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Testimony of Douglas E. Van Houweling
Merit Network, Inc.

Mr. Chairman, members of the Committee, I am pleased to appear on behalf of Merit Network, Incorporated, a not-for-profit organization of nine Michigan universities. Those universities include: University of Michigan, Saginaw Valley State University, Michigan State University, Wayne State University, Eastern Michigan University, Oakland University, Western Michigan University, Michigan Technological University, and Central Michigan University.

As you know, Merit is responsible for the management of the NSFNET backbone service under a cooperative agreement with the National Science Foundation (NSF).

You have requested that I address the following in my testimony:

- The current arrangement for operation of NSFNET;
- The NSF's plan for recompetition of the award for operation of the NSFNET backbone; and
- The key issues Congress needs to consider to help ensure a successful evolution of the current Internet to the NREN.

Before I address these specific points, let me make a few comments on the history behind the current cooperative agreement between Merit and the NSF.

A Brief History

Merit has been involved in data communications networking since the very beginning of the technology's development in the United States. Established in 1966, Merit began operating an inter-university packet switching data network in 1972. Today Merit provides the State of Michigan with Michnet, a state-wide data communications network. We are proud to have been pioneers in the development of this critical technology for the future.

The current management and operation of the NSFNET backbone service is based on Merit's cooperative agreement with the National Science Foundation (NSF).

In 1985, the NSF established five national supercomputing centers, and in 1986 linked those centers together at 56 kbps, thus establishing the original NSFNET. That original network proved so useful that it quickly became overloaded, and applications such as remote computing were increasingly difficult to perform. In addition, a number of regional networks wished to connect to the supercomputing centers and to each other.
As a result, in 1987 NSF solicited [1] proposals from organizations "to manage, operate, and continue development of a national network." A key point in that solicitation was that "the managing organization shall apply its expertise and creativity in devising innovative approaches.

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[1]Project Solicitation for Management and Operation of the NSFNET Backbone Network, National Science Foundation, OMB 3145-0058.

Proposers are encouraged to suggest alternate architectures and approaches that may be more appropriate, more cost effective, or offer better service."

The solicitation also stated:

> "The purpose of the NSFNET program is to provide scientists and engineers with a national computer communications network that will evolve to a national internetwork system for improving communication, collaboration, and resource sharing.... NSFNET is dynamic. It will change with evolving network affiliations, improved technologies, competing communications costs, varying traffic load, and other similar factors."

The solicitation went on to describe NSFNET's overall architecture to be a "three-level hierarchy:

(1) A transcontinental 'backbone' network, interconnecting

(2) a number of autonomously administered 'second-level' networks each of which interconnects

(3) as many as 30 academic, industrial, and/or government research campus networks."

Merit believed that higher education participation would be critical to the success and to the community's use of the backbone. Further, Merit's analysis of the needed capabilities, its understanding of the available funding from NSF, and the resulting required level of effort led to the conclusion that successful service would require a partnership with the computing industry and the telecommunications industry.

On August 14, Merit submitted a proposal in partnership with IBM and MCI. Two key aspects of that Merit proposal were:

1) The design and deployment of a 1.5 million-bit-per-second (T-1) network from the beginning, with a option for providing 45 million-bit-per-second (T-3) service after 1990 if NSF so desired;

2) Significant cost sharing, including hardware and software from IBM, connectivity from MCI, and funding from the State of Michigan's Strategic Fund.

In total, this cost sharing was more than double the proposed five-year NSF budget of $14 million. It is important to underscore that the NSF process was a highly competitive one. We understand that a number of companies in the telecommunications and computing industries as well as other universities submitted proposals.

On November 19, 1987, NSF announced a five-year cooperative agreement with Merit for the design, engineering, construction, and operation of a national backbone network service. NSF had the capacity to extend and modify the agreement, develop additional agreements and subcontracts, and provide additional funding as needed over the life of the agreement.

In July 1988, only seven months after the award, Merit and its partners deployed the backbone on schedule and within budget. Since that initial deployment, the NSFNET services have enjoyed phenomenal success due to NSF's leadership and the hard work and investment of a number of

industry participants. The traffic on the backbone has grown almost 7,000 percent, an average of 11 percent compounded every month, and new applications and uses are constantly emerging. This has been a challenge to manage, but even more of a challenge has been the growth in the number of networks that are now reachable via the NSFNET service. This number has doubled every year and is now approaching 5,000 networks worldwide.

In fact, the growth of the network and its use was so great that it posed significant technical challenges. Recall that, at the time, NSF and the Merit partnership were working on the leading edge of a new internetworking technology. Some of the technical hurdles were very difficult to overcome.

To accommodate this extraordinary growth, the backbone service was continuously upgraded — new connections were added, speeds increased, and routing and network management technology enhanced. Both NSF and the partners added new resources. NSF's additional funding commitment was augmented by continued major cost sharing by IBM and MCI.

The option to upgrade the network to T-3 speeds was exercised by NSF for four reasons:

1) Many of the emerging applications, such as graphic user interfaces that facilitated visualization of medical images and other applications,[2] such as ozone depletion, air pollution and fuel combustion studies, as well as the emerging distributed file systems, required broader bandwidth.

2) Many federal studies, including the September 1989 FCCSET report as well as the OSTP program, proposed the need to upgrade the speed of the network over time to T-3.

3) The projections of the extraordinary growth clearly indicated that the T-1 network would be congested unless additional capacity (e.g. by an upgrade to higher speeds) was deployed.

4) Finally, one of the overriding goals of all parties involved in the NSFNET backbone service has been to continue to push the limits of communications technology and maintain the U.S. competitive advantage in this field.

Leading-edge technology has been required all along the way. The challenge of incorporating such developmental technology in a production network has presented all of us with many problems, but it has also stimulated United States' research, industrial and commercial leadership in fast-packet switching data networking.

Organizational Change

As the backbone network service grew in complexity, and was re-engineered, the underlying organization also had to evolve. Increased focus and resources were needed to keep pace with the increasingly complex technical, business and policy environment.

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[2] Grand Challenges: 1993 High Performance Computing and Communications, FY 1993 U.S. Research and Development Program, Supplement to the President's FY 1993 Budget.

Therefore, with the agreement of NSF, on September 14, 1990, Merit, IBM, and MCI announced the formation of a new, not-for-profit corporation, Advanced Network & Services, Inc. (ANS). The certificate of incorporation states that ANS:

1) "is ... dedicated to the advancement of education and research in the interest of improving the ability of the United States to compete in the global economic environment";

2) "will concentrate on computer networking and related services,";

3) "shall help establish a high-speed computer network which will be maintained at the leading edge of technology,";

4) "will ... help to expand the access to and interchange of information technology resources among academic, government and industry users,"; and

5) "will engage in research and development work which will ...contribute to United States preeminence in high speed networking...."

ANS' board, of which I serve as Chairman, is broadly representative, its members drawn from industry and higher education across the nation. Both IBM and MCI made major contributions in the form of grants to ANS' establishment. In addition, both IBM and MCI bear substantial cost in providing equipment and services to ANS.

With the approval of the National Science Foundation, Merit contracted with ANS for backbone network service. The goals were:

1) To provide a stable nationally representative organizational and financial platform for the future of the NSFNET backbone service and its successors.

2) To begin the process of privatizing the network.

3) To provide a foundation for interconnecting commercial service providers with higher education and research enterprises.

It is important to note that there were no government asset transferred to ANS at the time of its establishment. The network hardware itself is owned by ANS, and the communications facilities are leased by ANS from MCI and others. Federal agencies, regional and state networks, other commercial networks, universities and private industry pay for their attachments to the ANS network.

The formation of ANS brought to the network's development an increased amount of private sector participation — a goal which Congress recognized in passing the High Performance Computing Act of 1991. The formation of ANS also was heralded by Senator Al Gore (D-TN), who stated that "Just as private contractors helped build the interstate highway system, this new corporation will help build the national information superhighway today's information age demands."

This increased participation of the private sector, spurred by ANS's entry into the field, also broadened the funding base and increased competition in the network's development. For

example, ANS has also submitted proposals to provide services to emerging state networks with other interexchange carriers. In addition, new test equipment vendors have been integrated into the network to improve network management for all users at very high speeds.

To accomplish the third goal, ANS on May 30, 1991 established a for-profit subsidiary, ANS CO+RE Systems, Inc., to serve commercial customers and link them to the research and education community. Discussions with representatives of the regional networks, FARNET, and the NSF were held to ensure that the cost of providing commercial services are completely reimbursed through non-governmental sources. Fees from commercial use of backbone services, minus operating expenses and taxes, are returned to ANS for reinvestment in the network infrastructure.

The creation of ANS CO+RE and its work with regional networks blazed the trail for major segments of the Internet to carry commercial traffic, creating many new commercial Internet service providers and taking a major step forward in pursuing the vision of the original drafters of the program.

The Results

Less than four years later, it is instructive to assess the results of the NSF's visionary plan.

First, access to the network has exceeded the most optimistic visions. The solicitation said, "It is anticipated that over the next five years NSFNET will reach more than 10,000 mathematicians, scientists, and engineers at 200 or more campuses and other research centers."

In fact, the NSFNET today provides access to millions of scholars and researchers in over 1000 institutions across the United States. Over 650 colleges and universities are connected representing approximately 80 percent of the nation's student population and 90 percent of the nation's federally sponsored research.

Further, NSFNET now provides access to more than a thousand high schools and several hundred libraries through the joint efforts of the NSF and the regional networks.

This data network is going to open up entire new vistas of information and learning techniques for America's students from kindergarten to post-graduate institutions. I believe it will spark a revolutionary change in the way we prepare our children for the challenges of the future.

This evolving network is clearly an example of where economies of scale make a difference in serving many diverse communities.

Second, federal funds have been leveraged in an extraordinary fashion. Every dollar spent by NSF on the backbone service is matched by more than four dollars from Merit and its partners. Further, each of these dollars has yielded an investment at least ten times larger in regional and campus networks.

Mr. Chairman, the bottom line is, every Federal dollar has stimulated at least a forty-dollar investment in an emerging technology critical to the nation's international competitiveness. With a small expenditure of federal funds, the government has spurred the development of an entirely new set of technologies and applications that will dramatically enhance our ability to compete in world markets.

Third, a new industry has begun to develop in which the United States not only leads technologically, but in the market. American companies lead the world in internet technology, and are growing rapidly. Not only are large communications carriers like Sprint, AT&T, MCI, Ameritech, and Bell Atlantic working vigorously to establish their presence, but smaller companies and regional and state networking organizations are growing rapidly. Merit and ANS are simply two of the many organizations in this rapidly growing marketplace.

In keeping with the goals of the High Performance Computing and Communications Program, the NSF program has been an extraordinary success in stimulating the growth of a critical new technology. The program grew from a federal government commitment to seed an infant technology, was helped and nurtured by a committed partnership of educational and research institutions, state government and private enterprises, and it is now demostrating its potential. Already, the United States is the world leader in exporting this new communications technology and its many related applications. Those increased exports are making a positive difference in our balance of payments.

