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ABSTRACT

This committee report is intended to accompany S. 1067, a bill designed to provide for a coordinated federal research program in high-performance computing (HPC). The primary objective of the legislation is given as the acceleration of research, development, and application of the most advanced computing technology in research, education, and industry. Each of the seven titles of the bill is discussed in detail: (1) Title 1 establishes an interagency National HPC Program to provide for coordination of the federal agencies involved in high-performance computing by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET); (2) Title 2 calls for the creation of a National Research and Education Network (NREN) to link researchers in government, industry, and universities around the country; (3) Title 3 makes the National Science Foundation the lead agency for ensuring that federally funded databases and network services can be accessed over the network; (4) Title 4 calls for expanded software research and development, especially on software for supercomputers; (5) Title 5 provides for research on supercomputers and encourages development of new supercomputing technology by the private sector; (6) Title 6 requires the White House Office of Science and Technology Policy (OSTP) to oversee and coordinate federal programs for basic research in computer technology and for the education of computer scientists, computational scientists, information scientists, and electrical engineers; and (7) Title 7 authorizes funding for the National Science Foundation and the National Aeronautics and Space Administration for the purposes of the bill. Also discussed are the benefits of and need for high-performance computing, and the legislative history of the bill. (DB)

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Calendar No. 710

101ST CONGRESS *2d Session*	SENATE	REPORT 101-387

HIGH-PERFORMANCE COMPUTING ACT OF 1990

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

OF THE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ON

S. 1067

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Calendar No. 710

101ST CONGRESS
2d Session

SENATE

REPORT
101-387

HIGH-PERFORMANCE COMPUTING ACT OF 1990

JULY 23 (legislative day, JULY 10), 1990.—Ordered to be printed

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

[To accompany S. 1067]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 1067) to provide for a coordinated Federal research program to ensure continued United States leadership in high-performance computing, having considered the same, reports favorably thereon with an amendment in the nature of a substitute and recommends that the bill as amended do pass.

PURPOSE OF THE BILL

The primary objective of the legislation is to accelerate research, development, and application of high-performance computing in research, education, and industry. High-performance computing is the most advanced computing technology—the most sophisticated computer chips, the fastest computers with the largest memories, the fastest algorithms, and the fastest computer networks.

This bill authorizes Federal funding for the development and use of new supercomputers, advanced software, and a National Research and Education Network (NREN), a computer network capable of transmitting billions of bits (gigabits) of data per second. In total, the bill authorizes $650 million for the National Science Foundation (NSF) and $338 million for the National Aeronautics and Space Administration (NASA) for fiscal years (FY) 1991-95.

The bill also establishes a National High-Performance Computing (HPC) Program involving NSF, NASA, the Department of Energy (DOE), and the Defense Advanced Research Projects Agency (DARPA) of the Department of Defense (DOD), as well as

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other agencies. This program would be planned and coordinated by the White House Office of Science and Technology Policy (OSTP).

Background and Needs

IMPORTANCE OF COMPUTING

In the last 30 years, computer technology has transformed American science and industry. Today, computers are indispensable tools found in almost every laboratory, office, and factory. They have enabled researchers to solve previously unsolvable problems; have transformed the way products are designed, manufactured, and marketed; have changed the way offices are operated; and have given teachers a new, powerful educational tool.

The last five years have seen a rapid increase in the use of supercomputers in science and engineering. Supercomputers are commonly defined as the most powerful computers available at any given time. They usually cost $1–$20 million and are 1,000 to 100,000 times more powerful than a typical personal computer. Today's supercomputers are capable of making billions of mathematical calculations per second, which is about 50 to 100 times faster than the fastest computers available just ten years ago. Using complex computer "models," researchers now can simulate and test the behavior of advanced aircraft designs, proposed new drugs, and new manufacturing techniques. Scientists have used supercomputer models to understand better the Earth's climate and weather, the Nation's economy, the evolution of our galaxy, and even the voting patterns of Members of Congress.

To facilitate communication among researchers, students, and educators, and to promote the use of advanced computers, NSF and other Federal agencies have established fiber optic computer networks, which link researchers around the country to supercomputers, to other computing facilities, and to each other. Unlike copper telephone wires, fiber optic cable is capable of carrying the billions of bits of data generated every second by supercomputers. Such high data rates are needed because, for many types of computer models, scientists need sophisticated "visualization" techniques to sort out their results. Computer graphics allow researchers to decipher data sets so large that they could fill hundreds of pages of computer printouts. Unfortunately, most computer networks operate at speeds of 1.5 million bits (megabits) per second or less, and thus network users cannot utilize supercomputers fully.

Faster networks also will allow researchers to retrieve huge volumes of data (e.g., satellite images) from data bases and to share their own data with others. Multi-gigabit networks would allow scientists and engineers to control and collect data from research facilities (e.g., particle accelerators and radio telescopes) from thousands of miles away, reducing the need for expensive, time-consuming travel. These high-speed networks would allow researchers around the country to collaborate over the network as effectively as they could face-to-face, leading to the creation of what has been termed a National Collaboratory.

In recent years, support has been growing for a large increase in Federal funding for high-performance computing. A November 1985, White House Science Council report, "Research in Very High

Performance Computing," states: "The bottom line is that any country which seeks to control its future must effectively exploit high-performance computing. A country which aspires to military leadership must dominate, if not control, high-performance computing. A country seeking economic strength in the information age must lead in the development and application of high-performance computing in industry and research." At a July 21, 1989, committee hearing on his nomination to his current position, Dr. Allan Bromley, the President's Science Advisor and Director of OSTP, stated that high-performance computing must be "a very high priority" because "it has a catalytic effect on just about any brand of research and development" and "will, eventually, transform industry, education, and virtually every sector of our economy, bringing higher productivity and enhanced competitiveness." In a similar vein, a 1989 OSTP report, written by representatives from over a dozen Federal agencies, calls for new funding to "maintain and extend U.S. leadership in high-performance computing."

CONGRESSIONAL ACTION

Similar interest has been shown in both houses of Congress. In order to spur development of faster computer networks and more advanced supercomputers, in 1986, the Committee reported legislation authorizing NSF programs, which included legislation introduced by Senator Gore, to require OSTP to provide Congress with an analysis of the computer networking needs of American researchers and the benefits and opportunities that a national high-speed fiber optic network for computers and supercomputers would provide. That legislation was enacted into law as part of the NSF Authorization Act for FY 1987 (P.L. 99-383, 100 Stat. 816).

As required by the legislation, OSTP released a report in December 1987 entitled "A Research and Development Strategy for High Performance Computing," which outlined an ambitious, comprehensive research program in supercomputing and computer networking, and proposed that the Federal Government spend an additional $1.74 billion over the next five years on high-performance computing. This report was followed in September 1989 by an implementation plan for the program, "The Federal High Performance Computing Program," which was developed by more than a dozen agencies working with OSTP. While that report presented a five-year funding profile for a high-performance computing program, the President has yet to endorse the additional funding needed to implement it. However, there are reports that the Administration is preparing a major initiative in this area for FY 1992. The high-performance computing program outlined in the OSTP reports has four elements: high-performance computers; software technology and algorithms; networking; and basic research and human resources.

In 1988, S. 2918 was introduced by Senator Gore to create a National HPC Program, similar to that outlined in the 1989 OSTP report. The following year, Senator Gore introduced S. 1067 authorizing funds for high-performance computing at NSF, NASA, DOE, and DARPA. As introduced and as reported this bill differs from the OSTP reports in several ways: it places more emphasis on pro-

viding access to scientific data; it seeks to increase industry involvement in a Federal HPC program; it emphasizes more the role of high-performance computing in education; and it specifies funding levels for the different agencies in the program.

The first title of the reported bill provides for coodination between the Federal agencies involved in high-performance computing through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which is chaired by the Director of OSTP. In recent years, FCCSET has provided critically-needed, high level interagency coordination of research in a number of areas, most notably global change. The second title of the bill mandates creation, by 1996, of the NREN, a national fiber optic network capable of transmitting billions of bits of data per second from coast to coast. The third title gives NSF responsibility for promoting development of data bases and other information services, which would be available over the NREN. The fourth title provides for development of improved software for supercomputers and other computers. The fifth title funds research and development on new, more advanced supercomputers and related systems. The sixth title calls for more basic research in computing and expanded efforts to educate and train computer scientists and computational scientists (users of high-performance computing). The seventh and final title provides authorizations for NSF and NASA for their contributions to the National HPC Program.

To fully reap the benefits of high-performance computing, the Federal Government needs to implement a comprehensive research and development program similar to that provided for in S. 1067. Because the components of the program are all closely linked, progress in high-performance computing will be hindered if the pace of development in any one area is not as fast as in other areas. For instance, if a national high-speed computer network were established, but if faster, more powerful supercomputers were not developed to handle the data that would flow across such a network, the result would be missed opportunities and wasted resources. Similarly, the development of faster supercomputers, without the development of software needed to utilize them effectively and of networks to access them, would be a poor investment of research funds. Clearly, there is a need for a balanced, comprehensive approach.

