisition of knowledge and skills through remotely accessed information and instruction, encompassing all technologies and other forms of learning at a distance. For the past decade, ED supported development of distance learning applications in grades K-12 through the Star Schools education technology program. Early on, this program relied principally on satellite delivery systems. In recent years, Star Schools have implemented new advances in telecommunications, especially via the Internet. Two other program initiatives, the Technology Innovation Challenge Grants (96 five-year grants between 1995 –1999) and the Learning Anytime, Anywhere Partnership grants (29 five-year grants in 1999), have greatly expanded ED's investment, as well as encouraged innovations in distance learning technology development. ED has invested heavily in cutting edge tools and open-source software development for both K-12 and post-secondary settings, and in creating new institutional arrangements, especially in higher education.

Virtual High School Cooperative

The Virtual High School Cooperative (VHSC) is a unique Internet-based set of courses for students at participating schools. The VHSC is made up of about 40 high schools nationwide and is funded by a $7.4 million Technology Literacy Challenge Grant to the Hudson Public Schools in collaboration with the Concord Consortium (a nonprofit organization devoted to educational innovation worldwide through creative technologies). This grant has enabled the project to undertake NetCourse, the first large-scale experiment in Internet-based courses at the pre-college level. The NetCourse design encourages participating schools to develop state-of-the-art, inter-disciplinary courses that bring together curriculum reform and advanced software development.

An artist's conception depicts a manned mission to Mars.

Pat Rawlings/NASA

This also includes Lotus Institute's LearningSpace, a software package specifically designed for teaching classes over the Internet. Over the next two years, the VHSC will expand to double the number of high school partners and courses and, more important, to expand NetCourse design and delivery, evaluation, technology, and dissemination. Lotus Development Corporation, Digital Equipment Corporation, and Interliant will help in this drive, along with new partners, 3Com, Motorola, and Sun Microsystems.

Technologies for Students with Disabilities

The Office of Special Education Programs in ED is also investing in technology by studying and supporting the development of technology-based instructional materials that respond to the diverse needs of students with physical, sensory, or cognitive disabilities. These materials will address the need for assistive technology adaptations as well as universal design innovations for learning in all content areas. They represent breakthroughs in access and instructional practice. For example, the Center for Applied Special Technology is developing new digital multimedia learning tools that are more versatile and combine many separate tools to create powerful hybrids-books that talk, a database that dials the phone, a video with an audio and text track and virtual reality. Unlike print, where "one size" is supposed to "fit all," digital media are malleable and can easily be tailored to individual learners.

Mars Millennium Project

The Mars Millennium Project— a cooperative effort by ED, the National Aeronautics and Space Administration, the National Endowment for the Arts, the J. Paul Getty Trust, and the White House Millennium Council— asks K-12 students to design a village for 100 transplanted humans on Mars in 2030. Students will be asked such questions as: How do sound waves travel on Mars, and what would happen if music were played there? What would art look like on Mars, since its atmosphere is different from Earth's? And what kind of government would human inhabitants of Mars need?

At schools around the nation, students have been provided information about the Mars surface, temperature, moons and volcanoes. With this information, students have created music, written about future Mars exploration, and developed Mars communities. Students have opportunities to understand Mars, exploration, science, technology, and the arts. The five national sponsors and 121 cooperating organizations working on the Mars effort plan to offer schools a network of instructional materials, information, and corporations willing to help schools or youth groups with design activities. The National Endowment for the Arts has produced instructional videos, and National Aeronautics and Space Administration has created a Web site and participation guide with information on Mars and ways to incorporate the Mars-millennium theme into curriculum and classroom activities.