This network is envied worldwide. It has allowed the U.S. to lead in building a high-speed data communications infrastructure. We are pioneering technological applications that will be among the most critical for research, education, and business in the 21st Century.

Fourth, and perhaps most important in the long term, is that government, higher education, and industry are working cooperatively to build a critical infrastructure for our nation. No one argues with the proposition that knowledge and information are critical commodities for our nation's future.

Key Issues For The Future

The NSFNET example and experience is providing the United States with the tool it needs to succeed in that future. NSF's vision and program have led us to this uniquely American approach to innovation. With a modest investment, they have energized a nation. Their program plan and strategy for introducing future technology will sustain the momentum. We believe NSF's program plan for recompetition of the cooperative agreement is appropriate, but entails substantial technical and management challenges.

Congress should consider the following key issues to help ensure a successful evolution to the NREN.

1) The successful triad of government, academic, and private industry should continue because it spawns innovation and technology transfer which makes this country stronger.

2) Any future program should seek to stimulate investment from private industry as the current program has so successfully done.

3) Congress should create an environment in which the natural tendencies for fragmentation of federal efforts are overcome by a coordinated program led by the NSF.

Merit and its partners have been pleased to have played their part in this extraordinary national program.

Testimony of Dr. Eric S. Hood, President, Federation of American Research Networks (FARNET), and Executive Director, NorthWestNet.

March 12, 1992

Chairman Boucher and members of the Committee, I am truly pleased to present testimony regarding the National Science Foundation Network (NSFNET) and the National Research and Education Network (NREN) on behalf of the Federation of American Research Networks (FARNET).

FARNET is a non-profit association chartered to support the evolution and wide-spread adoption of data networking to enhance research, education, and economic development. Our 32 members include operators of state, regional, and national computer networks, telecommunications vendors, and other organizations of like mission. A majority of the private network providers [e.g., Advanced Network Services (ANS), California Education and Research Foundation Network (CERFnet), and Performance Systems International (PSI)] are members, as are most of the other regional and state public networks connected to the National Science Foundation Network (NSFNET). FARNET also has liaison relationships with other national and international organizations with interests in networking, including the Coordinating Committee on Intercontinental Research Networks (CCIRN) and the Internet Engineering Task Force (IETF).

As a membership association, FARNET limits its public commentary on policy to questions which the membership has considered as a body. With regard to the issues before the Subcommittee, and in response to your questions regarding the NSFNET and the National Research and Education Network (NREN) as posed in your letter of February 28, 1992, the FARNET Board of Directors would like to communicate the following observations based on workshops, conferences, and focused electronic discussions conducted over the past six months.

"Assessment of NSF's efforts to provide networking support to the science and engineering research and education community, including your views on the current arrangement for operation of NSFNET."

The Division of Networking and Communications Research and Infrastructure (DNCRI) at NSF has done an exemplary job of enabling the provision of network access to the nation's research and education communities. Over the past five years, NSF has created a nd maintained an operational infrastructure which has successfully sustained exponential growth, as measured by the number of users, by the number of connected institutions, and by the volume of network traffic. In addition, NSF has demonstrated technical leadership in establishing standards for data networking and for supporting research into very high speed technologies. Furthermore, NSF's investments, which have been modest by Federal standards, have leveraged significant funding commitments on university campuses, from corporations, and from state governments.

Ten years ago in 1982, the Defense Advanced Research Project Agency's ARPANET deployed then state of the art technology to connect military facilities to approximately 10 or 15 research universities. The computing devices attached to the network numbered in the hundreds and ARPANET trunk speeds did not exceed 56 thousand bits per second. The custom-built hardware needed to accomplish the switching cost on the order of $100,000 to $200,000 per node. Computer scientists and engineers were the only regular users of the network.

In contrast, trunk bandwidths in the NSFNET now routinely exceed 25 times the capacity of the original ARPANET (or 1.5 million bits per second), and many trunks are capable of supporting 700 times this amount (or 45 million bits per second). The cost of the switching hardware is at least one, and can be two, orders of magnitude smaller. The computing devices that we use daily, from very fast personal computers to graphics workstations to parallel supercomputers, were barely envisioned by designers 10 years ago.

Today's NSFNET allows researchers and scholars to communicate electronically, to exchange text, data and graphical images, and to access geographically dispersed information resources. The NSFNET now connects over 630 colleges and universities, or approximately 35 percent of our nation's four year institutions of higher education. Over 90 percent of the nation's Federally sponsored research is conducted at institutions of higher education connected to the NSFNET. Approximately 70 percent of our nation' s student population attending four year colleges and universities have institutional access to the NSFNET. This communications and information infrastructure enables computer users at sites across the nation to share information and to work collaboratively on common tasks and projects. More than 1,000 institutions, including colleges, universities, and not-for-profit, government, and corporate research facilities representing every state, are currently connected to the NSFNET. Today's NSFNET is also an important part of a larger communications network, the global Internet, which connects an estimated 750,000 computers and 5 million users worldwide.

Such broad interconnectivity between our nation's colleges and universities has opened new avenues for communication among the nation's scholars. The NSFNET now empowers researchers and educators at more than just the Carnegie research universities. Over the network, faculty and students at comprehensive and liberal arts colleges now routinely collaborate electronically with their counterparts at our nation's elite research universities.

Over the past five years, NSF has provided national administrative and technical leadership in the field of research and education networking. Throughout this period, NSF has provided clear and consistent technical direction promoting the deployment of interoperable and open data communications technologies. The NSF has enabled the development of a national networking infrastructure capable of supporting communications across diverse computing platforms manufactured by multiple vendors. For those that have followed NSF's lead, inter-institutional connectivity across campus, corporate, state, regional, and national boundaries is now possible. Thus NSF has successfully leveraged technically sound investments on many university and corporate campuses in anticipation of national and global interconnectivity. One regional network, WESTnet, estimates that for each Federal dollar invested in the NSFNET program, the Federal Government leverages thirty-one dollars of state and local funds.

In constructing the plan for recompetition of the award for operation of the NSFNET backbone, NSF both solicited and implemented recommendations from network users and network providers represented by FARNET. With support from the National Science Foundation, FARNET conducted a workshop and electronic discussion in the late summer and early fall of 1991 to address the complex issue of inter-regional connectivity. Specifically, FARNET considered future options for the provision of connectivity among midlevel networks after the current agreement for NSFNET backbone services expires in November, 1992. Participants included representatives from FARNET member networks, other NREN stake holders (including telecommunications carriers and leaders in university information technology), Federal agency representatives, and legal and economic experts. Our report was well received by NSF. In fact, several key concepts from the FARNET report regarding network stability and multiple awards

to inter-regional connectivity service providers were included in NSF's report to the National Science Board, "Project Development Plan: Continuation and Enhancement of NSFNET Backbone Services." (A copy of FARNET's Recommendations to the National Science Foundation Regarding Inter-regional Connectivity is attached.)

In their report to the National Science Board, "Project Development Plan: Continuation and Enhancement of NSFNET Backbone Services," NSF identified the two seminal issues associated with the recompetition process: preservation of network stability and pro motion of competition. Regarding fair competition, NSF's report further identifies two essential points: that the incumbent provider is not favored, and that equal opportunity is provided to other firms desiring to participate in the provision of transcontinental TCP/IP networking services.

To facilitate the accomplishment of these objectives, the NREN Engineering Group (NEG) advising the National Science Foundation has proposed clear separation of the administration of network routing from the provision of transcontinental circuits and digital switching fabric. Operationally, this separation will be achieved through two independent solicitations. The NEG has recommended that the solicitation providing for the formation of an Internet Routing Authority (IRA) be awarded to a single entity. FARNET agrees that this single award is necessary to ensure the continued operational viability of the network. The solicitation for connectivity services will include the possibility for multiple awards. FARNET agrees and has strongly recommended that the provision of connectivity services be awarded to at least two competing providers. Thus all awardees will have appropriate incentives to cooperate with each other in the development and operation of interconnection facilities.

If implemented as outlined in the report to the National Science Board, the NSF plan for recompetition of the award for operation of the NSFNET backbone will indeed level the playing field for the commercial network providers while preserving an acceptable level of stability.

The plan as presented in NSF's report to the National Science Board, "Project Development Plan: Continuation and Enhancement of NSFNET Backbone Services," is consistent with the consensus position of a majority of FARNET's constituency. FARNET endorses the plan as presented, but must again emphasize the importance of multiple awards for the provision of inter-regional connectivity services.

Something significant is happening in our country. Over the past five years under NSF's leadership, America has made great progress toward creating a national data communications and information infrastructure to enable research, education, technology transfer, and economic development. This national resource is already delivering material benefit to research and education, both in the public and private sectors. Fully realized, the NREN holds the promise of significantly enhancing our national competitiveness in the global marketplace.

Over the past five years, the Federal Government has played a pivotal role in the creation, growth, and evolution of the NSFNET. Continued Federal investments in the NREN must be focused to ensure equal and ubiquitous access to our nation's information resources, to improve network reliability, performance, and usability, and to enable research in new and pre-competitive technologies. With judicious investments and the correct partnership among government, academia, and industry, we can realize the NREN vision.

FARNET endorses the right of equal access to our nation's information resources.

The NREN has the potential to reduce traditional impediments to data communication and access to information systems: geographic isolation, smallness of size, and sparseness of local resources. Through the NSFNET this vision has become reality for our re search and higher education communities interested in information exploration. From small town doctors collaborating with inner city clinicians on a difficult diagnosis, to patrons of a community library wishing to broaden their understanding of the world around them, the NREN can begin to deliver on this promise by funding programs aimed at enabling these previously disenfranchised communities.

Through the NREN, this vision can become reality for all Americans. The benefits provided by the NREN are not restricted to those who are resource poor, but are shared equally by stewards of unique resources. For example, the Smithsonian Astrophysical Center's collection of astronomical images in Boston and the globally distributed antennas of the National Radio Astronomy Observatory are equally accessible to scholars through the NSFNET. The evolution of the NREN must be guided by the principle of equality of access to scholarly information for all Americans.

There is considerable historical precedent for Federal leadership in supporting the creation, operation, and maintenance of the nation's commerce, transportation, and utility systems. In that spirit, FARNET recommends that Congress continue to support the extension of basic connectivity services to underserved and geographically remote communities through the programs of the Federal agencies participating in the NREN.

FARNET endorses the principles of ubiquitous access to and universal interconnectivity of our nation's information resources.

The strength of the Internet, the system of networks that includes the NSFNET, is its broad interconnectivity. Internet technology is now widely employed to electronically link computers — from microcomputers to supercomputers. These computers can be located within an organization at a single site or within multiple organizations at opposite ends of the country.

We are well on the way to creating a national, and in the near future, even global, communication and information network. Any decision that limits interconnectivity among segments of the Internet impedes the development and reduces the usefulness of this national resource. Educators, researchers, and students must have access to the full array of computing and information resources on the Internet. Balkanization of the Internet cannot be tolerated. Congress must discourage funding policies which allow procurement of network services from disjoint islands of service providers. Endorsing procurement criteria that require the service providers to guarantee interconnectivity to other service providers will ensure that we progress toward a national data communications fabric that reaches every campus, every library, every school, every home.