BENEFITS OF S. 1067

Most of the funding authorized in S. 1067 is in support of basic research. There is broad agreement on the general need for the Federal funding of basic research—basic research has been shown repeatedly to be a good investment. For example, in a soon-to-be published study, Dr. Edwin Mansfield of the University of Pennsylvania estimated that the annual rate of return on Federal investments in academic research is approximately 28 percent.

The return on investments in basic research on high-performance computing may be even higher. On July 26, 1989, in testimony before the Science, Technology, and Space Subcommittee, Dr. James H. Clark, Chairman and Founder of Silicon Graphics Computer Systems, told how a single $12 million DARPA research

grant which Dr. Clark and his colleagues received while he was a professor at Stanford from 1979 to 1982 led directly to the creation of SUN Microsystems, Silicon Graphics Computer Systems, and MIPS Computer Systems. Today, just eight years later, these three computer companies have combined total revenues of almost $2.5 billion per year and an average annual growth rate of 60 percent.

In addition, because high-performance computing represents an enabling technology which can increase greatly the productivity not only of computer scientists, but also of researchers in almost all fields of science and engineering, the returns are likely to be greater than the average return on investments in basic research. This research will lead to faster, more powerful computers than can tackle previously unsolvable problems; faster networks that can provide easier access to data and promote collaboration between researchers; and better software that can reduce the time spent computing the solution to a particular problem and thus allow researchers time to explore more facets of a problem.

The investment proposed by S. 1067 would provide needed tools for federally-funded researchers and enhance greatly their productivity. At a June 21, 1989, hearing of the Science, Technology, and Space Subcommittee, Dr. William Wulf, then Assistant Director of NSF's Directorate for Computer and Information Science and Engineering, testified that supercomputing and high-speed networking can increase the productivity of many American researchers by 100 percent, 200 percent, or more. Given that the Federal Government invests approximately $70 billion a year in research and development, such a productivity gain could produce enormous benefits and more than pay for the approximately $2 billion total cost of funding the National HPC Program for the next five years.

High-performance computing will allow researchers to tackle previously unsolvable problems, with huge benefits to society. For instance, better models of global climate change would lead to better policies to address global warming, policies which could have trillion-dollar impacts. Supercomputing could lead to a better understanding of AIDS, cancer, and genetic diseases, leading to breakthroughs impossible without more computing power.

Just as important as the benefits to American researchers are the benefits for American industry. Supercomputers are routinely used by automobile companies, both to design and to "crash test" cars; energy companies use them to analyze seismic data and prospect for oil; and even financial markets now utilize them to get real-time analyses of market behavior. On June 21, 1989, Mr. John Rollwagen, Chief Executive Officer of Cray Research Inc., testified before the Science, Technology, and Space Subcommittee that ARCO used a Cray supercomputer to determine how to increase production of its Prudhoe Bay oil field by two percent, which translates into an additional $2 billion in profits. The engines on Boeing's new 737 airplane were designed using a supercomputer and, as a result, are 30 percent more efficient than earlier models. ALCOA used supercomputer models to reduce the amount of aluminum needed to produce a soda can by 10 percent, resulting in millions of dollars in reduced materials, production, and transportation costs.

In the United States, the most extensive use of supercomputers has been for defense and aerospace applications. The National Security Agency (NSA) relies heavily on the fastest supercomputers for signal processing and breaking codes. Supercomputers are essential for anti-submarine warfare and for the design of new weapons systems. The Strategic Defense Initiative and other military research and development projects rely heavily on supercomputer modeling. NASA has several supercomputers devoted to modeling the aerodynamics of aircraft and spacecraft. These supercomputers can be used to replace or complement expensive wind tunnel tests.

In the future, high-performance computing will be utilized increasingly by the education and library communities. Supercomputers can store and sort through huge quantities of data, and with optical disk storage systems it is possible to store entire libraries of information electronically and retrieve them in seconds. The Library of Congress and other libararies are starting to develop the technology needed for "digital libraries" of books, journals, images, music, and videos—all stored in digital form and accessible over computer networks. Title III of S. 1067 as reported would provide for expanded efforts to develop such digital libraries.

In addition, title III provides for existing Federal data sets, like weather satellite data and census data, to be available on the NREN. At present, a great deal of scientific and economic data is stored in electronic form, but much of it, especially remote-sensing satellite data, is almost inaccessible to researchers and other users. The bill would make data sets like those at the Earth Resources Observation System (EROS) Data Center accessible over the NREN and other networks, thus greatly enhancing the usefulness of these data sets and ensuring that the United States maximizes the return on its investment in the collection of that data.

One of the most far-reaching impacts of the bill would be in the area of high-speed, fiber-optic telecommunications technology. Fiber-optic cable can transmit billions and even trillions of bits of data per second, thousands of times more than long-distance copper telephone cables. Scientists and engineers are using this new capability to develop technology for teleconferencing, for using supercomputers and other research equipment remotely, and for improving communication and collaboration among computer users. By creating a national, high-speed computer network, this bill would provide a demonstration of the potential of high-speed fiber optic computer networks.

Under this bill, the Federal Government would fund creation of a national multi-gigabit network and development of applications that use it. The technology and standards developed will be available publicly and will be applied quickly by private companies building commercial multi-gigabit networks. At present, the private sector is reluctant to make the multi-billion-dollar investments needed to build a national multi-gigabit network, in part because the technology has not been demonstrated and the market has not been proven. The Federal funding called for in this bill will demonstrate the benefits of a high-speed national network and lead to development of standards for such a network, this stimulating private-sector investment in multi-gigabit networking. At an October 4, 1989, hearing of the House Energy and Commerce Subcom-

mittee on Telecommunications and Finance, John Edwards from Northern Telecom testified that Federal funding authorized by this bill could accelerate the creation of a national, multi-gigabit network by 5 to 10 years. Like the interstate freeway system and other types of infrastructure, such a network would provide untold benefits to all sectors of the American economy.

HPC AND U.S. COMPETITIVENESS

The development of HPC will have a significant impact on U.S. technology competitiveness, particularly given the efforts of other countries to develop a supercomputing capability. The Japanese and other foreign competitors have been quick to recognize the benefits of supercomputing and fiber optic networks. In fact, the Japanese have targeted the world supercomputer market and are now producing some of the fastest supercomputers available. In April 1990, Japan announced a major research program to accelerate research and development on parallel processing supercomputers. Similarly, other countries are making massive investments in high-speed fiber optic networks. Japan's Nippon Telegraph and Telephone Corporation has announced that it intends to invest $126 billion to install a national fiber optic network which would reach every home, office, and factory in Japan by the year 2015 and be capable of transmitting hundreds of millions of bits of data per second. The Europeans are developing initiatives to build their own high-speed networks as part of EC 92.

Without additional Federal and private-sector investment in supercomputing, the United States risks losing the $2.4 billion world supercomputer market, and more importantly, it risks having to rely upon foreign suppliers for an essential tool in improving research and development, in increasing American competitiveness, and in enhancing U.S. national security. The funding authorized by S. 1067 would help the United States maintain its lead in the development and application of supercomputers.

NEED FOR ADDITIONAL HPC FUNDING

To provide supercomputing services to American researchers, the NSF created five supercomputer centers in the mid-1980s. For FY 1991, NSF is requesting $59.59 million to fund the centers. Other Federal agencies, including NASA and DOE, also maintain large supercomputers for use by Federal and academic scientists.

The science agencies also fund several computer networks, including NSF's NSFNET, NASA's NASNET and SPAN (Space Physics Analysis Network), DOE's MFENET and HEPNET, and DOD's MILNET. Together with many State-funded or for-profit regional networks, several of these networks are linked by the Internet, which consists of over 2,000 interconnected networks. While it is not known exactly how many computers communicate via Internet, most estimates are that well over 100,000 computers are linked in this way.

However, present supercomputing and networking programs are not adequate to meet the needs of researchers. The supercomputers at the NSF centers are chronically over-subscribed. DARPA and other agencies which fund development of new supercomputers

lack the money to fund more than a small fraction of the promising proposals for new types of machines, which can cost from $10 million to $500 million to prototype. Furthermore, researchers are often frustrated by the lack of useful research software for supercomputers which stems from the lack of adequate funding for supercomputer software development.

Perhaps even more importantly, inadequate funding levels would result in a delay in the establishment of the NREN. The NREN would be capable of transmitting gigabits (billions of bits) of data per second, and by 1996 would link up to 1,300 institutions and about a million researchers nationwide. The NREN would be about 2,000 times faster than the current NSFNET. While this nationwide computer network links over 500 institutions in all 50 States its data rate is only 1.5 million bits per second, more than a thousand times slower than the proposed NREN. Even after NSFNET is upgraded to 45 million bits per second this year, researchers will be unable to utilize fully the supercomputers and data bases connected to it. Since use of NSFNET is growing at a rate of 20 to 30 percent each month, its new capacity will not be enough to accommodate the increased usage expected in the next two or three years. For FY 1991, NSF has requested $22.04 million for NSFNET. Additional funding for both NSF and DARPA will be needed to develop a multi-gigabit NREN.