Department of Education:
http://www.ed.gov/

Related Sites
Research and Statistics Page:
http://www.ed.gov/stats.html

Department of Veterans Affairs

MISSION

The mission of the Department of Veterans Affairs (VA) is to serve America's veterans and their families with dignity and compassion. VA is their principal advocate in ensuring that they receive medical care, benefits, social support, and lasting memorials. In support of its mission, VA uses science and technology to advance the health and care of veterans and the nation. The department strives to:

- **Sustain an environment of inquiry that is conducive to the highest quality of research, education, and patient care;**
- **Combine basic, clinical, and applied research to meet the health care needs of veterans; and**
- **Ensure that new research results areshared with clinical care and health systems**.

VA researchers have developed a new technology that enables the design and manufacture of orthopedic footwear in record time.

Department of Veterans Affairs

I n FY 1999, VA invested approximately $674 million in R&D. The Veterans Health Administration (VHA) conducts individual medical and health care delivery projects as well as multi-hospital research programs. It is an intramural program supporting biomedical research efforts of VA employees—physicians, nurses, Ph.D.s, and other health care professionals working in VHA's hospitals, clinics, and out-patient facilities. VA-appropriated R&D funds are distributed to VA research investigators through open competition in a national peer review process. These in-house programs accounted for 45 percent of the VA's total R&D budget. The remainder of the R&D budget, 55 percent, was received from non-VA funding sources, such as the National Institutes of Health, national scientific and professional societies, foundations, and industry.

Examples of Recent VA S&T Achievements

New Approaches for Heart Attack Patients

Most patients who suffer a certain kind of heart attack known as a non-Q-wave infarction (approximately half of all heart attacks) can now be treated with a non-invasive approach that improves survival rates and reduces treatment costs. Under the conventional approach, invasive coronary angiography is the essential first step in treatment, followed by additional non-invasive tests or therapeutic interventions. Angio-graphy is a procedure that enables blood vessels to be seen on film after the vessels have been filled with material that shows up on an X-ray. The material is inserted through a fine flexible plastic tube into a major artery. This procedure is risky and costly. Thanks to research funded by VA, the patient may now undergo a radionuclide ventriculogram and symptom-limited stress test (treadmill test), followed by other procedures deemed necessary by the physician. In a radionuclide ventriculogram, an imaging agent is introduced into the body by ingestion or intravenous injection and accumulates in an area to be detected by a special camera. Not only is this approach less dangerous and less expensive, it reduces the mortality rate of heart attack patients.

Another VA study compared primary angioplasty, a technique to treat narrowing or blockage of a blood vessel or heart valve by introducing a balloon to the area to widen it, and thrombolytic drug therapy to dissolve clots. The study involved 3,100 patients and showed that thrombolytic drugs, also known as "clot-busters," produced excellent results and spared heart attack patients from invasive procedures. In addition, the use of the drugs is feasible at all VA hospitals, unlike angioplasty. Researchers found that heart attack patients treated with clot-busting drugs experienced rates of hospitalization and long-term mortality similar to those of angioplasty patients, and at costs that were $3,000 lower per patient. This research has significant positive treatment implications for more than 150,000 Americans currently eligible for clot busting treatments.

Department of Veterans Affairs:
http://www.va.gov/

Related Sites
Veterans Affairs Research & Development:
http://www.va.gov/resdev/

Advances in Orthopedic Footwear Design

Veterans with foot deformities and injuries depend on proper custom orthopedic footwear for their physical independence and well being. Six VA centers have ongoing demonstration projects to assist veterans with injuries from military service, complications from diabetes and arthritis, and other disorders. Researchers at the New York Department of Veterans Affairs Medical Center have created an advanced system for computer-assisted design and manufacture of orthopedic footwear. The system is faster and creates consistently better fitting, more comfortable and functional footwear, on average, than current commercial methods. An optical laser scanner digitizes 25,000 points over the surface of a patient's foot and ankle in two to three seconds. Shoe designers then input the data into a computer and interactively design and manufacture custom lasts (the forms over which shoes and insoles are built) and insoles. They account for stress points and voids, spreading the patient's weight and pressures from standing and walking more evenly over the entire foot. To ensure the best fit possible, the patient then tries on soft plastic "check shoes" that are made over the computer-carved lasts. The computer then designs the top part of the patient's shoes, ensuring that all of the pieces match every bump, indent, and curve of the patient's foot. The shoe pattern pieces are automatically cut out, and then stitched together, stretched over the lasts, and the soles glued and sewn on. Scanning and last, insole, and pattern design are all completed in under an hour, compared to the several days currently required using conventional methods. Assembly of the computer shoe with gluing and drying of leather takes approximately 2 days. In 1998, the VA pedorthotics team won the health care division category in the prestigious Microsoft "Windows World Open," the international competition that awards developers for innovative work in solving industrial problems with computer technology.