FARNET endorses continued efforts to improve the reliability, performance, and usability of the networking infrastructure.

Continuing enhancements of network capacity and performance, and improvements in network operations and engineering practices are essential to the development of a reliable and robust NREN. Providing an adequate level of stability and predictability, both in the operation of the current Internet and in the transition to new technologies or management paradigms, is critical to the continuing growth and use of the NREN. Until these advances in network capacity and performance occur as a natural consequences of private sector activity, judicious Federal

investments in the nation's communications infrastructure will be required. The continued investment of Federal funds will ensure that major segments of our population (i.e., remote areas, underserved communities, disadvantaged constituencies) are not disenfranchised from this national resource.

Greatly improved support for user and information services network-wide will enable the rapid extension, acceptance, and use of the NREN. This support should include plans for the provision of access to both public and private information resources, with early resolution of copyright and other intellectual property issues. Federal investment in research and development of directory services, network navigation tools, user documentation, and training services is a necessary prerequisite to enhancing network usability.

FARNET endorses the elimination of restrictions on the delivery of commercial services across the NSFNET and the emerging NREN.

We have reached a crossroads in the evolution of true network interconnectivity for our country. The network infrastructure that we are building has the inherent capability to promote research, education, technology transfer, and economic development. Yet, the current acceptable use restrictions on the Federally sponsored national backbone impede our progress.

Close collaboration, even partnership, among government, academia, and industry is essential in promoting the advancement of these critical technologies. Such collaborative efforts are enabled when all partners can, without restriction, access common infrastructure. Yet, current policies prohibit the use of the Federally funded network for commercial purposes. It is as if we were required to have two telephones on every desk, one for making purely "educational" calls and the second for making "commercial" calls. The economic inefficiencies and practical disadvantages of such a system are apparent. If the NREN is to realize its full potential, part of its evolution must include controlled experimentation permitting interconnection of the public and private sectors to achieve a "critical mass" of network users and suppliers.

To remedy the current limitations on interconnectivity between the public and private sectors, FARNET requests that Congress act to remove the current acceptable use restrictions on the Federally sponsored national network infrastructure. At a minimum, commercial traffic should be permitted on this infrastructure on an experimental basis and under suitably controlled conditions. This experiment should be designed to produce results which can be analyzed from multiple perspectives (i.e., technical, administrative, economic, and legal) and should be widely disseminated as envisioned in the High Performance Computing and Communications (HPCC) legislation.

FARNET endorses the principle of inter-agency cooperation and collaboration in the construction of the NREN.

As noted earlier, one of the great strengths of today's Internet is the provision of broad interconnectivity. Although this interconnectivity includes the current NSFNET and the national mission agency networks operated by the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the Defense Advanced Research Projects Agency (DARPA), today's Internet can not be characterized as a single, homogeneous entity. With such a broad and varied constituency, the Interim Interagency NREN is unlikely to evolve as a single, homogeneous initiative, at least in the short term. Yet insofar as existing technologies and current deployment strategies are sufficient to adequately support mission

agency activities, the Federal agencies must be encouraged to collaborate and cooperate to reduce costs and to promote the public good.

FARNET endorses further research into key technologies.

The nation must have focused research programs pushing the envelope of high performance production networking. Continued Federal support for basic research is essential to the solution of difficult problems that remain in several critical areas (e.g., network security, authentication, privacy, routing and addressing, high speed circuit and switching architectures).

Forging the appropriate mix of private investment and public sponsorship is critical to the continuing development and delivery of this important technology. Continued Federal investments in these key research areas will leverage private funds and enable the transfer of pre-competitive technologies from academic and government laboratories to private industry.

FARNET endorses the continued close collaboration among government, academia, and industry to realize the NREN vision.

Ten years ago, the Internet was a government-funded research project. Today, internetworking is a multi-billion dollar industry.

Ten years ago, access to this technology was limited to a small cadre of experts in computer science and telecommunications engineering. Today, an estimated 5 million researchers and educators, teachers and students, authors and librarians, physicians and clinicians, policy makers and corporate planners use the worldwide Internet.

Ten years ago, Internet devices were the constructs of research labs. Today, Internetworking hardware and software components are commercially available from a variety of vendors at commodity prices.

Ten years ago, telecommunications providers were offering dedicated digital services within and between only a few metropolitan areas. Today, every major provider offers, or has immediate plans to offer tariffed, high speed packetized digital services aimed at a burgeoning data networking market.

From these achievements it is clear that we have made considerable progress along the sometimes bumpy road toward commercialization and privatization of the Internet. The components of networking technology have matured and become available commercially. Prices of networking equipment, circuits, and services have dropped for all consumers. New vendors with new capital have been attracted into the market, creating new high-technology jobs and opportunities.

But the internetworking industry faces the classical set of challenges associated with success management. While business activity in the private sector grows, we must avoid the temptation to reduce government investment in new or pre-competitive technologies. While the costs of connectivity in our metropolitan areas continue to decrease, we must avoid the temptation to reduce government support for communities that are underserved.

If we move cautiously forward in the correct partnership of government, academia, and industry, our nation can work together to realize the NREN vision.

We trust that these observations will be of use to the Subcommittee in its March deliberations. These comments are respectfully submitted by Dr. Eric S. Hood, President of the Federation of American Research Networks (FARNET).

Testimony of Dr. A. Nico Habermann and Dr. Stephen S. Wolff

Part 1: Testimony of Dr. A. Nico Habermann

Mr. Chairman, thank you for the opportunity to appear before your committee today to provide information about the exciting program in networking supported by the National Science Foundation (NSF) and several other agencies of the U.S. government. I am privileged to serve as the Assistant Director of the NSF for the Computer and Information Science and Engineering Directorate, which has responsibility for broad national research, infrastructure and facilities programs in computer, communications, and information sciences and engineering. Included among my responsibilities is leadership of the overall NSF High Performance Computing and Communications(HPCC) Program with its important components in national Supercomputer Centers and the NSFNET, the subject of our discussion today.

In this latter respect, I am pleased to be accompanied by my colleague Dr. Stephen S. Wolff, Director of the Division of Networking & Communications Research & Infrastructure (NCRI). Dr. Wolff has provided leadership for this division since its inception and in this capacity has lead the creation and development of the NSFNET and the emerging NREN program. Before turning to Dr. Wolff, to elaborate on the NSFNET, I would very much like to place this activity in the larger context that it impacts.

Background

The President's High Performance Computing and Communications Program, which was announced on February 5, 1991, consists of four components, one of which is the National Research and Education Network (NREN). The NSFNET activity is part of the NREN component. The NREN is also a major subject of the High Performance Computing Act of 1991 (P.L. 102-194) that was signed by the President this past December. This Act, that your Committee was instrumental in drafting, provides important impetus to the presidential HPCC initiative.

Leadership and direction for the HPCC Program is provided by the Office of Science and Technology Policy, through the FCCSET Committee on Physical, Mathematical, and Engineering Sciences (PMES). The High Performance Computing, Communications, and Information Technology (HPCCIT) subcommittee is chartered under the PMES and is composed of an executive council and four task groups to coordinate science and engineering computing, computer research and development, Federal networking and communications, and education. Since October 1991, I have served as the Co-Chairman of this Networking activity.

As described in the Supplement to the President's FY 1993 Budget, "Grand Challenges 1993: High Performance Computing and Communications", NSF is designated as the coordinating agency for the NREN program. As the NREN title indicates, to quote from the Grand Challenges report, "The NREN program is both a goal of the HPCC Program and a key enabling technology for success in the other components. The NREN is the future realization of an interconnected gigabit computer network system supporting HPCC." If we are successful in deploying this technology for the research and education community, then aside from supporting current science and technology Grand Challenge Applications that are important to federal mission agencies, it will broadly influence communications technology development. However, it is important to bear

in mind, that the government program, as its name implies, primarily supports computer and communications networking for research and education, not general purpose usage. Nonetheless, the NREN component incorporates important testbeds and research for new communications technologies.

The NREN component is dedicated to promoting communications among researchers, educators, and students in the U.S. The NREN activities contribute directly to the goals of the High Performance Computing and Communications Program in three ways:

1) by extending U.S. technological leadership in computer communications;

2) by enhancing the dissemination and application of computer and communications technologies to enable advances on applications such as, Grand Challenges; and

3) by demonstrating innovative new means of communication to spur gains in U.S. productivity.

In order to achieve these goals, the NREN program consists of two sub-components: one that supports the development and enhancement of network backbone services, which serves the purpose of connecting a large number of regional research and education networks - the Interagency Interim NREN; and a second sub-component, which supports basic and experimental research in the design of large-scale, high-speed networks for future use (gigabit networks R&D).

The first NREN sub-component, developing connections between existing and growing regional networks, includes three network backbones supported by NSF, DOE and NASA. The backbone currently supported by NSF is the NSFNET, which connects a large number of regional networks at a variety of educational and research institutions throughout the U.S. The NSFNET backbone, all of whose services are competitively procured from the private sector, provides a networking superstructure that enables scientists and educators to communicate across the boundaries of their regional networks. The second NREN subcomponent, supporting networking research, includes a collection of five gigabit testbed networks, connecting experimental sites across the entire nation.

At each step of the development of the NSF NREN program, we must ask ourselves why the government should continue to be involved with the private sector in developing computer network infrastructure to support the research and education community. Although the private sector plays an increasingly important role, there are indeed cogent reasons why the government should stay involved in important aspects of a host of activities in network development and research. In order to put further discussion regarding NSF's role in networking in perspective, it seems proper to list here the main reasons, as we see them, for NSF's continued involvement in support of technology development and deployment.

> The proper and effective use of very high speed computer networks, and the connection between networks will require innovative research across various disciplines and technologies that government, industry, and academia working together are uniquely capable of providing.
>
> It is certain that the capabilities of networks can be increased at least a hundred-fold to support a mode of interaction we can only dream of today. (Imagine, for example, the impact of a hundred-fold increase in both aircraft speed and passenger capacity on travel, military, and on airports, etc!). To meet these challenges, industrial and academic R&D, coordinated and focused by the Federal Government, will concentrate on the advanced generic technologies required to realize a very high speed network.

Since there is practically no limit to further development of networking technology, the research and education community should be stimulated to find and explore innovative ways of communicating with each other and with growing information sources. At this time, we think that the development will lead to the use of networks for remote, interactive, real-time computing. However, experience with the ARPANET, designed in the mid-seventies, has shown that the outcome may well be both broader and richer than our original expectations.

Networks help broaden the participation for the entire country by providing equal access to advanced computer facilities, such as, the supercomputer centers, for remote and relatively isolated parts of the country and similarly help increase the involvement of minorities and under-represented groups in the research and education enterprise. This enables all scientists and students to more fully participate in leading-edge research and education opportunities that otherwise might not be affordable.

My final point supporting NSF involvement in this technology development and deployment relates to the need to encourage all educational institutions, including K-12, to explore the networking capabilities that allow them to access and use the tools that researchers develop and utilize in the work on the Grand Challenges. This can lead to more excitement in education and may stimulate more students to enter science and engineering.