The multi-gigabit NREN is needed if researchers are to use the new networking technology being developed in laboratories around the country. The first computer networks, built in the late 1960s, enabled computers to exchange data at rates of a few thousand bits of data a second (a single page of double-spaced text represents about 10,000 bits of data). Today, there are experimental computer networks that can transmit billions of bits of data a second, enabling computer users to share computer graphics and huge volumes of data in a few seconds. At a billion bits a second, the entire Encyclopedia Brittanica could be transmitted to any computer on the network in less than a second. Unfortunately, these experimental networks are limited, connecting only a few computers. More research and development will be needed before the NREN, which will connect thousands of computers, can be built.

According to the President's FY 1991 budget request (p. 85, "Budget of the United States Government)," in FY 1990, the Federal Government spent $448 million on high-performance computing, and for FY 1991, the President is requesting $469 million, an increase of five percent, which barely covers inflation. Without additional funding, researchers will not have access to the supercomputing resources they need; the NREN will be delayed; development of new, more powerful machines will be delayed; supercomputer software development will slow; and insufficient numbers of scientists and engineers will be trained to use supercomputers.

The funding authorized by S. 1067 would roughly double funding for supercomputing at NSF and NASA over the next five years, and would roughly triple NSF's networking budget. These funding increases parallel those outlined in the 1987 OSTP report and the follow-up report released in September 1989, "The Federal High Performance Computing Program."

Legislative History

On May 18, 1989, Senator Gore introduced S. 1067, legislation similar to S. 2918, which Senator Gore had introduced in October 1988. S. 1067 is cosponsored by Senators Jeffords, Durenberger, Pell, Kasten, Conrad, Fressler, Lott, Wirth, Sasser, Kohl, Bryan, Graham, Kerrey, Robb, Gorton, Reid, Kerry, Cranston, Boschwitz, Bingaman, Breaux, and Heinz.

The Subcommittee on Science, Technology, and Space held three hearings on S. 1067. The first hearing, on June 21, 1989, focused on the NREN. The second hearing, on July 26, 1989, considered the development and application of advanced software and visualization, and the third one, held on September 15, 1989, examined present and future technology for managin and distributing electronic data. Witnesses at the hearings included several leading computer scientists, representatives of computer, supercomputer, and telecommunications companies, and representatives of NSF, DARPA, the U.S. Geological Survey, and the National Library of Medicine (NLM). Witnesses testified on the many new applications of supercomputing, and enthusiastically endorsed the idea of a NREN. Dr. William Wulf, testifying for NSF, stated that the Administration endorses the goals of the legislation, but that it opposes S. 1067 because the funding authorized by the legislation had not been requested in the President's budget. In addition, the Administration believes that a five-year budget for research funding should not be made, because this field is evolving so rapidly.

At its April 3, 1990, executive session, the Commerce Committee considered in open session and adopted without objection an amendment in the nature of a substitute for S. 1067. As introduced, S. 1067 provided funding for DOE and DOD, as well as NASA and NSF. Because DOE and DOD programs are not generally authorized by the Commerce Committee, the substitute provides funding for only NASA and NSF.

Authorizations for the DOE high-performance computing program are contained in S. 1976, the DOE High-Performance Computing Act, introduced on November 21, 1989, by Senator Johnston and cosponsored by Senators Gore and McClure. The Senate Energy Committee held a hearing on S. 1976 on March 6, 1990, and ordered the bill reported on June 27, 1990. When it was introduced, the sponsors of S. 1976 indicated their intention to have S. 1067 and S. 1976 considered together by the full Senate once each was reported. Funding for the portion of the HPC program to be conducted by DOD's DARPA is expected to be provided in the DOD FY 1991 authorization bill.

Summary of Major Provisions

As reported, S. 1067 would authorize a five-year program roughly doubling Federal funding for research and development on supercomputers, advanced computer software, and computer networks. The major provisions are as follows.

1. Title I establishes an interagency National HPC Program involving NSF, NASA, DOE, DOD, and other relevant agencies. Interagency coordination and planning for the program would be

provided by OSTP's FCCSET, which is to work closely with industry.

2. Title II requires NSF to work with other agencies to establish a multi-gigabit NREN by 1996. This network would be capable of transmitting several billions of bits of data per second and would link hundreds of thousands of researchers in government, industry, and universities around the country.

3. Title III makes NSF the lead agency for ensuring that federally-funded data bases and network services can be accessed over the network

4. Title IV calls for expanded software research and development, especially on software for supercomputers. Most of the funding would go to scientists, engineers, and computer scientists using high-performance computing to solve so-called "Grand Challenges," fundamental problems in science and engineering, examples of which are provided in the bill as reported.

5. Title V provides for research on supercomputers and encourages development of new supercomputing technology by the private sector.

6. Title VI requires OSTP to oversee and coordinate Federal programs for basic research in computer technology and for the education of computer scientists, computational scientists, information scientists, and electrical engineers.

7. Title VII authorizes $338 million to NASA for FY 1991-95 for the purposes of the bill. For FY 1991-95, the bill authorizes for NSF $195 million to establish the network, $64 million for basic research and education, and $391 million for the other purposes of titles III, IV, and V. The total authorization for NASA and NSF for FY 1991 is $68 million.

Estimated Costs

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. Congress,
Congressional Budget Office,
Washington, DC, April 27, 1990.

Hon. Ernest F. Hollings,
Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, DC.

Dear Mr. Chairman: The Congressional Budget Office has prepared the attached cost estimate for S. 1067, the High-Performance Computing Act of 1990.

If you wish further details on this estimate, we will be pleased to provide them.

Sincerely,

Robert D. Reischauer,
Director.

CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

1. Bill number: S. 1067.
2. Bill title: The High-Performance Computing Act of 1990.

3. Bill status: As ordered reported by the Senate Committee on Commerce, Science, and Transportation, April 3, 1990.

4. Bill purpose: S. 1067 would require the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) to develop and implement a National High-Performance Computing Plan. It would also mandate that the National Science Foundation (NSF), in conjunction with the Department of Defense (DOD), the National Aeronautics and Space Administration, and other relevant federal agencies, establish a national network of high speed computers, which would be known as the National Research and Education Network (NREN).

The requirements of S. 1067 would affect numerous federal agencies as developers and users of the NREN. For example, the bill would requires the NSF and NASA to help develop software for the types of comp .ter used in the network; the National Institute of Standards and Technology, a part of the Department of Commerce, would be charged with developing government-wide standards for computer networks; and the DOD, through the Defense Advanced Research Projects Agency (DARPA), would have primary responsibility for research and development on technology needed for the network. The FCCSET would have the general responsibility for overseeing and coordinating the work of the agencies involved in this project.

To fund development of the network, the bill would authorize appropriations to the NSF and NASA of nearly $1 billion over five years. The bill would also authorize NSF to charge a fee for use of the system.

5. Estimated cost to the Federal Government:

[By fiscal year, in millions of dollars]

	1991	1992	1993	1994	1995
Specific athorizations	46	88	145	172	199
National Science Foundation	22	45	67	89	115
NASA					
Subtotal, specific authorizations	68	133	212	261	314
Estimated authorizations	12	13	13	14	14
Total authorization level	80	146	225	275	328
Estimated outlays	45	107	180	241	295

The costs of this bill would be in budget functions 250 and 370.

Basis of estimate: This estimate assumes that the full amounts authorized would be appropriated for each fiscal year. Based on information provided by the Department of Commerce, CBO estimates that the cost of research and studies required by the bill but not specifically authorized would be roughly $12 million per year beginning in 1991; this amount, with adjustments for inflation, is shown as the estimated authorization level in the table above. The estimated outlays are based on historical spending patterns.

CBO expects that fees for use of the network would be phased in once the network is operating, which would probably be in 1993 or 1994. Receipts from these fees could ultimately provide a signifi-

cant offset to the operating costs of the netwo k. Nevertheless, we do not expect that receipts would be significant during the five-year period covered by this estimate.

6. Estimated cost to State and local governments: None.
7. Estimate Comparison: None.
8. Previous CBO estimate: None.
9. Estimate Prepared by: Doug Criscitello and Michael Sieverts.
10. Estimate approved by: James L. Blum, Assistant Director for Budget Analysis.

Regulatory Impact Statement

In accordance with paragraph 11(b) of rule XXVI of the Standing Ruels of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation, as reported.

