Information Technology Research and Development

The President's FY 2001 budget proposes $2.315 billion for Information Technology (IT) Research and Development (R&D), $594 million more than last year's appropriations and a billion dollars more than the FY 1999 appropriation. The largest increases above FY 2000 funding are proposed for the National Science Foundation, which is leading the interagency effort (+$223M), the Department of Energy (+$150M), the Department of Defense (+$115M), the National Aeronautics and Space Administration (+$56M), and the Department of Health and Human Services (+$42M).

IT R&D Budget Summary

	FY 2000 ($M)	FY 2001 ($M)	Percent Increase
Department of Commerce (NOAA and NIST)	$ 36	$ 44	22%
Department of Defense (DARPA, NSA, and URI)	$ 282	$ 397	41%
Department of Energy	$ 517	$ 667	29%
Environmental Protection Agency	$ 4	$ 4	0%
Health and Human Services (NIH and AHRQ)	$ 191	$ 233	22%
National Aeronautics and Space Administration	$ 174	$ 230	32%
National Science Foundation	$ 517	$ 740	43%
TOTAL	**$1,721**	**$2,315**	**35%**

Information technology innovations are transforming the way we live, learn, work, and play. New computing, networking, and communications tools allow Americans to shop, do homework, and get health care advice online, and enable businesses of all sizes to join the international economy. Since 1995, more than a third of all U.S. economic growth has resulted from IT enterprises, and during the past decade, more than 40 percent of U.S. investment in new equipment has been in computing devices and information appliances.

As computers, high-speed communication systems, and computer software become more powerful and more useful, IT penetrates deeper into our home, work, and education environments. Nearly half of all American households now use the Internet, with more than 700 new households being connected every hour. More than half of U.S. classrooms are connected to the Internet today, compared to less than three percent in 1993. In 1993, only a few technical organizations knew what an address like http://www.whitehouse.gov meant, and today, there are nearly 13 million registered addresses. Today, more than 13 million Americans hold IT-related jobs, which are being added six times faster than the rate of overall job growth.

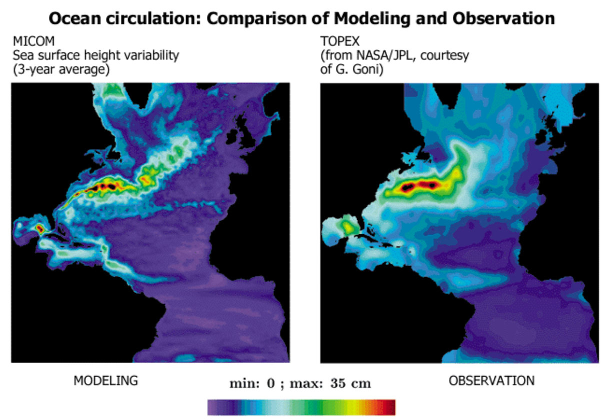
This astonishing progress has resulted from Federal agency investments in research conducted in universities, Federal research facilities, and partnerships with private firms. The Federal HPCC Program met its 1996 goals of demonstrating computers that perform a trillion operations per second and communication networks that transmit a billion bits per second. The Next Generation Internet initiative has exceeded its year 2000 goals by connecting more than 200 universities and other research centers at rates 100 times faster than those available when the project began and more than 20 institutions at rates 1,000 times faster. Ultra-high-speed networks are being developed that provide connections nearly 20 million times faster than typical Internet connections to home computers.

Creative businesses have translated the results of Federally-funded advanced research into the innovative products enjoyed today. The President's Information Technology Advisory Committee emphasizes, however, that continued Federal investment is essential to maintain this momentum. The Administration responded to the Committee's proposals in FY 2000 with a major increase in IT research funding through the Information Technology for the Twenty-first Century initiative and continues to build on the Committee's recommendations with additional increases in the FY 2001 budget, which reports all aspects of IT research in a single integrated program.