NSF welcomes the opportunity to work with the private sector on these and all other aspects of networking to the benefit of our science and education community in the interest of the Nation's future. And now with your permission, I would like to turn to my colleague Dr. Stephen Wolff to provide an overview of the current state of NSF's networking program and summarize the management and development plan and associated policy issues.

Part 2: Testimony of Dr. Stephen S. Wolff

Mr. Chairman, thank you for this opportunity to appear today before this committee to discuss the NSFNET and related activities.

There are three parts to my testimony. I will discuss first the current state of the NSFNET Backbone project, including its relationships to other networks that actually, or potentially connect to it, and also the management controls the NSF has in place with its awardee, Merit, Inc. Second, I shall report on the progress we have made in implementing the Project Development Plan for continuation and enhancement of NSFNET Backbone services which was approved by the National Science Board in November last. Finally, I shall briefly discuss the relationships between the NSFNET and NREN programs, including the interagency management structure now evolving for the NREN as an Administration program with a legislative authority.

Current State, Other Networks, and Management Controls

a. Current State The five year cooperative agreement between the Foundation and Merit, Inc. for management and operation of the NSFNET Backbone was signed in November, 1987, after a five month period of competitive announcement and merit review of proposals. Merit, and its partners IBM and MCI, put in place a 1 3-node, 1.5 mb/s (million-bits-per-second), or T1, network in a very short time. The new Backbone began to carry traffic in August, 1988. In that month, traffic doubled over the July figure for the original Backbone network that the new one supplanted.

Since August, 1988, traffic on the Backbone has increased more than fifty-fold, from 200 million to 11 billion packets per month. This increase in traffic has been accommodated by hundreds of minor engineering improvements to the network and two major upgrades. The first upgrade increased the number of links in the network from 14 to 19. This increased the robustness of the Backbone by multiply connecting all 13 nodes, and it increased capacity as well. The second upgrade increased the number of Backbone nodes from 13 to 16 (the three new nodes were competitively selected), and raised the transmission speed from T1 to T3 (1.5 to 45 mb/s).

All the engineering improvements and both major upgrades were clearly foreseen and discussed in Merit's original farsighted proposal to the NSF. Such are the economies of scale in telecommunications that the upgrades to accommodate a fifty-fold traffic increase have been achieved with only a doubling in cost to the Foundation - from the original $14 Million over five years to the present five-year project cost of $28 Million.

The NSFNET Backbone is the linchpin of the overall NSFNET project, which includes establishment of and assistance to regional networks that deliver Backbone service to every state in the union. Other significant measures of the size and success of the NSFNET project include:

> More than 600 of the 3-to-4,000 two-year and four-year colleges and universities in the nation are interconnected, including all the schools in the top two categories of the Carnegie Foundation classification of major research universities.
>
> Several hundred high schools are also connected, but the exact number is difficult to determine since regional networks have widely leveraged NSF funds to connect the smaller institutions without NSF's direct involvement.

Many industrial research organizations and commercial establishments that support the nation's scholarly enterprise are connected; indeed, the so-called ".COM" domain is the fastest growing segment of the network.

The NSFNET Backbone is the default infrastructure for the nation's research and education community. It carries, for example, ten times the traffic of the Department of Energy's ESnet Backbone which interconnects many NSFNET client sites with national laboratories and other DoE facilities.

By selecting a proven set of open communication protocols ("TCP/IP") and mandating their use in the NSFNET, the Foundation catalyzed an entire industry in which there are now upwards of a half dozen US manufacturers. US made packet switches and gateways dominate the world market, and a T1 packet switch can now be bought for well under $10,000. (By contrast, before NSFNET, the most widely used network packet switch operated at a speed of only 56,000 bits per second and was priced at $120,000. A further effect has been to substantially increase the connectedness of the scientific community as several other large networks, e.g., MFENET, the forerunner to ESnet, and European HEPNET, the European High Energy Physics network, have switched in recent years from their own proprietary communication protocols to those (TCP/IP) compatible with the NSFNET.)

NSFNET's selection of TCP/IP has led to it becoming the most widely used set of open communication protocols in the world. Procedures for transporting these protocols over emerging telecommunications services, such as the Switched Multi-megabit Data Services (SMDS) and Frame Relay have recently advanced to Draft Standard status. Because of this, NSFNET and the Internet will be able to benefit from whatever economies may be available from using the new offerings of the telecommunications carriers.

Scientists and educators on NSFNET can now collaborate over the network with their peers in 39 countries on 7 continents, and every month brings new requests for connection to the US network of which the NSFNET and its Backbone is the principal component.

b. Other Networks Another measure of the success and influence of the NSFNET project has been the emergence and rapid growth of private sector offerors of TCP/IP network services. These include: UUNET Technologies, which indeed predated the NSFNET, but has grown rapidly in recent years; Performance Systems International (PSI), a spinoff from the NSF funded regional network NYSERNET; Advanced Networks and Systems (ANS), who provide NSFNET Backbone Services under contract to Merit; US Sprint; InfoNet, a multinational TCP/IP provider; and CERFnet, which functions as a regional network in Southern California. Several of these private providers have formed a cooperative for interchanging traffic known as the Commercial Internet Exchange, or CIX, of which Mitch Kapor is Chair.

The NSFNET Backbone is limited to uses compatible with the NSF enabling legislation, as amended. There is an "NSFNET Backbone Services Acceptable Use Policy" (the "AUP", a copy of which is attached to this testimony) which was developed in consultation with an NSF Advisory Committee and the NSF General Counsel and expresses this limitation. The general principle is worth stating, "NSFNET Backbone services are provided to support open research and education in and among U.S. research and instructional institutions, plus research arms of for-profit firms when engaged in open scholarly communication and research"

By contrast, the private providers, have no such limitations. Although much of the traffic on their networks need not conform to the AUP, it is NSF policy to allow the private providers to use NSFNET Backbone services to exchange AUP-conformant traffic between their customers and NSFNET clients. However, the NSFNET Backbone may NOT be used by the private providers as a “transit network” - i.e., to interconnect their fee paying customers.

In this traffic sharing environment, ANS occupies an especially sensitive position since NSF indirectly, through Merit, is one of its customers. Accordingly, NSF has made special arrangements with Merit to monitor the quality of service afforded to NSFNET and to ensure that the traffic of ANS’ private customers does not adversely impact NSFNET Backbone services.

c. Management Controls The NSF participates with Merit, IBM, MCI, the State of Michigan, and (since its formation in 1990) ANS in three series of regular meetings which collectively form the primary means of oversight and control. There is a biweekly “Partner Conference Call” which functions at the tactical level, a monthly “Engineering Meeting” for technical desiderata, and a quarterly Executive Committee meeting which considers strategic issues. During the transition from the T1 Backbone to T3, the Executive Committee also scheduled weekly conference calls. As provided for in the Cooperative Agreement with Merit, NSF convened a blue ribbon review panel of academic and industry experts and conducted a two day long review of Merit’s Backbone performance at the eighteen month anniversary. The panel rated Merit’s performance “excellent”.

The Project Development Plan

In November, 1991, the National Science Board (NSB) approved a plan for continuation and enhancement of NSFNET Backbone Services beyond the expiration of the current cooperative agreement with Merit in November, 1992. The NSB also approved an extension of the agreement for a period not to exceed eighteen months in order to allow new providers to be competitively selected and to provide for an orderly transition. A copy of the Plan is attached to this testimony.

The Plan was developed after more than a year of external consultation. During this year of consulting the external community, NSF supported two workshops at the Kennedy School of Government at Harvard - one in March 1990 and the second in November, 1990. These workshops involved university networkers, economists, specialists in public policy (especially telecommunications policy), telecommunications carriers, and others. NSF’s sister Federal agencies involved in the NREN were consulted at a meeting convened for this purpose in July, 1991, since the NSFNET Backbone is the most heavily used Backbone network among the several agency networks that are developing the NREN. The Foundation sponsored a workshop in August, 1991, by the Federation of American Research Networks (FARNET), a trade association that was inaugurated in 1987 to act as the voice of the regional networks, the “users” of Backbone services. The workshop was also attended by all the private providers of Backbone services, as well as telephone company representatives.

In addition, the Networking & Communications Research & Infrastructure Division Advisory Committee was consulted at its meeting in November 1991. That Committee includes leading researchers in the communications and networking field, private network providers, and telephone company representatives. Moreover, NCRI staff participated at public meetings of the networking community, such as meetings of the Internet Engineering Task Force (sponsored by industry), Net ’90 and Net ’91 (sponsored by the academic and user community), and others. The

Plan has a schedule that includes release of a draft Solicitation in February 1992, a three month period for public comment, followed by release of the final solicitation in May.

Owing to unexpected delays in releasing a separate but related solicitation, and the technical complexity of the proposed new NSFNET Backbone architecture, it has not been possible to adhere to the original schedule. The other solicitation has been released, NSF's engineering experts have been consulted, and it now appears the draft solicitation will be ready at the end of March, so the schedule has slipped by about eight weeks. We believe there is still adequate time to accomplish the solicitation-review-award-transition process within the eighteen month extension authorized by the NSB. The technology permits a planned, gradual, and orderly transition of traffic from one provider's facilities to another's.

The transition, now in progress, of moving traffic from the T1 Backbone to T3 provides practical experience for the future. The Plan provides for a degree of continuing competition among two or more TCP/IP service providers in furnishing NSFNET Backbone Services. There will however be no significant changes in the rules for access to NSFNET Backbone Services by commercial service providers. The Acceptable Use Policy, developed in consultation with the NCRI Division Advisory Committee and the NSF General Counsel represents, in the opinion of Counsel, the most liberal interpretation possible under the NSF enabling legislation, as amended. This current policy allows access to commercial services for the support of open scholarly research and education under the General AUP Principle stated above.

NSF believes the next award will clarify the issues in free and open competition for the provision of Backbone services, and will conclude with at least two fully qualified and experienced providers of bulk services. It is likely, therefore, that NSFNET Backbone funds may - after the end of the next award (i.e., by FY 1996) - be distributed competitively to those organizations (currently the regional networks) who require Backbone services so that they may procure them competitively on the open market and free of Federal intervention. NSF had wished to employ this model at the expiration of the Merit award, but was advised at the FARNET workshop that the regional networks (the "users") were unprepared for that degree of operational complexity on their part. Moreover, sister Federal agencies felt in addition that such a procedure would, at the current state of technology, result in serious routing instability in the network, prejudicial to the accomplishment of their missions, since they depend heavily on the NSFNET to reach many of their grantees and contractors. NSF will continue working with the regional networks and the sister Federal agencies to overcome these obstacles.

In a separate, but closely related activity, the NSF has just released a competitive solicitation for Network Information and Registration Services. These are services which have traditionally been provided for the worldwide Internet by Network Information Centers (NlCs) associated with the major US Backbone networks (i.e., ARPANET, NSFNET, ESnet, and the NASA Science Internet) as well as by Centers operated by NSF regional networks, by campus network organizations, and by the private TCP/IP network providers. The principal NIC, however, was for many years operated by SRI International under contract to the Defense Communications Agency (now the Defense Information Systems Agency, DISA). In a recent re-competition held by DISA, SRI lost the contract to another firm. DISA is funding the new contractor, GSI, to serve only the Defense Data Network; accordingly, NSF is funding GSI on a month-to-month basis for service to the rest of the Internet (including, of course, its largest component, the NSFNET) until NSF's recently released solicitation can result in a new Network Information Center. During the month-to-month funding, NSF is closely monitoring GSl's operation. It is

interesting to note that the commercial users of the Internet, many of whom are clients of the private TCP/IP providers, form the largest single user class of GSI's services.