NUMBER OF PERSONS CONVERED

This legislation provides additional funding for research and development in high-performance computing. This will not result in new regulations, because the additional funding provided by the legislation would be distributed according to existing regulations regarding NSF research grants and NASA contracts. These regulations would apply only to those persons and companies choosing to apply for this funding.

ECONOMIC IMPACT

This legislation authorizes $988 million in additional Federal spending for FY 1991-95. By providing for improved inter-agency coordination, this legislation should improve the effectiveness of Federal research and development on high-performance computing.

This legislation also requires the National Institute of Standards and Technology (NIST) within the Department of Commerce (DOC) to develop guidelines and standards: (1) to provide for interoperability of Federal computer networks, and (2) to promote the use of "open systems software" which can run on several different computer systems. These guidelines should be cost-effective in increasing the usefulness of Federal networks and software purchased by the Federal Government.

PRIVACY

This legislation will not have any adverse impact on the personal privacy of individual Americans. The creation of the NREN and associated databases will make existing Federal scientific data bases (including economic data and census data) more accessible to users throughout the country, but personal data already protected by rules and regulations (e.g., tax returns and individual census forms) will remain confidential.

PAPERWOEK

This legislation requires FCCSET to submit an annual report to the President and the Congress on the National HPC Program. The National Telecommunications and Information Administration (NTIA) within DOC is to report to Congress on whether State and

Federal telecommunications laws and regulations hinder or facilitate private industy participation in the data transmission field. OSTP shall report to Congress on options for charging users of the NREN and the databases connnected to it. DOC is to report to Congress on whether Federal procurement regulations discourage the development of better software development tools and on whether export controls hinder the development of foreign markets for North American manufacturers of high-performance computer systems.

Section-by-Section Analysis

SECTION 1.—SHORT TITLE

This section states that the bill may be cited as the "High-Performance Computing Act of 1990".

SECTION 2.—FINDINGS AND PURPOSES

This section contains the Congressional findings and purposes of the Act. Under subsection (1), Congress finds, among other things, that advances in computer technology are vital to the propsperity, national and economic security, and scientific advancement of the United States. Under subsection (b), to maintain leadership in computer technology and its applications, and to reap the benefits of high-performance computing, the reported bill calls for expanding Federal support for research, development, and application of high-performance computing, and improving planning and coordination of Federal research and development on high-performance computing. Subsection (b) states that this legislation is intended to help establish a high-capacity national research and education computer network; expand the numbers of researchers, educators and students with training in and access to high-performance computing; develop a system of data bases and other services available through such a network; accelerate development of more powerful supercomputers and other advanced computer systems; stimulate research and development of better software for both supercomputers and other computers; promote application of high-performance computing to "Grand Challenges" of science and engineering; and provide for basis research in high-performance computing.

SECTION 3.—DEFINITIONS

Definitions of "North American Company" and "Grand Challenge" are provided in Section 3.

Several provisions in this bill are designed to assist U.S. industry. However, the recently signed Free Trade Agreement between the United States and Canada is to encourage economic cooperation between the two nations and reduce economic barriers. Therefore, the term "North America company" is used to allow Canadian and U.S.-Canadian joint ventures to benefit from these provisions.

A "Grand Challenge" is a fundamental problem in science and engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources. Examples of Grand Challenges include modeling of global

change, designing of new materials and drugs, and deciphering of the human genome.

TITLE I

SECTION 101.—NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

This section amends the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq., hereinafter referred to as "the Science Act") in order to establish a National HPC Program coordinated by OSTP. This section would add a new title VI to the Science Act, with the following sections:

New section 601 contains findings similar to those in section 2 of the reported bill.

New section 602 mandates a National HPC Plan, which under subsection (a)(1) is to be developed and implemented by FCCSET. FCCSET is chaired by the Chairman of OSTP, who is traditionally also the President's Science Advisor. It is currently charged with addressing research issues and coordinating research programs that involve more than one Federal agency. For instance, in recent years, FCCSET has done an exemplary job of providing high-level coordination on global change research. The National Global Change Research Program can serve as a model for the National HPC Program. As with global change research, high-performance computing involves several agencies, and there is no one agency with the expertise, breadth, and facilities to oversee all Federal efforts in the field. FCCSET provides a mechanism for building on existing agency programs, preventing duplication of effort, and identifying previously unaddressed problems, without establishing a new bureaucratic entity. In addition, building on existing agency programs, rather than creating a separate agency for high-performance computing, would ensure that new developments in high-performance computing are utilized by individual agencies to accomplish their different missions.

Under subsection (a)(2) of new section 602, the plan is to establish the goals and priorities for a National HPC Program, to set forth the roles and computer research budgets of the agencies involved, and to include the results of studies by Federal agencies and departments, the National Research Council (NRC), and other entities. The Committee expects that the plan would be similar to the 1989 OSTP report, "The Federal High-Performance Computing Program," except that it also would include a budget showing the level of funding for each of the activities undertaken in support of the program by each of the agencies involved and provide a comprehensive inventory of what high-performance computing programs are currently underway throughout the Federal government that could contribute to the National HPC Program.

Under subsection (a)(3), the plan would summarize the activities of NSF, DOC, NASA, DOD, DOE, the Department of Health and Human Services (HHS), the Department of Education, the Library of Congress, the NLM, the National Agricultural Library, and other relevant agencies.

Subsection (b) of new section 602 provides that FCCSET will have the lead in developing and implementing the plan. At least once a

year, the Chairman of FCCSET will report to the President on how to improve implementation of the plan.

Working through the Executive Office of the President, and especially with the Office of Management and Budget (OMB), FCCSET should provide the high-level coordination needed to direct and implement effectively the National HPC program. Coordination between OMB and FCCSET will be critical to the success of the program. Under subsection (b)(3), prior to the submission of the President's annual budget request, FCCSET will review each agency and department's budget estimate to determine how it contributes to the implementation of the HPC program. This review is intended to guide OMB in determining each agency's budget for high-performance computing.

In addition, FCCSET will work with Federal agencies, the NRC, and other groups involved in high-performance computing to formulate and implement the plan. To receive advice from industry and academia, OSTP is directed under subsection (c) of new section 602 to establish an HPC Advisory Panel which will consider issues pertaining to the program and evaluate its progress, focus, and direction. This panel primarily should provide advice on policy decisions regarding the National HPC Program. The Committee realizes that additional funding will be necessary for this panel and encourages the Administration and the Appropriations Committees to increase funding for OSTP accordingly.

This new section in subsection (d) also describes the existing missions of ten of the agencies that will contribute to the National HPC Program. By summarizing the agenices' existing roles, the Committee intends to ensure that existing agency programs are incorporated into the National HPC Program. The inclusion of current research roles is not intended to limit agency responsibilities or to interfere otherwise with the flexibility that will be required by FCCSET to develop and implement a comprehensive national research program. The Committee expects agency responsibilities to evolve over time, as the challenges associated with high-performance computing change and the technology advances. In addition, this subsection requires the agencies to work together to connect their computer networks and to improve, share, and distribute computer software they have developed.

As outlined in the 1989 OSTP report, the four key agencies in the National NPC Program are NSF, DARPA, NASA, and DOE. NSF will continue to fund university research and development in high-performance computing and provide researchers with access to state-of-the-art supercomputers. In addition, NSF is to implement the NREN. DARPA's first priorities will be to develop the multi-gigabit network technology needed to build the NREN and to fund development of future generations of supercomputers and other advanced computer systems. DARPA will fund development of new advanced conventional and massively-parallel supercomputers. DARPA also will work with and provide technical support to the high-performance computing research programs within the Army, the Navy, the Air Force, the National Security Agency, and other parts of DOD. NASA will continue to conduct basic and applied research on high-performance computing, with particular emphasis on the development of applications for supercomputing in

areas like aeronautics and the processing of remote-sensing data. DOE will continue to conduct basic and applied research in high-performance computing, particularly in software development and development and use of parallel-processing supercomputers.

Concerns have been expressed in the past that technology developed at DOE has not been transferred effectively to the private sector. As part of the National HPC Program, DOE and other agencies will ensure that unclassified computer research is readily available to North American companies. This provision should not be interpreted as barring foreign firms from access to high-performance computing technology developed with Federal funding, but simply requires that special emphasis should be given to encouraging technology transfer to North American firms, which often have been slower to utilize federally-funded research and development than their foreign competitors.

While the amount of funding provided for NIST for its part of the National HPC Program is a small fraction of that provided to the four key agencies, NIST has a critical role to play in developing the standards and guidelines needed to ensure compatibility of different computer systems and networks. In conjunction with the NSA, NIST has important responsibilities in the area of computer security. The privacy of network users and the integrity of data bases connected to the network must be protected. In addition, under section 403 of this bill, NIST will play a key role in promoting use by the Federal Government of "open systems software," which can be easily transported from one type of computer system to another. It is anticipated that additional funding requests for high-performance computing programs at NIST will be needed.