Corticosteroids Reduce Damage from Spinal Cord Injury

More than one million Americans live with disabilities caused by spinal cord injuries. Crushing injuries to the spinal cord trigger a cascade of biochemical events that may cause more damage than the initial trauma. To counter this destructive cascade, VA investigators tested two corticosteroids, methylprednisolone and trilizad, in animals with spinal cord injuries. Results show that animals receiving either drug within eight hours following injury could regain up to 25 percent of lost neurological function. Subsequent clinical trials of patients with acute spinal cord injury established that this early intervention treatment can help reduce permanent damage, setting the standard for treatment of acute compression spinal cord injury. Further research by VA is underway on other compounds that may further reduce the disability and medical care costs of these injuries.

Veterans Administration research is enabling disabled veterans such as

those pictured at left to lead longer and more productive lives.

Department of Veterans Affairs

Environmental Protection Agency

MISSION

The mission of the U.S. Environmental Protection Agency (EPA) is to protect human health and to safeguard the natural environment, on which all life depends. S&T activities play a fundamental role in accomplishing EPA's mission by helping to identify, understand, and solve environmental problems. EPA's S&T activities reduce the uncertainties in risk assessment and management practices and identify data gaps that can be filled by basic and applied research on the environment. The Office of Research and Development (ORD) serves as the primary research arm of the agency.

In FY 1999, EPA invested approximately $669 million in R&D. Approximately 43 percent of that total supported in-house R&D, 12 percent was allocated to industry, 27 percent funded research at academic institutions, 8 percent was allocated to non-profit organizations, and the remaining funding was spent at other external organizations. EPA's investment in S&T supports basic and applied research to provide a sound basis for its regulation and enforcement of programs. EPA maintains strong multidisciplinary in-house research programs complemented by competitively awarded, peer-reviewed grants and by fellowship programs.

Examples of Recent EPA S&T Achievements

Particulate Matter and Health Risks

Particulate matter (PM) produced by sources such as power plants and motor vehicles is one of the nation's most serious air pollution problems. Particulates may cause up to tens of thousands of premature deaths each year, and they are linked to increased hospital admissions, aggravated asthma, and related health problems. Elderly people and individuals with cardiopulmonary disease are especially susceptible to particulate-related illnesses. EPA has developed a research strategy in accordance with National Academy of Sciences recommendations to respond to this major public health problem.

The agency has established five university-based PM research centers to support integrated research addressing highest-priority problems. To date, EPA has focused research on how metals and other components of particulates exert their toxic effects. EPA's research also measures pollutant concentrations at outdoor monitoring sites and compares these measurements to actual human exposure. These data will improve risk assessments and interpretation of epidemiological studies. EPA has also developed methods to determine compliance with the PM standards.

EPA is sponsoring research that seeks to explain the recent rise in frog deformities. Possible causes include UV-B radiation, parasites, and chemicals. The deformity seen in the frog has been found in many amphibians from Minnesota and other states.