Agencies will continue to support the basic goals established in last year's initiative, focusing on fundamental research in software; development of information systems that ensure privacy and security of data and allow people to get information they want, when they want it, in forms that are easy to use; support for continued advances in high-speed computing and communications, including work needed to ensure that raw speed translates into usable speed; and work to understand the social, economic, and other impacts of IT with emphasis on ensuring that all Americans will benefit from these technologies. The U.S. research community responded to last year's call for research ideas with a flood of creative new proposals. As a result, with FY 2000 funding, NSF will start 25 small research centers and five larger centers.

FY 2001 IT R&D priority areas include:

Teams to Exploit Advances in Computing: Expanded activities will support new partnerships where information scientists, mathematicians, and experts in areas such as medical research, weather modeling, and astronomy can work together to build tools for solving the Nation's most pressing information problems. These partnerships will advance information science and lead to research breakthroughs in application areas. Partnership projects will dramatically improve the way we design and test new drugs before using them on humans; simulate weather to forecast the paths of hurricanes and tornadoes with greater precision and longer lead times; predict the impacts of El Niño and La Niña events; simulate complex systems such as high-energy accelerators and nanoscale material structures; and understand global climate change. They will also allow design of new materials and chemical processes and contribute to our understanding of the basic forces that have shaped our universe – the formation of stars, galaxies, black holes, and other objects discovered in distant space.



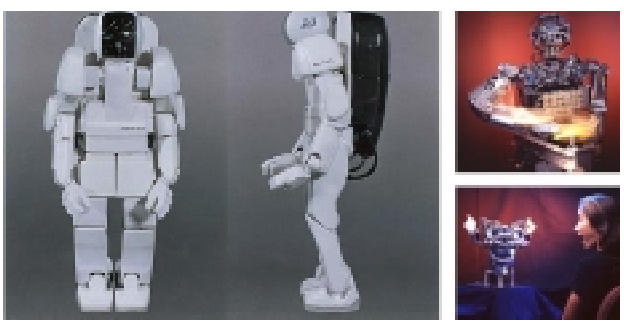
Close correlation between simulated and observed data result from improved numerical models and high resolution capabilities of advanced computing systems.

Infrastructure for Advanced Computational Modeling and Simulation. In FY 2001, NSF plans to establish a second terascale computing facility to support the civilian research community. Operating at speeds more than five trillion operations per second, this facility, along with the initial site to be established using funds appropriated in FY 2000, will enable our Nation's scientists and engineers to tackle the most challenging computation- and information- intensive problems. DOE will accelerate the development of component software technologies and other software infrastructure essential to the effective application of terascale systems to scientific problems.

More Reliable Software. Despite advances in IT, software bugs continue to shut down airports, delay product shipments, and crash 911 emergency systems. Our goal is to develop ways to design and test software that can be as productive, and predictable, as the tools used to design and test aircraft and bridges. One aspect is finding better ways to ensure that software written for one generation of computers can be moved to new machines without error-prone adjustments.

Storing, Managing, and Preserving Data. The amount of on-line information is growing daily, and current networks and data storage systems are straining to support these vast amounts of data. Research will include developing devices capable of storing a year's output of such systems in hardware the size of PC hard disks; searching data in a variety of formats including pictures, video, and audio; and developing improved ways of filtering information, mining data, and tracking lineage and quality of information. The ability to better store and manage data is critical to programs such as NOAA's long term data archival. In December 1999, NASA launched its flagship Earth Observing System (EOS) satellite, Terra, to monitor climate and environmental change on Earth. Terra's five scientific instruments will produce more than 194 gigabytes of data per day, with one gigabyte equaling about four sets of 29-volume encyclopedias. When fully deployed, the first series of EOS missions will generate 500 gigabytes of data per day. New data assimilation and visualization technologies will serve to translate this vast quantity of data into usable information products.