The National Oceanic and Atmospheric Administration (NOAA), responsible for managing much of the earth science data collected by Federal programs, has an important role to play in the National HPC Program, both as a user of advanced computer systems and networks, and as a supplier of data to users for the NREN and others. NOAA has huge archives of remote-sensing satellite data, such of which has not been analyzed thoroughly. The NREN and the supercomputers developed as part of this program will help researchers make better use of existing NOAA data and of data that will be collected in the future.

Other agencies involved in the National HPC Program will play important roles, epecially in developing applications for supercomputing and networking for use in both the research community and beyond. In particular, the Committee encourages the DOE, through its library programs, to initiate and fund projects that promote linkages between existing library and information science networks and the NREN. The benefits of this enhanced resource sharing among networks are improved end user document delivery, improved interlibrary resource sharing and electronic interlibrary loans, and improved communication between users in the NREN and users outside the NREN.

The three national libraries—the Library of Congress, the National Agriculture Library, and the NLM—have long been at the leading edge of automation of library functions, creation and standardization of bibliographic and information data bases, and electronic transmittal of information about their holdings to libraries

across the county via library networks. All three libraries are now experimenting with electronic formats for entire portions of their collections, including some use of the Internet. The advent of the NREN will permit new opportunities for the research and academic communities to benefit from these information resources in performing research and in the creation of new knowledge that will improve the U.S. economic competitiveness.

The Committee is particularly interested in the work being done at the NLM, and elsewhere, to use national computer networks for the sharing of biomedical research information. For instance, the NLM's Medline system provides references and abstracts from medical literature to doctors throughout the country, providing an invaluable service, especially to doctors in rural areas as far from major libraries. Ongoing research at NLM is providing the technology needed for doctors thousands of miles apart to share X-ray images, CAT scans, PET scans, and other medical imagery. In this way, a general practitioner will be able to obtain advice from specialists anywhere in the country.

A biomedical community clearly has much to gain from advances in high-performance computing and the use of computer networks, and should be encouraged to take advantage of this technology. Unfortunately, relatively few laboratory-based biomedical researchers at universities, and almost no clinical researchers or health care practitioners, use the current Internet. At the same time, it is clear that new computer-based technologies, such as clinical imaging, are essential to accurate diagnosis and treatment and to the conduct of biomedical research. Improved methods of communications among health care practitioners and life sciences researchers will facilitate basic and clinical research, and accelerate the search for cures of many human diseases.

Therefore, it is envisioned that within HHS, the National Institutes of Health (NIH) and the NLM will establish the appropriate mechanisms to ensure the development of a biomedical component of the NREN and promote and facilitate the use of the NREN by the biomedical research community. The NREN will serve as an invaluable testbed for development of networking applications for the health care community since most Federal health care agencies (e.g., NIH and NLM) will be connected to NREN as will many university medical centers, hospitals, and other medical facilities. The medical community will help spur the development of high-speed commercial computer networks as doctors become more and more dependent upon medical imaging and as they recognize the potential of high-speed networking technology.

Finally, under new section 602(e), each Federal agency and department involved in high-performance computing, as part of its annual request to OMB for appropriations, is to submit a report to OMB identifying its high-performance computing activities. OMB is to review each such report in light of the HPC Plan and shall include in the President's budget each agency or department's budget allocation to high-performance computing activities.

New section 603 mandates that the Chairman of FCCSET submit an annual report to the President and the Congress on the National NPC Program. The report shall summarize, among other things, the progress made by the program, detail the agency budgets for

high-performance computing, and recommend any additional action or legislation which may be required to assist in achieving the purposes of the legislation.

SECTION 102.—AMENDMENTS TO THE SCIENCE ACT

This section would amend section 102(a) of the Science Act, which identifies the principles that form the basis for national science and technology policy. The list of principles would be expanded to emphasize the need for comprehensive long-term planning of research to address complex scientific issues of national and international concern. The purpose of such planning would be to ensure a scientific basis for policy decisions.

This section, in subsection (b), also amends section 401 of the Science Act, which defines the responsibilities of FCCSET. Section 401 also provided for FCCSET's initial creation. However, during a 1977 reorganization, FCCSET was abolished, its functions were transferred to the President, and it was later reestablished under executive order. Section 401(a), as amended, simply restates the responsibilities of FCCSET under the Science Act, reflecting that reorganization.

Section 401(b), as amended, would provide FCCSET with new authority to develop and coordinate interagency research. FCCSET would formulate plans that would identify critical research needs and provide for cooperation among government, industry, and academic scientists in the United States and overseas. Section 401(c) and (d), as amended, address FCCSET's authority to perform advisory duties assigned by the President or its chairman and the requirement that Federal agencies represented on FCCSET furnish necessary assistance to FCCSET. Also section 401(e), as amended, would add the development of interagency plans to the purposes for which FCCSET committees and working groups may be formed.

TITLE II—NATIONAL RESEARCH AND EDUCATION NETWORK

SECTION 201.—FUNCTIONS OF THE NETWORK

This section requires NSF to work with DOD and other relevant agencies to establish a national computer network capable of transmitting more than two billion bits of data (gigabits) per second. Such a network would connect more than half a million computers and their users at more than 1,000 colleges, universities, Federal laboratories, industry laboratories, libraries, and other institutions in all fifty States. This would provide access to supercomputers, computer data bases, and other research facilities.

The NREN would be developed in close cooperation with the computer and telecommunication industries and with potential users in government, industry, and the higher education community, including researchers, librarians, educators, and information services providers. The network is to be established in a manner that fosters competition and private-sector investment in high-speed data networking within the telecommunications industry.

One way to meet these goals is to develop and operate the NREN in much the same way as NSF's NSFNET, a national computer

network connecting the five NSF supercomputer centers and over 500 colleges and universities. NSF funds NSFNET's high-speed (1.5 million bits per second), interstate "backbone" which connects the supercomputer centers and other facilities. Regional networks, both private or non-profit, connect the backbone to individual colleges and universities which in turn have their own local campus networks. The NSFNET backbone has been built and managed by MERIT, a consortium of Michigan universities, in cooperation with MCI Telecommunications and IBM, which provide fiber optic phone lines and computer hardware as well as technical expertise. This kind of industry-government-academia partnership provides for the rapid development of networking technology and its rapid dissemination.

In order to ensure that the NREN does not compete unfairly with commercial high-speed networks, paragraph (8) provides that it is to be phased out when national commercial high-speed networks can meet the networking needs of American researchers, by providing a cost-effective alternative to the NREN. To provide for a smooth transition to commercial service, mechanisms shall be established under paragraph (7) for charging network users or their institutions for their use of the network. Otherwise, if networking is provided free to the user, networking resources will be wasted, and it will be very difficult to phase out the NREN and replace it with commercial networks.

In addition under paragraph (7), mechanisms for charging for the use of copyrighted material available over the NREN shall be implemented, where technically feasible. These mechanisms should not be implemented without due consideration of both the rights of authors and the rights of users of copyrighted material. Specifically, provision needs to be made for the fair use of copyrighted works for teaching, scholarship, or research.

The development and implementation of pricing schemes for users of the NREN likely will be technically difficult when gigabit networking technology is in its infancy. The inability to implement such schemes, however, should not delay the deployment of a gigabit network.

SECTION 202.—AGENCY RESPONSIBILITIES

This section requires under paragraph (1) that FCCSET establish a Federal Networking Advisory Committee to provide technical advice to FCCSET from the interest involved in existing Federal research networks and the NREN. In contrast to the HPC Advisory Panel established under title I, in new section 602(c) of the Science Act, this advisory committee is not intended to provide advice on broad policy issues, but instead will address technical problems encountered in establishing the NREN. In addition, FCCSET is to submit to Congress, within one year of enactment of this bill, a report on how best to fund and commercialize the NREN.

Under paragraph (2), NSF and all other Federal agencies which provide research grants shall allow grantees to use grant monies to pay for use of computer networks. Although policies vary with each agency, today most recipients of Federal research grants cannot use grant money for any type of telecommunications expenses. Pro-

viding funding for computer networking would increase the productivity of researchers, who are increasingly dependent upon computers and computer networks to manipulate, search, store, and share their data.

DARPA shall have primary responsibility under paragraph (3) for developing the gigabit networking technology needed to create the NREN. Under paragraph (4) NIST, in cooperation with other agencies, shall adopt government-wide networking standards and guidelines to enable government networks to be linked together. These standards will be adopted with the advice and comment of private industry, will provide common user interfaces to systems, and will provide enhanced security for the NREN. It is expected that, in addition, work being done at NIST, such as measurement research and development needed to develop advanced optical fibers and optoelectronic components for high-performance optical fiber communications, will contribute to the National HPC Program.

Within one year of enactment, NTIA under paragraph (5) shall report to Congress on whether State and Federal telecommunications laws and regulations hinder or facilitate private industry participation in the data transmission field. In particular, the report should focus on development of data transmission systems, using high-speed fiber optic networks.