Minnesota Pollution Control Agency

Assessing Ecological Health – Regional Assessments

To help the mid-Atlantic states develop cost-effective approaches and uniform tools with which to evaluate and protect vulnerable ecosystems, EPA formed the Mid-Atlantic Integrated Assessment (MAIA), a partnership among many agencies, states, and organizations in the mid-Atlantic region. The MAIA released its first major product, An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas, in April 1998. The Atlas uses satellite imagery and spatial databases to describe patterns of land cover and land use across the 125 watersheds of the mid-Atlantic. The result is an ecological "snapshot" that allows the reader to visualize environmental conditions across the region. These data were recently used as the basis for requiring a full environmental impact statement for proposed coal mining in West Virginia.

Environmental Protection Agency:
http://www.epa.gov/

Related Sites
Researchers and Scientists at the EPA:
http://www.epa.gov/epahome/research.htm

Endocrine Disruptor Screening Program Web Site:
http://www.epa.gov/scipoly/oscpendo/

Another major MAIA product was the December 1998 Condition of the Mid-Atlantic Estuaries report. Maryland used this information to help establish a state version of the National Estuary Program to protect its coastal bays. Estuarine sediment collected for this report has also helped fill gaps in EPA's Report to Congress on the National Sediment Quality Inventory published in January 1998.

Children's Health

Some environmental factors, such as air pollution and pesticides, pose greater risks to infants and children than to the majority of the population. Yet, environmental regulations have not always considered risks specific to children. To better understand and quantify these risks, EPA has substantially increased its intramural and extramural efforts. Since 1998, EPA established nine Centers for Children's Environmental Health and Disease Prevention in conjunction with the National Institute of Environmental Health Sciences. These centers are focusing on asthma and other childhood respiratory problems, effects of pesticide exposure among children in agricultural communities, and developmental effects among inner-city children from exposures to indoor pollutants, such as lead paint. The in-house program has focused on developing tools for assessing environmental exposures in children. This effort includes analyzing children's exposure data gathered in the recently completed National Human Exposure Assessment Survey pilot projects. EPA is also redesigning much of its toxicology research by developing and refining age-appropriate testing methodologies. These methodologies are being used to address a number of key issues associated with the developing immune, reproductive, and nervous systems of children.

Drinking Water

Continued outbreaks of waterborne disease each year demonstrate that bacteria, viruses, and parasites can still threaten drinking water. In support of the Safe Drinking Water Act Amendments of 1996, EPA's drinking water research programs have contributed significantly to understanding the risks posed by microbial pathogens and other contaminants and to developing reliable, cost-effective water treatment techniques. For example, the research has demonstrated potential health effects of arsenic and chlorination by-products and has identified potentially harmful chemicals created when ozone is used to disinfect water. Research has also led to new, more sensitive methods for detecting contaminants such as Crypto-sporidium, bromate, and aldehydes in drinking water. In addition, EPA is collaborating with CDC to analyze data for 1997-1998 on the occurrence and causes of waterborne disease outbreaks in the United States. Goals include characterizing the outbreaks of waterborne disease and identifying water treatment system deficiencies and specific contaminants.

EPA is charged with improving the quality of the air we breathe. To accomplish that goal, the agency

Endocrine-Disrupting Chemicals

Scientific evidence suggests that exposure to some manufactured chemicals may affect the body's endocrine (hormone producing) system, leading to human cancers and male reproductive disorders, and changing

conducts research and develops national programs for controlling air pollution.

Steve Zinski

the behavior, physiology, and reproductive capability of wild animals. Exposure to high concentrations of chemicals such as pesticides, industrial chemicals, drugs, and contaminants can clearly induce a variety of adverse health effects. But scientists do not know whether similar effects occur in response to low level ambient exposures in the general human population or among wildlife species. EPA is leading national and international efforts to define the scope of the problem, identify areas of scientific uncertainty, and conduct research. EPA's Endocrine Disruptor Screening and Testing Advisory Committee provided recommendations for implementation of the Food Quality Protection Act of 1996 and the Safe Drinking Water Act. The recommendations led to the development of the Endocrine Disruptor Screening Program (EDSP). EPA has begun to implement the EDSP and will use the EDSP data to help identify and characterize hazardous chemicals. The program will ultimately lead to the integration of information about how potentially harmful a chemical could be in relationship to likely exposure. Based on these data, EPA will determine how best to regulate the chemicals in question.