Relation to NREN

Finally, I would like to turn briefly to the relation of the NSFNET to the overall NREN program that is part of the AGENDA Program described earlier by Dr. Habermann. The planning process for the HPCC Program is coordinated by the HPCCIT Subcommittee. This subcommittee meets regularly to coordinate agencies' HPCC programs through information exchange, common development of interagency initiatives, and review of individual agency HPCC proposals and budgets. This process provides for agency participation through agency proposal development and review, budget crosscut development and review, and interagency program coordination. Agency programs are reviewed against a set of evaluation criteria for merit, contribution, readiness, linkages to industry, and other factors.

During 1990, in order to provide for broader and more inclusive coordination of research and education communities, the NSF, as part of its HPCCIT network task group activities, created the Federal Networking Council (FNC) and initiated the creation of an FNC Advisory Committee (FNCAC) as an NSF advisory committee.

The FNC consists of representatives from Federal agencies that have requirements for operating and using networking facilities, mainly in support of research and education, and for advancing the evolution of the Federal portion of the Internet. Membership lists of the FNC and FNCAC are attached to this testimony. Achieving the goals of the NREN will require close coordination of the NSFNET, NASA Science Internet (NSI) and Energy Sciences Network (ESNet) programs to meet the expectations of scientists working on the Grand Challenge problems. At the same time, however, the NSFNET program will vigorously pursue wider NREN goals of developing the technologies that will enable access by libraries, use for lifelong education, and connection to health care systems, etc. The NSF will continue to involve the private sector to the greatest extent possible for meeting the goals of public policy in this arena in the most cost-effective and technically responsive way. NSF is participating with the other agencies in the FNC in the drafting of the NREN report required of the Office of Science and Technology Policy by the High Performance Computing Act of 1991 (P.L. 102-194.)

Statement of Michael M. Roberts, Vice President, EDUCOM

Chairman Boucher and members of the Committee, I am pleased to present testimony today on behalf of the EDUCOM Networking and Telecommunications Task Force, a group of forty-eight universities with joint interests in the development of advanced computer networks to support research and education. NSFNET Success. Over the past five years, NSFNET has compiled one of the most remarkable success stories in the history of American science. In this short period of time, through a partnership of government, industry and higher education, an advanced production network with the highest level of bandwidth available anywhere in the world has been designed and deployed in the research and education community in the United States. At the same time, the network has been transformed from one serving a narrow group of supercomputer centers and federally supported research sites into one with connections to more than six hundred colleges and universities and over a thousand public and private research sites. The global Internet family of research and education networks, of which NSFNET is a part, is growing equally rapidly and now reaches more than three-quarters of a million computer systems in more than one hundred countries. On the campuses of the members of the EDUCOM networking task force alone, more than one million students, faculty and researchers have gained access to NSFNET and the Internet. Of special note is the fact that NSFNET now connects more than a thousand high schools and several hundred libraries as a result of an effort by NSF and the regional networks to reach all levels of education.

In addition to the benefits within research and education, the success of NSFNET has materially aided the growth of a commercial market for Internet products and services which it is estimated will exceed four billion dollars in 1992, with growth at the rate of seventy-five percent a year.

This progress - in advanced network services, in access provided to the research and education community, and in technology transferred to the private sector - far exceeds the levels planned five years ago and is a tribute to the commitment of the NSFNET partners and to the able leadership of the Foundation and its Networking Division.

In the remainder of this statement, I would like to focus on three key issues - a new cooperative agreement for NSFNET, a commitment to a common infrastructure with participatory governance for the NREN, and the linkage of the NREN program to establishment of a broadband communications network for all Americans. We are submitting additional EDUCOM background material on NSFNET and the NREN for the record. NSFNET Competition for New Cooperative Agreement. Last November, the National Science Board approved a proposal by the Networking Division of NSF that it conduct a competition leading to new cooperative agreements for continuation of NSFNET for the period 1993-1996. In developing its proposal, NSF drew on studies and recommendations from a number of organizations within the networking community, including EDUCOM.

We believe that the plan for new cooperative agreements is an excellent one that not only provides stability of network service but promises to continue the progress in technology that has been an important feature of the current agreement. However, we wish to comment on the aspect of the intended plan that deals with competition for the award within the private sector and a related issue, raised in recent press articles, that NSF should be obligated, in a spirit of fairness, to provide a level playing field for competitors.

First, it should be understood that the new award will not be for standard commercial telecommunications services. It will be a cooperative agreement among partners in an effort to

maintain and improve a leading edge, state of the art computer network which continues to meet the demands of the best science of which the United States is capable. That is the stated goal of the NREN legislation sponsored by your committee last year and of the program under development by the Administration. We should set our sights no lower.

Second, with respect to levelness of playing field, it is not and has never been the responsibility of a federal agency to guarantee market entry for a private sector firm. Nor is it the responsibility of federal agencies to transfer technology to the private sector in a manner which guarantees market entry. What NSF has done very successfully in the current award, and proposes to do again, is establish the criteria under which firms, or joint ventures of firms with public sector participation, may join with the Foundation in designing, testing, and deploying advanced network technology. The greater the size of the funding and resource commitment that is made by private sector firms in competing for the award, the greater the likelihood of rapid progress in advancing network technology. It is important to distinguish between competition for the new cooperative agreement, and the creation of a competitive market in the private sector for network services based on NSFNET/NREN technology. Progress made during the course of the next agreement will support and strengthen an already impressive level of commercial network services that has developed in the last several years. Common Infrastructure for the NREN. At the present time, federal agencies participating in the HPCC program are preparing an NREN technical and management plan under the aegis of the Federal Networking Council (FNC). It is premature to comment on specifics of the plan until it has been released and reviewed. However, the view has been expressed by some that it is sufficient for the NREN to be just a family of largely independent networks, with connectivity and services under the control of individual agencies. This is clearly an unsatisfactory approach. It fragments the available federal resources. It confuses industry, which will be unsure of which agency approach will win out over others. It will reduce the rate at which the common infrastructure can be developed and implemented.

Some federal officials have the opinion that full support for the NREN would jeopardize mission critical network applications such as real time satellite data collection and nuclear energy experiments. These special applications have never been part of the NREN as envisioned by the universities and constitute a small fraction of total agency use of computer networks for research and education.

The universities, having made major investments in their campus networks and NSFNET connections, and having joined together to create and sustain the regional networks, believe that their federal agency partners in the NREN should make a similar commitment to a common networking infrastructure. Such a commitment must include agreement on mechanisms for participation in the creation and application of standards and policies for the network. When your committee continues its review of the Administration's NREN program later in the year, we believe this matter deserves further inquiry. NREN Linkage to National Information Infrastructure (NII). As the revolution in computer networking has gained momentum in recent years, the potential value of NREN technology is being recognized in areas beyond the original leading edge, Grand Challenge research objectives. Mr. Chairman, you and Representative Oxley have taken the Congressional initiative in the House with the introduction of HR2546, which calls for rapid deployment of broadband technology in the national communications infrastructure. In a related development, the Computer Systems Policy Project (CSPP) has called for a broader vision of the NREN and specifically recommended that the Administration "establish a technology and policy foundation for an information and communications infrastructure for the future." The FCC has also taken note of these developments in holding

future network hearings last spring and issuing a Notice of Inquiry into Intelligent Networks last December.

The university community believes that both the NREN and a broadband communications infrastructure for America are important, perhaps critical, national objectives. However, they are not the same, and neither should be treated as hostage or servant to the other. EDUCOM recommends that an explicit linkage be created between the two objectives. The NREN, guided by a government, industry and education partnership in developing and deploying advanced network technology, should be the means by which the country supports its research and education goals, and at the same time develops, tests, and transfers to the private sector its successes in technology.

The NII, guided by new federal and state communications legislation, should be the means through which a revitalized communications industry, utilizing digital and fiber optic technology, brings the benefits of the Information Age to every American. Forging a new national communications policy which protects the public interest and enhances the private sector role in providing advanced communications services is a difficult challenge. We in higher education have a major stake in the creation of a broadband communications infrastructure to help us fulfill our educational mission. We are prepared to assist the Congress in achieving this vision, which will assure continued U.S. leadership in a world which is rapidly becoming a global information society. Summary. In conclusion, I would like to reiterate five key points:

First, NSF leadership in the development and delivery of NSFNET has been outstanding. Research and education are being extraordinarily well served by the NSFNET program, the success of which is obvious from every measure of network connectivity and use.

Second, the NSFNET program has positively stimulated the marketplace and there are a growing number of commercial providers of network services based on this technology where there were none only three or four years ago.

Third, we in the research and education networking community believe that the planned "recompetition" for a new NSFNET cooperative agreement is an appropriate and manageable compromise between conflicting objectives. It increases participation from the private sector while continuing a successful management structure proven during the current agreement.

Fourth, we urge the Congress to insure that the infrastructure and governance of the NREN reflect an effective partnership between the broadly based research and education community and the federal agency establishments so that standards and policies for the network will be formulated for the broadest applicability and greatest good.

Fifth, we recommend that the National Information Infrastructure and implementation of broadband communications envisioned in HR2546 be explicitly linked to the NREN program, though in no way merged, so that the NREN may take early advantage of broadband infrastructure to support research and education goals while leading in the advancement of the technology.

Testimony of Mitchell Kapor, President, Electronic Frontier Foundation and Chairman, Commercial Internet Exchange

Mr. Chairman:

My name is Mitchell Kapor. I want to thank you for inviting me to present my views on the importance of research and education networks, and the beneficial role that commercial forces can play in this arena. At your request, I come before this Committee in two capacities. As the President of the Electronic Frontier Foundation, a public interest advocacy organization concerned about promoting the democratic potential of new computer and communications technologies, I hope to offer a vision of how the National Research and Education Network (NREN) can enhance research and educational opportunity for an ever-growing community of users. As the Chairman of the Commercial Internet Exchange, a trade association that promotes the commercial Internet market, I will give some suggestions on ways that Congress can help to eliminate some of the current impediments which unnecessarily limit entrepreneurial innovation in the Internet arena.

For those who may not know me, I am also the principal developer of the Lotus 1-2-3 spreadsheet program and served as the CEO of the Lotus Development Corporation between 1982 and 1986 during which time it grew into a $200 million dollar a year software company.

I believe that Congress, and this Committee in particular, has a vital role to play in:

-ensuring that NREN services reach the broadest possible community of users;

-creating an environment which stimulates the development of new network technologies and applications, and;

-leveraging federal involvement with private sector cooperation.

Again, thank you for the opportunity to participate in this process.