TITLE III—INFORMATION SERVICES

SECTION 301.—DATA SERVICES

This section gives NSF responsibility for working with other relevant Federal agencies to promote development of several information services over the NREN. In particular, NSF shall provide for a directory of users of the NREN and other networks. It also shall provide directories of the different data basis available over the NREN. In addition, it is to identify and provide for access to Federal scientific data bases (e.g., whether data, satellite data, economic data, and other research data) and provide data bases and knowledge banks for use by artificial intelligence (AI) programs. AI experts have developed computer programs called "know-bots" which can search data bases and knowledge banks for the information users need. Knowledge banks consist of textbook knowledge stored in computer-based form so that AI programs can access and use it.

This section also requires NSF to help provide access to "digital libraries" of video programming, books and journals stored in electronic form, and other computer data. It is expected that NREN users will have access to commercial information services like Lexis-Nexis and Dialog, with appropriate mechanisms for charging customers of these services. NSF also shall provide for orientation and training of users of networks and data bases, by providing training software on the networks they use and by providing experts to guide and teach users of those networks.

The NREN also will provide access to research facilities like radio telescopes, seismometers, and manufacturing facilities. A particularly noteworthy example of such a manufacturing facility is one operated by DARPA. Called MOSIS (for Metal Oxide Semiconductor Implementation System), it allows integrated circuit design-

ers to send their designs electronically over a network to an integrated circuit foundry where the design can be turned into hardware in only a few weeks. This rapid turn-around time compares to typical turn-around times of several months. Several other federally-funded programs, including DOD's CALS and MANTECH (Manufacturing Technology) programs, DOC's Product Design Electronic Specification (PDES), and NIST's Manufacturing Technology Centers programs, are using vicualization and electronic specifications ("electronic blueprints") to improve the productivity and flexibility of American manufacturers.

SECTION 302.—OSTP REPORTS TO CONGRESS

This section requires that, within ıe year of enactment of the legislation OSTP shall report to Congress on several issues, including mechanisms for charging information service providers for access to the NREN, the technology needed to charge users of such services for their use of them, and charge-back mechanisms and other ways to pay copyright holders royalties for use of their material by NREN users. In addition, the Committee has become increasingly concerned by the growing number of reports of computer viruses and unauthorized use of government and university computer systems. Therefore, OSTP is to report on appropriate policies to ensure the security of data bases and other resources available on the NREN and protection of the privacy of NREN users. In developing this report, OSTP should work closely with OMB, which is involved in establishing many aspects of government information policy.

TITLE IV—SOFTWARE

SECTION 401.—THE GRAND CHALLENGES

This section instructs OSTP in subsection (a) to coordinate and oversee research and development of software for high-performance computer systems. Under subsection (b), this software is to be developed, in particular, to address so-called Grand Challenges of sciences and engineering, complex problems of great economic and scientific importance whose solution requires the use of the most advanced computer systems and software. This subsection lists several examples of Grand Challenges to be addressed by NSF and NASA, including prediction of global change, accurate modelling of turbulence, and processing of the huge volumes of data produced by telescopes and other astronomical facilities. The Grand Challenges listed in this section are merely examples and are not meant to limit the scientific problems that might be addressed. Some other potential Grand Challenges are in the fields of molecular biology, superconductivity, the human genome, theoretical physics, nuclear fusion, and oil and gas exploration. An appendix to the 1989 OSTP report summarizes twenty Grand Challenges. Both NSF and NASA shall provide support to interdisciplinary groups of scientists, engineers, computer scientists, and computational scientists to develop the high-performance computer systems and software needed to address the Grand Challenges.

DOE has funded several such groups, including University of Tennessee/Oak Ridge National Laboratory Joint Institute for Computational Science, which has focused on development of computational tools for massively-parallel supercomputers needed to address a number of Grand Challenges, and the National Supercomputing Center for Energy Research at the University of Nevada, Las Vegas (UNLV), which is using high-performance computing to study radioactive waste management, among other issues. These DOE programs bring together resources from the Federal Government, universities, and industry, and can serve as models for similar cooperative efforts at other agencies.

In addition to addressing Grand Challenges, NSF will support, under subsection (c), basic research on software and development of tools and techniques for accelerating the development of software, especially for supercomputers. Such tools and techniques are essential if supercomputing is to become a routinely-used research tool. This is particularly true for massively-parallel supercomputers, which often can be used for only a limited set of problems because existing software does not allow for use of the full capabilities of the systems.

SECTION 402.—SOFTWARE CLEARINGHOUSE

This section instructs NSF to establish and maintain clearinghouses of research software. Too often, scientists and engineers supported by Federal research grants develop new computer programs for a particular project on which they are working, and then, after they have completed the project, they set aside these programs, never to be used again. Later, another researcher working on a similar project has to develop new software because there is no way of knowing that the needed software is already available elsewhere.

These clearinghouses would allow researchers to deposit voluntarily their research software at the clearinghouse where it would be catalogued and made available to others. Staff at the clearinghouse could make such software easier to use and accessible to other researchers over the NREN. In addition, the clearinghouse would provide funding to researchers to upgrade and document their software so that other researchers would be able to use it more easily and more broadly. The clearinghouses are to promote the commercialization of particularly popular and useful software, always respecting the intellectual property rights of the researchers who originally created the software. The committee believes that the NSF Supercomputer Centers are well-equipped to serve as clearinghouses for software for both supercomputers and less powerful computers.

SECTION 403.—SOFTWARE STANDARDS

NIST will develop, in conjunction with industry, standards that will promote the Federal Government's use of so-called "open systems software," which can be used on many different computer systems. Such software can reduce greatly the time and effort required to shift software from one system to another and thus increase the productivity of computer users.

SECTION 404.—COMMERCE DEPARTMENT REPORTS

This section requires that, within one year of enactment of this Act, the Secretary of Commerce (Secretary) shall report to Congress on the impact of Federal procurement regulations which require that contractors share the rights to proprietary software development tools and on whether Federal procurement regulations discourage the development of better software development tools and techniques. It is expected that this report will be written in consultation and cooperation with DOD, NASA, and other agencies which contract for large amounts of customized software. At present, in most agencies, if a contractor sells software to the government, that contractor must not only provide the software itself, but also must provide the software used to develop it. Today, many software companies use proprietary software tools to streamline software development, and these tools can require more money and manpower to make than the software that they are used to produce. Because of anachronistic procurement regulations, companies are discouraged from developing better, easier-to-use software tools, and if they do develop them, they do not use them to produce government software, resulting in the government paying higher prices for lower-quality software.

TITLE V—COMPUTER SYSTEMS

SECTION 501.—RESEARCH ON COMPUTER SYSTEMS

This section requires NSF to provide for research and development on high-performance computer systems. Such research is not to be limited only to supercomputers, but shall include work on input/output devices, memory and mass storage devices, communication devices, and the systems software required to make for the operation of supercomputers.

SECTION 502.—PROCUREMENT OF PROTOTYPE MODELS OF SUPERCOMPUTERS

In the 1970s, several Federal agencies, including DOE, DOD, and NSA, purchased prototype or early production models from American computer manufacturers. Such purchases gave fledging companies, like Cray Research, Inc., the money they needed to become viable companies. Equally important, Cray and other companies were able to have their machines tested by scientists and engineers working on real problems. The first Cray 1 was installed at Los Alamos National Laboratory before Cray had been able to complete the systems software for the new machine. Input from DOE scientists helped make Cray the work leader in the supercomputer industry.

Unfortunately, in recent years, many agencies have been discouraged from making purchases of prototypes by regulations stemming from the so-called "Brooks Act" and other laws regulating Federal purchases of computer equipment. Although this was not the intent of the Brooks Act, regulations resulting from that Act make it very difficult for an agency to contract to buy a supercomputer before it is in production. Unfortunately, without such pre-

production contracts, a fledging supercomputer company is unlikely to survive.

This section makes clear that Federal agencies can and should buy prototype and early production models of leading-edge, high-performance computer systems and subsystems. Such purchases provide critically-needed opportunities to test new design concepts and can be particularly effective in promoting commercialization of leading-edge technologies. This section also provides that particular emphasis is to be given to promoting development of advanced display technology (which will be needed for high-definition television (HDTV) and subsequently digital TV), supercomputers with alternative architectures, advanced storage devices, and very high-speed (multi-gigabit-per second) communications links.

SECTION 503.—REPORT ON EXPORT CONTROLS

This section requires the Secretary, within 120 days of date of enactment, to review and report to Congress on, export controls that hinder the development of foreign markets for North American manufacturers of high-performance computer systems. Supercomputer technology is advancing so quickly that export restrictions often become out-dated in a few years. Export controls imposed 10 years ago would prohibit export to many countries of most personal computers available today. Therefore, it is essential that export controls be reviewed frequently so that North American supercomputer manufacturers are not at a disadvantage relative to foreign competitior operating under more relaxed export controls. This section also requires that any review is to be conducted in consultation with the Department of State, DOD, the Central Intelligence Agency, NSA, and other appropriate agencies, in order to take into account national security and other concerns.