Central Intelligence Agency

MISSION

The Central Intelligence Agency (CIA) collects and analyzes information to support the President, the National Security Council, and all Federal officials who make and execute U.S. national security policy. CIA uses science and technology to:

- **Provide accurate, evidence-based, comprehensive, and timely foreign intelligence related to national security; and**
- **Conduct counterintelligence activities, special activities, and other functions related to foreign intelligence and national security as directed by the President.**

Themescape—the data visualization system pioneered by CIA-funded researchers—helps analysts understand and manipulate enormous data sets. Themescape presents information in the form of the interactive contour map pictured above.

Cartia

Many technological breakthroughs at CIA help maintain U. S. security and have significant value because they are kept secret. Some of these technologies in the fields of electronics, computer sciences, and analytical methodologies can eventually be released and applied to the civilian problems. The following are three examples of technological breakthroughs that have made their way from the intelligence to the civilian community.

Examples of Recent CIA S&T Achievements

Image Processing

CIA originally developed image processing techniques and specialized tools for detecting missiles and other strategic targets from aerial imagery. In 1994, CIA provided technology to the medical community to assist in the early detection of breast cancer. The techniques use mathematics to perform focused searches on mammograms to detect possible cancerous tissue. Doctors can use this technique to clue them to hard- to-detect masses far in advance of a direct visual examination of the data. This is especially important for younger women because their physiology makes mammograms difficult to read. Estimates indicate that these technologies may reduce breast cancer-related fatalities of American women under the age of 50 by 30 percent.

Data Visualization – Image Perspective Transformation

CIA developed a form of data visualization called image perspective transformation. It uses the digital manipulation of two-dimensional images to form three-dimensional views. This technology transforms several snapshots of a subject into a model that can display the subject from all angles. For example, a photographer who needs to show a building viewed from a busy freeway can generate the desired scene from a few shots taken from more accessible angles. The urban planning community can utilize the technique to show the impact of new roads or structures in an area, or to show a new photo-realistic skyline before a building is built or an old one razed. The system can generate ground-level perspectives from aerial photography. The data from these tools can be combined to form full motion video simulating walk-throughs, drive-throughs, or fly-throughs. Originally it took several days to generate a scene, but by 1995, near real-time scene generation was available. The media used this technology during the 1996 Olympics to generate flythrough visualizations of the athletic facilities.

Data Visualization - ThemeScape

Themescape is an information retrieval and visualization system that automatically retrieves and organizes documents from large, complex data sets such as local computer directories and the World Wide Web. The system organizes the retrieved documents based on their content subject matter and graphically depicts the subject matter in the form of a contour

Central Intelligence Agency:
http://www.cia.gov/

Related Sites
Directorate of Science and Technology:
http://www.cia.gov/cia/ dst/index.html

map. The features on the map, such as hills and valleys, represent subject matter areas and amount of information found on each area from the retrieved documents. ThemeScape provides the capability to interact with the map, to access the retrieved documents, and to provide easy access and help in understanding large and complex unstructured information sets. CIA developed this software tool, with DOE's Pacific Northwest National Laboratory to assist analysts in sorting through massive amounts of information. This technology is currently being commercialized and will provide an effective capability to sift through increasingly overwhelming amounts of information. Examples of this technology used to access news stories are currently available on some commercial Internet sites.