I. Background

A. The Electronic Frontier Foundation

The Electronic Frontier Foundation (EFF) was founded on a shared conviction that a new public interest advocacy organization was needed to educate the public about the democratic potential of new computer and communications technologies and to work to develop and implement public policies to maximize civil liberties and competitiveness in the electronic social environments being created by new computer and communications technologies. Our primary mission is to insure that the new electronic highways emerging from the convergence of telephone, cable, broadcast, and other communications technologies enhance First and Fourth Amendment rights, encourage new entrepreneurial activity, and are open and accessible to all segments of society.

The EFF is committed to ensuring that the rules, regulations, and laws being applied to emerging communications technologies are in keeping with our society's highest traditions of the free and open flow of ideas and information while protecting personal privacy.

B. The Commercial Internet Exchange

The Commercial Internet Exchange Association (CIX) was formed in 1991 as a trade association open to all commercial Internet carriers. All members agree to exchange traffic at a fixed and equal cost set by the association. The primary goal is to provide connectivity among cooperating carriers, with no restrictions on the type of traffic allowed.

Today, there are seven CIX members with both domestic and international networks: BARRnet, CERFnet, EUNet, Performance Systems International (PSI), Unipalm Limited, UUNET Technologies, and US Sprint. Over 3000 commercial firms can be reached through the CIX member networks, with no restrictions on use. The top 20 computer companies in the US are all connected via the CIX, and many are delivering commercial support services (e.g., software/hardware and consulting) over it.

The CIX is structured to grow and migrate with the emerging needs of the commercial Internet. Many multinational carriers and at least three dozen regional networks in the US, Europe, and Japan have expressed interest in joining. In response to this interest, the CIX membership has developed plans to improve network technology support services that benefit the entire community. The CIX will also actively encourage new services on the commercial Internet.

II. Visions of the NREN

The NREN is intended to "link research and educational institutions, government, and industry, in every State,"[1] together. Agencies responsible for implementing the NREN "shall work with State and local agencies, libraries, educational institutions and organizations, and provide network service providers in order to ensure that researchers, educators, and students have access to the Network." The NREN will not be created out of thin air. Rather, it is an expansion of the Internet, a twenty-year old international network that links over three million users in 30 countries. The Internet is a vital part of the interim NREN.

Wearing my Electronic Frontier Foundation hat, I believe that this committee should take a broad view of the possibilities of an NREN that reaches into all levels of schools, libraries, hospitals, community centers, and even homes. These are some goals that the Committee should strive for in its long-term NREN implementation plans:[2]

A. Expand the number of users who have access to the Internet and NREN

The tremendous popularity of the Internet has already demonstrated the value of public data networks among higher education and research institutions. Congress should adopt policies which help make Internet resources accessible to an ever-broadening community of users. In the 1960s, the average fifth grader had no need to use the ARPANET to access remote computing power. But in the 1990s, students down to the elementary school level can benefit from having access to libraries and other on-line educational resources from all around the country.

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[1]High Performance Computing Act, Pub. L. No. 102-194, 105 Stat. 1594(1991) ("HPCA"), Sec. 5(a)

[2]See also, M. Kapor & J. Berman, "Building the Open Road: The NREN As Test-Bed For The National Public Network," in Building Information Infrastructure: Issues in the Development of the National Research and Education Network, 1992 (B. Kahin, ed., McGraw-Hill)

As information technology becomes more and more sophisticated, some have warned that we could be dividing American society into the "information haves and havenots." Let us use the NREN as one of many tools to enable all segments of society to have access to important information and communication resources.

B. Enhance "access to electronic information resources maintained by libraries, research facilities, publishers, and affiliated organizations."[3]

Millions of scientists, students, government workers, and even the occasional Congressional staffer rely on the Internet as a primary computer and communications tool. Researchers exchange scientific information, students further their education, government workers communicate with others working on publicly-funded projects, and some of us even use the Internet to stay in touch with political developments.

The more information that is accessible over the Internet, the greater its value to its users, but the potential of the Internet as an information dissemination medium for both public and private institutions has only just begun to be explored. Congressional policies that allow both non-commercial and commercial information providers to offer their services over the NREN will enhance the productivity and creativity of researchers, educators, students, and other NREN users.

C. Support the free flow of ideas

The academic community relies on the Internet as a forum for exchanging scholarly research and data. So, traditional academic freedom of speech, as guaranteed by the First Amendment, should be protected in this new forum. D. Promote "research and development leading to commercial data communications and telecommunications standards."[4]

The HPCA recognizes two important areas of research for the development of the NREN. First, much basic engineering work remains to be done in order to provide the high-speed (gigabit) data transmission services required by certain applications, such as supercomputing and high definition video and graphics. Second, in order to bring the benefits of network information services to a wider community of users, standards for data presentation and access need to be developed. For example, because most libraries catalog books according to standard systems which we have all been taught, we can walk into almost any library and find the books we need. If electronic information services are to be truly useful beyond a narrow group of technical workers, much progress must be made toward making the services easy to use.

E. The NREN as a Testbed

In enacting the NREN legislation, the Congress is taking a critical step toward what I call the National Public Network, the vast web of information links organically evolving from computer and telephone systems.

By the end of the next decade, these links will connect nearly all homes and businesses in the U.S. They will serve as the main channels for commerce, learning, education, and entertainment

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[3]HPCA, Sec. 5(e)
[4]HPCA, Sec. 5(d)(2)

in our society. The new information infrastructure will not be created in a single step: neither by a massive infusion of public funds, nor with the private capital of a few tycoons, such as those who built the railroads. Rather the national, public broadband digital network will emerge from the "convergence" of the public telephone network, the cable television distribution system, and other networks such as the NREN.

Not only will the NREN meet the computer and communication needs of scientists, researchers, and educators, but also, if properly implemented, it could demonstrate how a public information network can be used in the future. As policy makers debate the role of the public telephone and other existing information networks in the nation's information infrastructure, the NREN can serve as a working test-bed for new technologies, applications, and governing policies that will ultimately shape the larger national network.[5] So, as the Committee acts to implement the NREN, I urge you to remember that the patterns set by pioneering networks such as this will play a critical role in shaping the Nation's information infrastructure.

III. Recommendations for Transition to Full Commercial Operation

In passing the High Performance Computing Act, Congress provided a clear set of goals for the NREN and guidance on how to achieve those goals.

This Committee and the entire Congress have made it clear that the Network services should be provided in a "manner which fosters and maintains competition within the telecommunications industry and promotes the development of interconnected high-speed data networks by the private sector."[6]

Under the NSF's management, the use of the Internet by commercial organizations has been wildly successful. Nearly 60 percent of all registered computing sites on the Internet are commercial organizations. Within two years this number is expected to grow to nearly 90 percent. It is not surprising, in light of this rapid change in the Internet environment, that even with the best intentions on the part of NSF, some problems occurred along the way. I am optimistic that new policies based on a careful look at the market today can create a thriving commercial environment on the Internet.

The task that this Committee begins today is to shape an implementation strategy that achieves these important national goals by carefully examining the recent history of the NSFNET and the rapidly changing structure of the data networking marketplace.

The HPCA sets as a goal that "the Network shall be phased into commercial operation as commercial networks can meet the needs of American researchers and educators."[7] Speaking as Chairman of the Commercial Internet Exchange, I can say with confidence that the commercial Internet providers already in the market can meet the networking needs of current NSFNET users for T1[8] now and will be able to meet the needs for T3[9] services in the very near future.

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[5]The NREN "would provide American researchers and educators with the computer and information resources they need while demonstrating how advanced computers, high-speed networks, and electronic data bases can improve the national information infrastructure for use by all Americans."
HPCA, Sec 2(a)(6)

[6]HPCA, Sec. 5(d)

[7]HPCA, Sec. 5(d)(3)

[8]T1 services have the capacity to transmit data at 1.544 megabits persecond.

Therefore, I offer the following short-and long-term recommendations for reaching the goal of a fully commercially-operated NREN.

A. Short Term - Until November 1992

1. Modify the NSF Acceptable Use Policies to encourage the availability of commercial information services and promote competition among carriers.

As part of its current management of the NSFNET backbone, the NSF has set a series of "Acceptable Use Policies" which define the type of traffic that can be carried over the NSFNET backbone. The AUP restriction most relevant to today's hearing requires that all data carried over the NSF backbone be "in support of research and education." This restriction frustrates two important NREN goals by precluding widespread offering of commercial electronic information services, and discouraging commercial organizations from making full use of the Internet.

A brief note about the three-level structure of the Internet may be helpful here. At the lowest level are local networks maintained by each connected institution. Next, mid-level or regional networks connect a number of local networks together. Finally, there are backbones which link regional networks together. The NSFNET is a backbone that connects a number of regional networks and offers interconnection to other government networks and international networks. But other providers, including two CIX members, PSI and Alternet, have their own international backbones which interconnect with several regional networks, commercial organizations, and international networks. Funding for local and region networks comes from a variety of public and private sources, but the NSF backbone is paid for by NSF funds.

As the Internet was growing, the NSF wisely instituted an AUP that allowed for a wide variety of uses of the network, including some that could strictly be classified as "commercial." This open policy encouraged extensive use of the Internet and made it a success. An unfortunate side effect of this openness is that there is substantial confusion about what kind of traffic is allowed and what is forbidden. In practice, electronic mail users can make commercial use of the Internet with impunity because e-mail is private. But the uncertain scope of the AUP discourages many potential commercial users of the Internet from joining the network.

In 1990, an exception to the commercial use restriction in the AUP was created by the NSF. In an agreement between the NSF and Merit, the primary NSFNET backbone contractor, Merit was allowed to subcontract the backbone services to a new non-profit corporation, Advanced Network Services (ANS). ANS in turn created a for-profit subsidiary called ANS CO+RE which now has been given the exclusive right by NSF to sell backbone connections that carry commercial traffic across the NSF sponsored gateways between the T3 backbone and the regional networks. This commercial traffic would otherwise be in violation of the AUP.

NSF and Merit arranged for ANS CO+RE to pay some portion of the cost of carrying the commercial traffic into a fund that is intended to benefit the regional networks connected to the backbone. However, ANS CO+RE is still the only network service provider which has thus far been authorized by NSF to pass commercial traffic over the backbone to regional networks.

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[9]T3 service carries 45 megabits of data per second.

Retaining ANS as the only firm that is able to offer commercial access to the NSFNET backbone creates market distortions which impede the commercial expansion of the Internet and limit the scope of services available to future NREN users. When the NSF created the current arrangement, little was known about how the commercial Internet market would develop and the impact NSF's choices would have. In planning for the future, Congress should begin now to take steps to achieve the NREN goals of promoting the development of commercial services and an open, competitive environment.

2. Encourage Cooperative Efforts within the Commercial Internet Industry Which Enhance Interconnection Among Carriers

Since the backbone arrangements that NSF structured did not allow for open routing of commercial Internet traffic, CIX members and ANS have recently begun negotiations to address these problems. Fruitful discussions are underway between the concerned parties with the intent of developing interconnection arrangements that promote the open flow of commercial traffic to all parts of the Internet that are willing to accept it. I hope that this Committee can lend its support to these efforts and set them as a model for voluntary resolution of various industry "growing pains."