Intelligent Machines and Networks of Robots. Ubiquitous robots of all scales, from human to millimeter and micron, will revolutionize our daily lives. Intelligent spacecraft carrying optical units will fly together to create a single deep space telescope of unprecedented size, or a swarm of micro-rovers will collectively explore portions of Mars. Robots will assist surgeons, monitor the environment for pollutants or biochemical pathogens, conduct hazardous tasks, or simply perform household tasks. NASA researchers, with university and industry partners, are seeking ways to put new levels of intelligence into exploratory machines. These machines, working with human explorers, will investigate the cosmos and provide information that may change our views of the universe. They will be smart, adaptable, curious, self-sufficient in unpredictable environments, and capable of collaborating. Closer to Earth, these advanced information technologies will provide a catalyst or



DARPA-funded researchers are using information technology to build robotic prototypes that can better understand and emulate human intelligence.

profound change. A new generation of cognitive computer prostheses, for example, will help pilots and air traffic controllers achieve safer aircraft operation in increasingly congested air and ground spaces. And an intelligent, adaptive web of Earth orbiting satellites will collect and extract knowledge in genetics research to improve our ability to fight disease and cure human illnesses.

Ubiquitous Computing and Wireless Networks. DARPA and NSF research in embedded computer devices will help free humans from keyboards and wires and overcome language barriers. These embedded systems will enable people to communicate with computer devices via speech, gesture, and haptic (touch) devices, and may even be able to sense a human's intentions and automatically provide needed information. With the next generation of connectivity, individuals will want access not only to people around the world, but to millions of sensors, controls, and other embedded information systems. The importance of a central Internet will be augmented by the need to network thousands of "smart," primarily wireless devices that we will carry with us or will move with us in our automobiles or appliances. These devices will require ubiquitous communication to give us consistent views of our environment, our health, and the changing world. Advances in this research will allow for safer management of highways and air traffic, safer and more reliable hospitals and other medical care facilities, and more responsive command and control systems for national security.

Managing and Ensuring the Security and Privacy of Information. As computing and communications technologies merge, data are becoming increasingly vulnerable to unintended use. To help protect data in applications such as e-commerce, software distribution, network protection, and digital watermarking, DoD and NIST will continue to support cryptography and encryption research begun in the late 1970s. Public-key encryption uses different "keys" (or codes) for communication so that one *public* key allows encryption and another *private* key removes the encryption. Public-key cryptography has revolutionized computer-communication security by providing new approaches to authentication and confidentiality. As the amount of sensitive on-line data grows, and as the sophistication and frequency of "hacker" intrusions increase, we will continue to support basic research in cryptography and encryption to help protect tomorrow's data.

Future Generations of Computers. New paradigms will use advances in quantum computing and molecular or nano-electronics to devise radically faster computers that will solve problems previously described as "uncomputable," such as climate modeling, full-scale biosphere simulations, dynamics of the universe, and surgical simulations. For example, bio-informatics research will help us manage vast quantities of genomic data, understand the expression and control of genetic circuits, and advance treatments for certain kinds of cancers.

Viewing cells as computational devices will help enable the design of the next generation of computers. Unlike current computational devices, these computers will feature self organization, self repair, and adaptive characteristics seen in biological systems.

Broadband Optical Networks. DARPA-funded researchers have shown that optical networking can provide 1,000 fold improvements in network backbone speeds, and these technologies are already employed in commercial high-speed backbone links. For end users to take full advantage of these speeds requires improvements in optical switching and development of all-optical end-user access technologies. Optical networking has near-term application in health care, meteorology (for use in air traffic control), and other civilian infrastructures.

Social, Economic, and Workforce Implications of IT. IT is already transforming our society in many ways, and the pace of advances in IT is accelerating. To realize the promise of these new technologies, NSF will invest in research to identify, understand, anticipate, and address the promises and social, economic, and workforce challenges resulting from the rapid integration of IT in our lives.

Educate and Train a New Generation of Researchers. New researchers will be critical to increase the capacity for IT research and teaching. These IT investments will fund additional researchers and support major research centers. Programs such as the partnerships to exploit advances in computing will provide NSF, DOE, and NIH opportunities to bring together related specialties and train a new generation of researchers whose skills will cross-disciplinary boundaries.