National Aeronautics and Space Administration

MISSION

The National Aeronautics and Space Administration (NASA) leads America's exploration of air and space. NASA's primary mission requires investments that will:

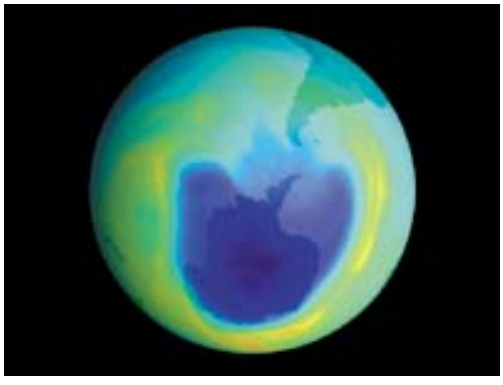
- **Advance and communicate scientific knowledge and understanding of Earth, the solar system, and the universe;**
- **Advance human exploration, use, and development of space; and**
- **Research, develop, verify, and transfer advanced aeronautics, space, and related technologies.**

In FY 1999, NASA invested approximately $9.7 billion in R&D. Approximately 24 percent of that total supported in-house R&D, 49 percent was allocated to industry, 7 percent funded research at academic institutions, 11 percent supported Federally funded R&D Centers, and 4 percent was allocated to nonprofit organizations.

Examples of Recent NASA S&T Achievements

Low Emissions Aviation

Depletion of the Earth's ozone layer has been attributed to engine exhaust, specifically nitrous oxide (NOx). In addition, increasing amounts of carbon dioxide (CO2) in the atmosphere have been linked to global warming. NASA, in partnership with Federal Aviation Administration (FAA) and industry, has developed breakthrough technology to reduce aircraft emissions, including technology to enable a 50 percent reduction in NOx compared with current standards. Programs to develop technologies to reduce aircraft emissions even further have been planned by NASA, FAA, and other government agencies. The Ultra Efficient Engine Technology pro-gram starting in FY 2000 will reduce NOx by 70 percent and CO2 by 15 percent. Overall engine efficiency and CO2 emissions are also being improved by fewer compressor and turbine stages, advanced materials, and supporting subsystems.



NASA has been measuring Antarctic ozone levels since the early 1970s. Though ozone holes (shown in blue) of substantial size and depth are likely to continue to form during the next few years, scientists expect to see a reduction in ozone losses as levels of ozone-destroying chemicals are reduced.

NASA

John Glenn Space Shuttle Mission

The number of Americans 85 years or older is projected to grow from 3.3 million today to 18.9 million by 2050. Gerontologists say more research into diseases affecting the elderly could reduce the number of individuals requiring expensive, full-time medical care in their later years. Space flight life sciences research has demonstrated a number of parallels between the effects of spaceflight and those of aging, including bone mineral loss and muscle atrophy, changes in cardiovascular regulation, disturbances in the control of balance, disruption of sleep and circadian rhythms, and changes in immune system functioning. The gerontology research community is interested in the possibility of using many of the physiological changes induced by spaceflight as models for better understanding processes associated with aging. NASA is working jointly with the National Institute on Aging at NIH, to understand better the relationship between aging and spaceflight.

The Space Shuttle mission with John Glenn, STS-95, provided a boost for this new and exciting area of research. NASA collected important preliminary observational data from experiments, including studies of the effects of space flight on sleep regulation, muscle atrophy, cardiovascular regulation, balance and posture, and immune function. Future experiments will examine the changes in younger crew members and compare them to older people
on Earth. NASA is also using appropriate animal and cell culture models.

National Aeronautics and Space Administration:
http://www.nasa.gov/

Related Sites:
NASA Commercial Technology Network:
http://www.nctn.hq.nasa.gov/

Non-surgical Breast Biopsy Technique

A new, non-surgical and much less traumatic breast biopsy technique, based on technology developed for NASA's Hubble Space Telescope, is now saving women time, pain, scarring, radiation exposure, and money. Radiologists predict the new technique, known as stereotactic large-core needle biopsy, will reduce national health care costs by approximately $1 billion annually. Performed with a needle instead of a scalpel, the procedure leaves a small puncture wound rather than a large scar. The patient is conscious and under local anesthesia.