3. Find Alternatives to the Current NSFNET Backbone Arrangement with ANS which are Fair to All Parties

The National Science Board should be asked to reconsider its decision to extend the current backbone arrangement for an extra eighteen months past November 1992. This may have appeared to be an easy, natural transition from the NSFNET to the NREN. However, commercial service providers now in the market are fully prepared to offer the services necessary to maintain the existing level of NSFNET service while the higher speed NREN is being built.

In the early history of the Internet, organizations that needed network access relied almost exclusively on connections offered by the Federal sponsors of the Internet. At its birth, when it was known as ARPANET, little was known about how to build large public data networks. Federal research support played a critical role providing network access and in the development of public networking technologies. Because early Federal support was so successful, the Internet operating protocols have been adopted as international standards and are used in data networks across the country and around the world.

As current networking technology has stabilized, many private sector sources — including members of the CIX — are now able to offer Internet access as well. By offering low-cost connections and individualized service, private network service providers have made Internet access available to many who do not receive direct government sponsorship. The NREN legislation lays out ambitious plans for development of advanced networking technology, but private providers now have the experience to offer standard Internet services. Therefore, active government involvement in providing network access services can be ended. Furthermore, given the problems already noted, any extension of the current arrangements without a fully competitive selection process would be unwise.

B. Long Term: Find Ways to Phase Out the Current Backbone Structure After November 1992

In the long-run, those agencies responsible for the continuation of the current NSFNET services should seek alternatives to a centrally-controlled backbone. When the upgraded NSFNET of the mid-1980s was experiencing growing pains and performance degradation, building a high speed backbone was a reasonable response on the part of the NSF. The data transmission technology at the heart of the backbone[10] was in experimental stages; so, a government-funded backbone was appropriate to help develop this technology. But now, five years later, the building blocks of the backbone are available "off the shelf" and can easily be interconnected without direct government intervention. Internet connectivity is now a commodity service which can be purchased on the open market just like other carriage services such as long distance telephone service, shipping, air freight, or overnight mail.

Rather than making payments to backbone and regional network providers, the NSF and any other government agencies that have responsibility to connect institutions to the Internet should give the subsidy directly to the target institution. The institution can then take this money and purchase Internet connectivity from a variety of service providers.

As in the long distance telephone market, or the rail service, carriers will have to enter into cooperative agreements to be sure that an Internet customer on one carrier's service can send and receive data from customers on other services. Even with the backbone in existence, a significant amount of inter-regional traffic bypasses the backbone as part of bilateral arrangements between various regional networks. The Internet community has a long established tradition of promoting interconnection, and developing and adhering to international standards. So, there is every reason to believe that this pattern of cooperation will continue.

C. Research Priorities

1. Direct support for development of advanced research network —the gigabit network envisioned by the NREN

Funds allocated for work on advanced network engineering should be targeted exclusively to the development of high-speed gigabit networking technology. An important part of the NREN will be an experimental, high-speed research network which is capable of sending data many times faster than the current NSFNET. But this new research network should not be confused with the existing "production" network now called the NSFNET. Research dollars should be kept for research networks that will expand our understanding of how to do high-speed networking, not for subsidizing existing network services. Conversely, users who depend on the Internet for routine work should not have the reliability of their services compromised by the inevitable vagaries of a research network under development. The research network should certainly be interconnected with the production network, but their operation and funding should be kept as separate as possible.

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[10]T1 and later T3 services.

2. Stimulate applied development activities

In addition to basic network engineering that increases speed and capacity, some research support should be directed to development of applications that make network easier to use and access for end users. Ease-of-use was not a major concern in the early days of the Internet, since most users had technical backgrounds. But, if we are to meet the goals of the HPCA which seek to make the Network available to a larger class of non-technical researchers and students, efforts to make network services more "user-friendly" are essential. Furthermore, the NREN is an opportunity to create a variety of "test-bed" applications that will help lead the way to more advanced uses of electronic networking. So in addition to meeting the needs of today's users, research dollars should be allocated with an eye to stimulating applications for the next generation of networks.

D. Public Process is Essential

Much of the recent negative publicity surrounding the NSFNET has come because important decisions about the network were made without opportunity for public comment or input from commercial Internet providers.

The NSFNET is now managed with the help of a number of advisory boards, such as the federal Network Advisory Committee. As the NSFNET and NREN grow, they will be built with the participation of many more service providers than are currently involved in the NSFNET. Therefore, it is important that the NSF's advisory boards be expanded to reflect new market conditions. With broader representation on these boards, the NSF will be sure to receive the guidance it needs to make wise implementation decisions.

IV. Conclusion

I want to thank the Committee for inviting me to appear on these important matters at this critical moment in the development of the NREN. I am optimistic that with Congressional leadership government agencies, public institutions and the private sector can work together to realize the highest goals of the NREN for the benefit of all.

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Executive Summary: The Internet, the most innovative mass communications infrastructure of this century, was begun by DARPA and is now primarily managed by the NSF. This testimony briefly describes my knowledge of a series of actions, agreements, and events resulting in the inappropriate privatization of the NSFNet backbone. Given the private nature of the agreements, the delay in revealing the agreements, and the apparent conflicts of interest shared by the principals, I am providing this Subcommittee with my understanding of the dates, involved parties, public rationale, actual results, and my conclusions regarding this privatization of the NSF resource. These actions were unfortunate and unnecessary and should be repaired before the government invests even more heavily in attempting to achieve the goals of the NREN.

Mr. Boucher, Committee Members and staff:

My name is Bill Schrader, and like my carpenter father and his father before him, I am a builder. In 1989, a long time friend, Martin Schoffstall, and I saw an opportunity to build a company to sell computer networking services to colleges and businesses around the world. With our spouse's and children's full support, we borrowed against our houses, withdrew our savings, worked two jobs, raised money from our parents, family and close friends and founded Performance Systems International, Inc. (PSI). We now employ 40 people in offices in New York, Virginia and California, serve 1,500 organizations plus 3,000 individuals in forty states and ten countries. In terms of marketshare, we are about 15% of the world-wide network of networks called the Internet. We are profitable and pay taxes.

Prior to PSI, I helped start NYSERNet, one of the first Regional Networks, with Dr. Richard Mandelbaum, Marty Schoffstall and others. I also helped start two supercomputer centers, one at Cornell University with Kenneth Wilson and one at Syracuse University under DARPA. My career for the past 12 years has included many areas covered by the HPCC.

We operate our own public data internetwork, called PSINet, consisting of a nation-wide T1 network using leased telephone circuits and PSI owned equipment. PSINet is interconnected with all similar U.S. commercial networks through the Commercial Internet Exchange Association, (CIX) which we helped found to ensure an open and level playing field for this new industry. The CIX is headed by Mitchell Kapor as Chairman of the Board. We connect to the NSFNet backbone for research and academic activities, and to several international networks. Through these many connections, our customers communicate electronically with all of the 7,500 organizations on the global Internet and the 20,000,000 people who read electronic mail regularly. Our services range from unlimited electronic mail for an organization at $25/month (suitable for high schools and small businesses), to high performance full service supercomputer connections at over $50,000 per year.

We are technology builders, having led the industry in the design of network management software, now licensed to DEC, SONY and over two hundred other computer and telephone

systems manufacturers, resellers, and consumers. We are actively helping many small and large computer software, hardware and service companies begin to offer their products over the network. We are pleased to be competing in this industry and believe it is one area where American companies enjoy a lead and are well positioned to keep it.

The information I am providing today covers three topics:

1. NSF Policy Decisions
2. The Economics of the NREN
3. Recommendations for Congressional action

1. NSF Policy Decisions

The NSF initiated and operated the NSFNet program during a rapid evolution of the technology and the demand in the marketplace. Below is a brief review of some decisions made by NSF.

Decision A NSF Signed Merit/IBM/MCI contract - 1987

% Rationale - Achieve a national backbone network rapidly by leveraging the NSF budget by inducing private contributions of: a) equipment, b) personnel, and c) bandwidth, and encourage the development of high speed networking technology.

% Actual Events/Impact - One year was required to bring the network up reliably, because IBM computer equipment was used as routers, and new software had to be written. All the existing Regional Networks and other networks were using commercial grade, off-the-shelf routers available at that time. No IBM routers were ever marketed based on the design used in this project, and thus did not contribute to the nation's commercial position. MCI and IBM provided staff, but all network engineering, operations, and management work was performed by Merit staff (paid by NSF). Discounted bandwidth was paid for by NSF budget.

% Conclusion - The IBM equipment contribution was valued at about $100,000 per site, but could have been supplied commercially for $25,000 per site. In contrast to openly bid DARPA R&D programs in advanced technology, this program produced no useful prototypes and was delivered by IBM which was not leading in the field nor using any innovative designs. Except for the R&D staff converting computers to routers, the staff contributions by MCI and IBM were in sales and marketing. NSF essentially funded an IBM R&D project which never produced a product, and was justified on the basis of cost sharing to leverage the NSF budget.

> The success of the NSFNet and of the industry is not to be confused with the success of any individual contractor or grantee. NSF leveraged their budget by a factor of two by obtaining cost sharing in equipment and staff overvalued and not particularly well suited for the task. It is clear to many that the same amount of NSF budget spent without such leveraging would have produced a better, more reliable network, sooner, and would not have unduly shifted NSF policy to favor a single entity.

Decision B NSF requires international connections at backbone switches - 1989

% Rationale - To produce organized international connectivity which is cheaper and better than marketplace decisions made by others.

% Actual Events/Impact - For all new connections using any NSF funds, all connections were terminated at Merit/ANS nodes, allowing ANS to own the connection to a foreign market. Free market decisions by non-NSF funded parties were delayed up to 6 months, while NSF insisted on seeking approval from foreign PTTs for these "non NSF connections". Connections from the UK, Germany, Singapore and Korea which involved no NSF funds were denied access to NSFNet for up to six months. According to NSF, this delay was caused by State Department regulations.

% Conclusion - NSF has effectively given ANS indirect control over many international connections, while free market connections continue to be delayed.

Decision C NSF approves ANS organization, (and privately authorizes ANS's exclusive use of NSFNet for commercial use) - 1990

% Rationale - ANS was formed by the Merit, IBM, MCI team to leverage MCI/IBM equipment, staff, and bandwidth and to position itself for competition in the future. Private ANS meetings with NSF and select Regional Networks, and public comments about a complex shared "infrastructure pool", introduced a packet charging concept (called settlements) which ANS would fund by charging commercial customers attaching through the Regionals. There was no public mention or debate of the exclusive commercial use by ANS, which was the key element of their earlier private agreements with the NSF. Yet, these private agreements between NSF and ANS drove these complex agreements with the Regionals.

% Actual Events/Impact - This situation publicly positioned ANS as a not-for-profit, public spirited company willing to share its "profits" with Regional Networks which were willing to sign additional (complex) agreements. NSF approved this subcontracting arrangement without prior public notice, debate, or open bidding. Further, NSF helped provide visibility with press releases quoting Senator Gore and Dr. Wolff.