TITLE VI—BASIC RESEARCH AND EDUCATION

SECTION 601.—BASIC RESEARCH AND EDUCATION

This section requires OSTP to oversee and coordinate efforts of the relevant agencies and departments to support bas earch on computer technology and create technology transfer n nisms to ensure that the results of such basic research are read available to North American companies. These provisions should not be interpreted as barring foreign companies from access to federally-funded technology. In addition, under this section ASTP is to coordinate efforts to promote basic research in computer science and engineering, computational science, library and information sciences, electrical engineering, and materials science, and to train more researchers in computer science and computational science. "Computational scientists" come from all disciplines of science and engineering, but all use high-performance computing to find solutions to the problems they are studying.

NSF traditionally has had a large role in funding basic research and education in colleges and universities. However, other agencies have a role as well. According to the 1989 OSTP report, NSF, NASA, DOE, and DARPA are planning to allocate at least ten per-

cent of their budgets for high-performance computing to basic research and education.

TITLE VII—AUTHORIZATIONS

For FY 1991-95, the reported bill authorizes $338 million to NASA for the purposes of titles II, III, IV, V, and VI. This is in addition to funds authorized in other legislation. To maximize the President's flexibility in implementing the high-performance computing program, the funding for NASA's part of the program has not been divided among the various components of the program.

Authorizations for NSF for the purposes of titles III, IV, and V total $391 million. Of that amount, the Committee expects that between 10 and 15 percent shall be allocated for the purposes of title III. In addition, there is authorized to NSF $195 million to establish the network and $64 million for basic research and education. The separate authorizations to NSF for the NREN and for basic research are to highlight the importance of those two activities. These authorizations are in addition to those made in the NSF Authorization Act of 1988 (P.L. 100-570), which authorized funding for NSF for FY 1989--93. Since that legislation was enacted, the use of high-performance computing in research has become more widespread, and it has become clear that additional funding is required to expand NSF's high-performance computing program.

The authorizations provided in this legislation do not include monies for DARPA and DOE, the other two principal agencies in the National HPC Program. DOE, and in particular its national laboratories, has on-going high-performance computing programs that would be expanded as part of the national program. The authorization of funding for DOE's part of the National HPC program is provided in S. 1476, which the Senate Committee on Energy and Natural Resources ordered reported on June 27, 1990. Funding for DARPA's high-performance computing program is expected to be authorized in the DOD FY 1991 reauthorization bill.

AUTHORIZATIONS IN S. 1067

[In millions of dollars]

	Fiscal year					Total
	1991	1992	1993	1994	1995	
For NSF:						
Networking	15	25	55	50	50	195
Information Services, Software, and Computer Systems	23	53	77	107	131	391
Basic Research and Education	8	10	13	15	18	64
Total	46	88	145	172	199	650
For NASA	22	45	67	89	115	338

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted

is enclosed in black brackets, new material is printed in italic, existing law in which no change is proposed is shown in roman):

NATIONAL SCIENCE AND TECHNOLOGY POLICY, ORGANIZATION, AND PRIORITIES ACT OF 1976

Section 102 of That Act

DECLARATION OF POLICY

SEC. 102. (a) PRINCIPLES.—In view of the foregoing, the Congress declares that the United States shall adhere to a national policy for science and technology which includes the following principles:

(1) through (5) * * *

[(6) The recognition that, as changing circumstances require periodic revision and adaptation of title I of this Act, the Federal Government is responsible for identifying and interpreting the changes in those circumstances as they occur, and for effecting subsequent changes in title I as appropriate.]

(6) The development and implementation of long-range, interagency research plans to support policy decisions regarding identified national and international concerns, and for which a sustained and coordinated commitment to improving scientific understanding will be required.

(b) through (c) * * *

Section 207 of That Act

ADDITIONAL FUNCTIONS OF THE DIRECTOR: ADMINISTRATIVE PROVISIONS

SEC. 207. (a) The Director shall, in addition to the other duties and functions set forth in this title—

(1) serve as Chairman of the Federal Coordinating Council for Science, Engineering, and Technology [established under Title IV]; and

(2) serve as a member of the Domestic Council—

(b) through (c) * * *

Section 401 of That Act

[ESTABLISHMENT AND FUNCTIONS

[SEC. 401. (a) There is established the Federal Coordinating Council for Science, Engineering, and Technology (hereinafter referred to as the "Council").

[(b) The council shall be composed of the Director of the Office of Science and Technology Policy and one representative of each of the following Federal agencies: Department of Agriculture, Department of Commerce, Department of Defense, Department of Health, Education, and Welfare, Department of Housing and Urban Development, Department of the Interior, Department of State, Department of Transportation, Veterans' Administration National Aeronautics and Space Administration, National Science Foundation, Environmental Protection Agency, and Energy Research and Development Administration. Each such representative shall be an official of policy rank designate by the head of the Federal agency concerned.

[(c) The Director of the Office of Science and Technology Policy shall serve as Chairman of the Council. The Chairman may designate another member of the Council to act temporarily in the Chairman's absence as Chairman.

[(d) The Chairman may (1) request the head of any Federal agency not named in subsection (b) of this section to designate a representative to participate in meetings or parts of meetings of the Council concerned with matters of substantial interest to such agency, and (2) invite other persons to attend meetings of the Council.

[(e) The Council shall consider problems and developments in the fields of science, engineering, and technology and related activities affecting more than one Federal agency, and shall recommend policies and other measures designed to—

[(1) provide more effective planning and administration of Federal scientific engineering, and technological programs,

[(2) identify research needs including areas requiring additional emphasis,

[(3) achieve more effective utilization of the scientific, engineering, and technological resources and facilities of Federal agencies, including the elimination of unwarranted duplication, and

[(4) further international cooperation in science, engineering, and technology.

[(f) The Council shall perform such other related advisory duties as shall be assigned by the President or by the Chairman.

[(g) For the purpose of carrying out the provisions of this section, each Federal agency represented on the Council shall furnish necessary assistance to the Council. Such assistance may include—

[(1) detailing employees to the Council to perform such functions, consistent with the purposes of this section, as the Chairman may assigned to them, and

[(2) undertaking, upon request of the Chairman, such special studies for the Council as come within the functions herein assigned.

[(h) For the purpose of conducting studies and making reports as directed by the Chairman, standing subcommittees and panels of the Council may be established. Among such standing subcommittees and panels of the Council shall be the Subcommittee on Food, Agriculture, and Forestry Research. This subcommittee shall review Federal research and development programs relevant to domestic and world food and fiber production and distribution, promote planning and coordination of this research in the Federal Government, and recommend policies and other measures concerning the food and agricultural sciences for the consideration of the Council. The subcommittee shall include, but not be limited to, representatives of each of the following departments or agencies; the Department of Agriculture, the Department of State, the Department of Defense, the Department of the Interior, the Department of Health and Human Services, the National Oceanic and Atmospheric Administration, the Department of Energy, the National Science Foundation, the Environmental Protection Agency, and the Tennessee Valley Authority. The principal representatives of the

Department of Agriculture shall serve as the chairman of the subcommittee.]

FUNCTIONS OF COUNCIL

SEC. 401. (a) The Federal Coordinating Council for Science, Engineering, and Technology (hereinafter referred to as the "Council") shall consider problems and developments in the fields of science, engineering, and technology and related activities affecting more than one Federal agency, and shall recommend policies and other measures designed to—

(1) Provide more effective planning and administration of Federal scientific, engineering, and technological programs;

(2) identify research needs, including areas requiring additional emphasis;

(3) achieve more effective utilization of the scientific, engineering, and technological resources and facilities of Federal agencies, including the elimination of unwarranted duplication; and

(4) further international cooperation in science, engineering, and technology.

(b) The Council may be assigned responsibility for developing long-range and coordinated plans for scientific and technical research which involve the participation of more than two Federal agencies. Such plans shall—

(1) identify research approaches and priorities which most effectively advance scientific understanding and provide a basis for policy decisions;

(2) provide for effective cooperation and coordination of research among Federal agencies; and

(3) encourage domestic and, as appropriate, international cooperation among government, industry, and university scientists.

(c) The Council shall perform such other related advisory duties as shall be assigned by the President or by the Chairman of the Council.

(d) For the purpose of carrying out the provisions of this section, each Federal agency represented on the Council shall furnish necessary assistance to the Council. Such assistance may include—

(1) detailing employees to the Council to perform such functions, consistent with the purposes of this section, as the Chairman of the Council may assign to them; and

(2) undertaking, upon request of the Chairman, such special studies for the Council as come within the scope of authority of the Council.