The new technique involves a NASA-driven improvement to the digital imaging technology known as a Charge Coupled Device (CCD) which is a high tech silicon chip that converts light directly into digital images. In the breast imaging system, a special material enables the CCD to convert X-rays to visible light, giving the system operator "X-ray vision." Prior to the development of NASA's Hubble Space Telescope, this thin and highly sensitive CCD was not available commercially.

Hot Spot Watch

In Spring 1999, the extensive fires in Florida, Mexico, Brazil, and Indonesia catapulted wildfires into the news headlines. From April 15-19, 1999, the closure of a 60-mile stretch of Interstate 75 in Florida caused major congestion on alternate east-west routes. To the north of the Interstate, wildfires in the Everglades continued to burn acres of sawgrass. NASA remote sensing capabilities enabled experts to predict "hot spots" of potential risk in future fires. Providing a valid warning system, NASA helps environmental agencies prevent disasters rather than simply react to contain the disaster.

Using data from satellite sensors, aircraft, and ground-based initiatives, scientists are working to develop a new global fire-monitoring program that will enable them to better understand the myriad implications of this problem. Specifically, efforts are underway to quantify the total area of forests and grass land burned each year and to more precisely estimate the amount of resulting emission products. These newer and better data will facilitate development of more robust computer models that will enhance scientists' abilities to predict how biomass burning will impact climate, the environment, and air quality.

National Science Foundation

MISSION

Created in 1950, the National Science Foundation (NSF) promotes and advances progress in science and engineering research and education in the United States. NSF's authorizing legislation directs the Foundation to initiate and support:

- **Basic scientific research and research fundamental to the engineering process;**
- **Programs to strengthen scientific and engineering potential;**
- **Education programs at all levels in all fields of science and engineering: and**
- **An information base for science and engineering appropriate for the development of national and international policy.**

NSF-funded research in the polar regions has led to a greater understanding of global warming, Earth's history, and the origins of the universe.

National Science Foundation

For five decades NSF has promoted and advanced S&T progress in the national interest by investing in the intellectual and physical infrastructure for science and engineering in the United States. During this time, NSF has supported 100 U.S.-based Nobel Prize winners doing research in areas ranging from physics and astronomy through economics and medicine. NSF recognized the promise of 18 of these 100 Nobel Prize winners early on, investing in their graduate research and education endeavors through the NSF Graduate Fellowships program.

One recent example of Nobel prize-winning work enabled by NSF support is that of Daniel Tsui of Princeton University, Horst Stormer of Columbia University and Lucent Technologies, and Robert Laughlin of Stanford University. They shared the 1998 Nobel Prize in Physics for the discovery of a new form of quantum fluid with fractionally charged excitations. Tsui and Stormer made the discovery in 1982 using the extremely powerful magnetic fields and low temperatures available to users of the NSF-funded National Magnet Laboratory located at MIT. According to conventional wisdom at the time, the observed behavior was impossible. Within a year of the discovery, Laughlin successfully explained their result. Knowledge of how electrons behave is essential to our understanding of how electronic circuits in computers work. And as individual elements of these circuits become smaller, these quasi-particles may become an important force that in turn could impact the future information society.

In FY 1999, NSF invested approximately $2.7 billion in research, with $650 million allocated to relevant science, mathematics, engineering, and technology education. Approximately 1 percent supported intramural research, 5 percent was allocated to industry, 80 percent was allocated to research in academic institutions, 4 percent was allocated to Federally Funded R&D Centers, and 11 percent funded research at other nonprofit organizations. Much of the NSF funding that goes to non-academic organizations is used to support academic research infrastructure. NSF funds creative, innovative ideas proposed by the most capable people in the pursuit of new knowledge, discoveries, and innovation. The agency provides Federal funds through grants to approximately 2,000 colleges, universities, K-12 schools, academic consortia, nonprofit institutions, and small businesses throughout the United States. These grants support nearly 200,000 scientists, engineers, mathematicians, teachers and students ranging from K-12 to postdoctoral associates, while indirectly impacting far greater numbers through dissemination activities.

Examples of Recent NSF S&T Achievements

Plant Genomes

NSF, working with other organizations here and abroad, was the lead agency in establishing Arabidopsis thaliana as a model for understanding

the biology of flowering plants. Arabidopsis, commonly called the thale cress or mouse eared cress, is a small annual weed that belongs to the mustard family. It has the smallest known genome of any flowering plant. In cooperation with genome centers worldwide, NSF expects that the complete genomic sequence of Arabidopsis will be available by the end of this year.

Scientists have already sequenced approximately 80 percent of the Arabidopsis genome, and existing sequence data are freely available to the scientific community through public databases. Scientists are using this genetic information to explore the basic biology of all flowering plants and to engineer improvements in agriculturally-important crop plants. For instance, NSF-supported researchers recently succeeded in engineering plants that are more tolerant to cold temperatures. This work has profound implications for agricultural productivity since crops that are even a little hardier are much more likely to withstand sudden cold snaps that often cause major crop losses.

Developing Essential Competencies in Mathematics and Science

NSF helps in the development of essential skills in mathematics and science for all Americans by promoting system-wide reform in science, mathematics, engineering and technology education that is based on national standards. Educators in the NSF-supported Urban Systemic Initiative (USI) initiated science and math education reform in urban areas with the largest number of children living in poverty. Twenty-one cities are using the USI to enhance access to high quality math and science education through various approaches such as modifying curricula, facilitating teacher training, and creating partnerships with communities. Activities benefit more than 4,000 schools and reach nearly 3.4 million children. For example, fourth grade students in Detroit Public Schools nearly doubled their math proficiency from 1994 to 1998, and the science proficiency of fifth grade students nearly doubled from 1996 to 1998.

The NSF-funded genome research project to map Arabidopsis will yield important information about how flowering plants interact with their

Role of Polar Research in Understanding Global Systems and the Environment

The polar regions have special significance for studies of the environment and provide insight into global change mechanisms and the possible effects of a greenhouse world. Polar regions are especially sensitive to climate change because of the many processes that are affected by low temperatures or by phase changes of water between the liquid and solid state.

In October 1997, a joint venture of NSF, NASA, the Canadian Space Agency, and the RADARSAT Corporation developed the first complete radar mapping coverage of Antarctica. It is an accurate map of the Antarctic ice sheets and ice shelves, and provides an unprecedented baseline for studies of glacial processes. Monitoring changes in the configuration of the ice sheet is now possible. Research projects to exploit this map are now underway as a joint effort of the NSF and NASA.

environments.

Martin Yanofsky, University of California at San Diego

At the other pole, an icebreaker was frozen into the Arctic ice-pack for a full year to serve as a platform for collecting information that is critical to improvements in Global Circulation Models (GCMs) used to predict future climates. Results indicate that the ice pack has undergone major melting episodes and that the resulting increase of moisture in the atmosphere is contributing to an increased rate of ice pack melting. Initial results have already shown ways that GCMs can be improved to account for the influence of the ice packs on global climate.

The Bose-Einstein Condensate: A New State of Matter

Our fundamental understanding of matter at the quantum level has been impacted by the recent creation of a new state of matter: the Bose-Einstein Condensate. This discovery promises profound technological implications in the 21st century. Using modern laser technology, with its adaptation to laser cooling techniques, NSF-supported scientists created this new state of matter in the laboratory. The Condensate is the coldest matter in the universe, and scientists are now beginning to develop tools and techniques to probe and manipulate it. Applications could include the development of new lithography techniques for assembly of tiny, nanoscale objects, and the possible creation of an atom laser.