(e) For the purpose of developing ingeragency plans, conducting studies, and making reports as directed by the Chairman, standing committees and working groups of the Council may be established.

New Title VI of That Act

TITLE VI—NATIONAL HIGH-PERFORMANCE COMPUTING PROGRAM

FINDINGS

SEC. 601. The Congress finds and declares the following:

(1) In order to strengthen America's computer industry and to assist the entire manufacturing sector, the Federal Government must provide leadership in the development and application of high-performance computing. In particular, the Federal Government should support the development of a high-capacity, national research and education network, make information services available over the network; facilitate the development of software for research, education, and industrial applications; continue to fund basic and applied research; and provide for the training of computer scientists and computational scientists.

(2) Several Federal agencies have ongoing high-performance computing programs. Improved interagency coordination, cooperation, and planning could enhance the effectiveness of these programs.

(3) A 1989 report by the Office of Science and Technology Policy outlining a research and development strategy for high-performance computing provides a framework for a multi-agency high-performance computing program.

NATIONAL HIGH-PERFORMANCE COMPUTING PLAN

SEC. 602. (a)(1) The President, through the Federal Coordinating Council for Science, Engineering, and Technology (hereafter in this title referred to as the "Council"), shall develop and implement a National High-Performance Computing Plan (hereafter in this title referred to as the "Plan") in accordance with the provisions, finding, and purpose of this Act. Consistent with the responsibilities set forth under subsection (d) of this section, the Plan shall contain recommendations for a five-year national effort, to be submitted to the Congress within one year after the date of enactment of this title and to be revised at least once every two years thereafter.

(2) The Plan shall—

(A) establish the goals and priorities for a Federal high-performance computing program for the fiscal year in which the Plan (or revised Plan) is submitted and the succeeding four fiscal years;

(B) set forth the role of each Federal agency and department in implementing the Plan;

(C) describe the levels of Federal funding for each agency and specific activities, including education, research activities, hardware and software development, and acquisition and operating expenses for computers and computer networks, required to achieve such goals and priorities; and

(D) consider and use, as appropriate, reports and studies conducted by Federal agencies and departments, the National Research Council, or other entities.

(3) The Plan shall address, where appropriate, the relevant programs and activities of the following Federal agencies and departments—

(A) the National Science Foundation;

(B) the Department of Commerce, particularly the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Telecommunications and Information Administration;

(C) the National Aeronautics and Space Administration;

(D) the Department of Defense, particularly the Defense Advanced Research Projects Agency and, as appropriate, the National Security Agency;

(E) the Department of Energy;

(F) the Department of Health and Human Services, particularly the National Institutes of Health;

(G) the Department of Education;

(H) the Library of Congress, the National Library of Medicine, and the National Agricultural Library; and

(I) such other agencies and departments as the President or the Chairman of the Council considers appropriate.

(b) The Council shall—

(1) serve as lead entity responsible for development and implementation of the Plan;

(2) coordinate the high-performance computing research and development activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

(3) prior to the President's submission to the Congress of the annual budget estimate, review each agency and departmental budget estimate in the context of the Plan and make the results of that review available to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget;

(4) work with Federal agencies, with the National Research Council, and with academic, State, industry, and other groups conducting research on high-performance computing.

(c) The Office of Science and Technology Policy shall establish a High-Performance Computing Advisory Panel consisting of representatives from industry and academia to provide the Council with an independent assessment of (1) progress made in implementing the Plan, (2) the need to revise the Plan, (3) the balance between the components of the Plan, (4) whether the research and development funded under the Plan is helping to maintain United States leadership in computing technology, and (5) other issues identified by the Director of the Office of Science and Technology Policy.

(d)(1) The Plan shall take into consideration, but not be limited to, the following missions and responsibilities of agencies and departments:

(A) The National Science Foundation shall continue to be responsible for basic research in computer science and engineering, computer technology, and computational science. The Foundation shall continue to solicit grant proposals and award grants by merit review for research in universities, non-profit re-

search institutions, and industry. The National Science Foundation shall also provide researchers with access to supercomputers and have primary responsibility for the establishment, by 1996, of a multi-gigabit-per-second national computer network, as required by section 201 of the High-Performance Computing Act of 1990. Prior to deployment of a multi-gigabit-per-second national network, the National Science Foundation shall maintain, expand, and upgrade its existing computer networks. Additional responsibilities include promoting development of information services and data bases available over such computer networks; facilitation of the documentation, evaluation, and distribution of research software over such computer networks; encouragement of continued development of innovative software by industry; and promotion of science and engineering education.

(B) The National Institute of Standards and Technology shall be responsible for developing, through the open standards setting process, standards, guidelines, measurement techniques, and test methods for the interoperability of high performance computers in networks and for common user interfaces to systems. In addition, the National Institute of Standards and Technology shall be responsible for developing benchmark tests and standards, through the open standards setting process and in conjunction with industry, for high performance computers and software. Pursuant to the Computer Security Act of 1987 (Public Law 100-235; 100 Stat. 1724), the National Institute of Standards and Technology shall continue to be responsible for adopting standards and guidelines needed to assure the cost-effective security and privacy of sensitive information in Federal computer systems. These standards and guidelines shall be developed through the open standards setting process and in conjunction with industry.

(C) The National Oceanic and Atmospheric Administration shall continue to observe, collect, communicate, analyze, process, provide, and disseminate data about the Earth and its oceans, atmosphere, and space environment. The National Oceanic and Atmospheric Administration shall improve the quality and accessibility of the environmental data stored at its four data centers and shall perform research and develop technology to support its data handling role.

(D) The National Aeronautics and Space Administration shall continue to conduct basic and applied research in high-performance computing, particularly in the field of computational science, with emphasis on aeronautics and the processing of remote sensing data.

(E) The Department of Defense, through the Defense Advanced Research Projects Agency and other agencies, shall continue to conduct basic and applied research in high-performance computing, particularly in computer networking, semiconductor technology, and large-scale parallel processors. Pursuant to the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3701 et seq.) and other appropriate Acts, the Department shall ensure that unclassified computing technology research is readily available to United States industry. The National Secu-

rity Agency, pursuant to the Computer Security Act of 1987 (Public Law 100–235; 100 Stat. 1724), shall continue to provide, where appropriate, technical advice and assistance to the National Institute of Standards and Technology for the adoption of standards and guidelines needed to assure the cost-effective security and privacy of sensitive information in Federal computer systems.

(F) The Department of Energy and its national laboratories shall continue to conduct basic and applied research in high-performance computing, particularly in software development and multi-processor supercomputers. Pursuant to the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3701 et seq.) and other appropriate Acts, the Department of Energy shall ensure that unclassified computer research is readily available to North American companies.

(G) The Department of Education, pursuant to the Library Services and Construction Act (20 U.S.C. 351 et seq.) and the Higher Education Act of 1965 (20 U.S.C. 1060 et seq.), shall encourage the distribution of library and information resources, through library linkages to the National Research and Education Network and through other means.

(H) The Library of Congress, the National Library of Medicine, and the National Agricultural Library, as national libraries of the United States, shall continue to compile, develop, and maintain electronic data bases in appropriate areas of expertise and provide for dissemination of, access to, and use of these data bases and other library resources through the Network.

(2) The Plan shall facilitate collaboration among agencies and departments with respect to—

(A) ensuring interoperability among computer networks run by the agencies and departments;

(B) increasing software productivity, capability, and reliability;

(C) encouraging, where appropriate, agency cooperation with industry in development of software;

(D) promoting interoperability of software;

(E) distributing software among the agencies and departments; and

(F) distributing federally-funded, unclassified software to State and local governments, industry, and universities.

(e)(1) Each Federal agency and department involved in high-performance computing shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report identifying each element of its high-performance computing activities, which—

(A) specifies whether each such element (i) contributes primarily to the implementation of the Plan or (ii) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

(B) states the portion of its request for appropriations that is allocated to each such element.

(2) The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency and departmental responsibilities set forth in the Plan, and shall include, in the Presi-

dent's annual budget estimate, a statement of the portion of each agency or department's annual budget estimate that is allocated to each element of such agency or department's high-performance computing activities. The Office of Management and Budget shall ensure that a copy of the President's annual budget estimate is transmitted to the Chairman of the Council at the same time as such budget estimate is submitted to the Congress.

ANNUAL REPORT

SEC. 603. The Chairman of the Council shall prepare and submit to the President and the Congress, not later than March 1 of each year, an annual report on the activities conducted pursuant to this title during the preceding fiscal year, including—

(1) a summary of the achievements of Federal high-performance computing research and development efforts during that preceding fiscal year;

(2) an analysis of the progress made toward achieving the goals and objectives of the Plan;

(3) a copy or summary of the Plan and any changes made in such Plan;

(4) a summary of agency budgets for high-performance computing activities for that preceding fiscal year; and

(5) any recommendations regarding additional action or legislation which may be required to assist in achieving the purposes of this title.

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