Once approved, ANS took over the NSFNet leadership from Merit in the marketplace by hosting all negotiations and discussions with Regionals, and issuing policy/contract related statements which represented NSF backing. ANS began competing for commercial and non-commercial customers by telling prospective customers that they could "connect directly to the backbone" without using the Regional Networks, and that they should connect to ANS since "at any time, ANS could disconnect PSI or any of the Regionals which had not signed the ANS agreements".

In 1991, ANS represented itself as the only network which could guarantee full commercial use of the NSFNet. This was true then and is true now. One example of this is Dialog, a large commercial supplier of electronic information to academic, government and commercial users. It appears that ANS first convinced Dialog that it should connect to NSFNet (ANSNet) for "commercial only" traffic. ANS then attempted to use Dialog to attract the Regional Networks to sign the complex ANS connection agreements, preventing those who did not sign from reaching Dialog. Few Regional Networks signed, and when Dialog discovered that it could access fewer than 5% of the Internet users it converted to a normal ANS customer, and agreed to comply with the NSFNet policy of supplying only research and education traffic.

% Conclusion - NSF has thus positioned the ANS/Merit/NSF/IBM/MCI partnership to approach commercial, government, and academic customers with significant advantages no one else can offer, without disclosing this to the public or allowing anyone else to bid.

ANS's handling of Dialog's attachment, and subsequent month long delay in disclosing Dialog's request to change, was seen by many as clear positioning for ANS's for profit subsidiary ANS CO&RE to gain marketshare.

Decision D Upgrade T1 to T3, and Privatize the NSFNet - 1990

% Rationale - Push networking technology to avoid congestion on the T1 backbone. Leverage NSF funds by allowing some private use.

% Actual Events/Impact - NSF negotiated the T3 upgrade arrangement with no apparent technical compliance specifications and no penalty clause for non-compliance. To date, less than half of the T3 nodes are operational beyond test mode, after 15 months of full payments, despite intermittent claims of full operational status by NSF and the contractor.

ANS used IBM-provided T3 equipment which was not the same as that used on the T1, had no significant R&D preparation, and failed when deployed. As during the earlier T1 IBM router design, the commercial R&D on T3 routers had been underway for two years by other router vendors using their own limited funds (eg. Proteon, Cisco) and could have been used. The use of IBM computers produced a poor quality network, and damaged these leading commercial suppliers investment in R&D.

In November of 1990, ANS's president claimed in a public talk at a Harvard workshop that "in essence, we have privatized the NSFNet". Although few understood, he meant that the NSF was now buying its NSFNet service as a portion of ANS's private network, rather than paying him to operate the NSF's network. While the NSF had sole use of the NSFNet T1, the NSFNet T3 was provided through a "cloud" and could also be used by ANS for their own customers. After the agreements which the NSF had signed creating ANS, and providing it with exclusive commercial access were released in December of 1991, it was clear that ANS's president was correct, the T3 had been privatized. This occurred without public discussion or disclosure, and was effectively hidden for a year.

% Conclusion - NSF perceived a need to leverage its budget further, enlarged the scope of the contract from T1 to T3, upgraded the financial size from $4 million to $10 million per year, and privatized the original contract, using private agreements, without additional bidding, and without notice once it was completed.

Privatizing a federal facility without notice, and at no cost to the recipient/contractor is improper and should be illegal for any agency of the government.

Decision E NSF and other FNC agencies accept apparent conflicts of interest, and unclear boundaries, routinely

% FNC/ANS - The Federal Networking Council (FNC) consisting of NREN agencies created an Advisory Council (FNCAC) charged with helping agencies understand how to best spend NREN funds. On the FNCAC are the venture funding directors of ANS (John Armstrong from IBM, and Richard Liebhaber from MCI), and another member of the ANS board, Mr. Joe Billy Wyatt from Vanderbilt University. No private providers are represented.

% ANS Formation - The Chairman of the Board of Merit, Inc., Dr. Douglas Van Houweling, negotiated the multimillion dollar government subcontract with his newly formed subcontractor, ANS, for which he serves as co-founder and Chairman of the Board. When ANS formed its for-profit subsidiary ANS CO&RE, he also became its Chairman of the Board. He remains on the Board of Merit, and as Vice Provost for the University of Michigan, oversees the President of Merit, Inc. He sits here today representing Merit, Inc. to Congress.

% NSFNet Operations - For both operational and oversight questions, Merit retains the prime contract for the NSFNet. It subcontracts 100% of it's responsibility to ANS, which operates the T1 network as an NSF facility and the T3 network as ANSNet. ANS then sub-subcontracts some, or all of, the technical and operational aspects of the NSFNet and ANSNet back to Merit. This apparently includes ANS's non-commercial customers as well as its commercial ANS CO&RE customers. ANS staff use computers at Merit, Inc. and the University of Michigan for their work. ANS can subcontract to any new subcontractor without NSF's approval. When something fails to work on this network, finding the person (or organization) who has an "arms length relationship", that is, who will withhold payment for non-compliance, is not possible.

% ANS/ANS CO&RE - An ANS salesperson who is selling a commercial or non-commercial connection to ANSNet does not know whether he/she is charging travel and labor hours to ANS or ANS CO&RE until after the sale is made. ANS CO&RE pays tax on profit, which is revenue in excess of cost. However, does ANS CO&RE's cost include the circuits paid for by MCI's donation to ANS (the not-for- profit), space rented by ANS for its offices, ANS CO&RE's prorata share of the depreciation of equipment donated by IBM to ANS, the travel costs by its Chairperson/Board member to testify before Congress when wearing at least three hats? Do funds received from government contracts pay for attorneys, accountants, and public relations firms to keep these involvements straight and attempt to present the correct image to the government and the marketplace?

% Standards Process - ANS hired a number of well positioned people in the industry, including the head of the Internet's public open technical group, the Internet Engineering Task Force, as one of nine vice presidents. Dr. Phillip Gross continues to hold his position in IETF. This provides ANS (and ANS CO&RE) with advanced knowledge of industry technical developments as well as some influence in guiding the timing and structure of emerging standards.

% Conclusion - Clear or apparent conflicts of interest situations occur in many aspects of ANS, Merit, NSF, IBM, and MCI. The entire group, which is now publicly self-characterized as a "partnership" has total control over the $50 million NSFNet backbone contract, now privatized, and well positioned to win any NREN contracts in the future.

In my opinion, there is little question that the actions of the ANS, Merit, NSF, IBM, MCI "partnership" have:

1) interfered with international and interstate commerce;
2) used the structure of the arrangements to influence NSF to make extraordinary decisions, privately;
3) planned their actions together, in advance; and
4) provided unfair advantage to ANS for the duration of the contract and beyond.

These arrangements do not provide a distinct separation between the role of the NSF oversight and the operation of the network by private parties. The lines between the government and the contractor (grantee) have confused the regulators with the regulated.

Decision F NSF extends the Merit contract for 18 months, announces a rebid - 1991

% Rationale - More time is needed to plan the follow-on. NSF must provide the backbone because the Regional Networks do not want to take responsibility for buying their own connections, even with NSF funds. There is concern that two backbones cannot operate together smoothly with today's technology.

% Actual Events/Impact - Extending the current contract provides up to $15 million more to ANS without competitive bidding, assuring ANS and Merit a steady revenue stream for 28 more months. ANS maintains its exclusive rights to sell direct backbone connections and guaranteed commercial use of NSFNet to all commercial and non commercial customers.

When, and if, a follow-on contract is signed and implemented, the NSF rebid plan calls for the same bandwidth, and a reduction of payments for each successful bidder to $3 million (down from $10 million).

% Conclusion - It seems that the NSF will save at least $4 million per year ($10 million current cost, $6 million for two suppliers after the rebid) if the rebid is completed before the Merit/ANS contract expires in November 1992. ANS continues to establish its own policies, representing them as NSF policy, such as settlements and infrastructure pools described earlier. There is a danger that this appears to be NSF policy which it is not.

In my opinion, NSF hired a contractor and then allowed that contractor to unfairly influence its policy, funding, and technical decisions through the period of the contract and beyond. Many decisions were made, but some of the more serious policy and contracting decisions failed to recognize the larger market, were made privately without open discussion, did not allow full participation, and did not follow proper contracting procedures.

2 The Economics of the NREN

Sound economic principles may have been considered in the design of the NREN legislation. However, the market has evolved more rapidly than planned. Basic market forces have shifted the geographic, economic, technological and political realities of the NREN to their natural equilibrium of ubiquitous networking. Therefore, rather than investing NREN's hundreds of millions of dollars in the technology, it is better to invest in connecting people to the network, making it easier to use, and teaching them how to participate.

NREN is still built on the principle of "putting money into the backbone". It has been proven by the ANS contract that doing so produces little innovation and results in no self-sufficiency, since organizations will not pay for a free good. The correct method for government involvement in a burgeoning industry like this is to subsidize individual target organizations: colleges and public libraries at first to ensure public access, then high schools and elementary schools to ensure access for children.

A program using "Yellow Stamps" was first proposed in 1989 by the National Research Council's report "Toward a National Research Network", and again in 1991 by Dr. Wolff. In

this program, NSF would directly fund these organizations' networking projects, and could be traded in with any network supplier which had met the criteria established by NSF. This program would require serious work to handle thousands of organizations, but would create the most stable results and still allow the national network to reach gigabit speeds in the same time frame. The difference is whether the NSF feeds the market at the bottom, or attempts to lead the market with advanced technology. Since the market has been reliably ahead of the NSF's technical program for the entire five year term of the current contract, there is sufficient reason to believe NSF cannot lead the market and, therefore, should feed it from demand.

If this program is created, I believe in five years we will see:

- local control and interest, where users come to value the network
- local leveraging of funds, 100 to 1 as seen in the university sector
- local control to buy from provider(s) of choice, on local schedule
- opportunity for all competitors to offer services, build economies of scale on their own initiative.
- a natural, permanent aggregation of traffic from hundreds of thousands of small and large NREN target organizations
- a natural convergence of commercial and NREN traffic on the highest speed "gigabit highways", taking advantage of fiber economies of scale
- no single monopoly, but instead a working, integrated commercially built operation provided with the service distinctions required by each market segment
- a smooth way for government funds to be ramped down after the five year program, for those organizations which participated in the early days
- direct political recognition of NREN's value in each local area, by parents, teachers, local political leaders and taxpayers.

3 Recommendations for Congressional action

Overall: Direct the NSF to A) remove the unfair advantages ANS has acquired, B) to consider industry and economic trends in future policy decisions, and C) to cease signing large contracts without administrative due process.

Specific Actions:

- Terminate the ANS contract on schedule. Congress should direct NSF to force ANS to either:

A) remain under contract for NSFNet funds for the duration of the contract and extension, providing a service only to NSF, or

B) sell commercial and academic access connections on the open market, but terminate the NSFNet contract on schedule in 1992.

ANS cannot be allowed to continue both the contract and the private use, since it will then be able to continue to use its government subsidized backbone network to offer its service to commercial and academic customers at prices which do not reflect actual cost.

- Open Commercial Access. Congress should direct NSF to either remove ANS's right to sell commercial access to NSFNet funded gateways or to allow other commercial carriers equal access at no cost.

% Make NSF the NREN lead agency. NSF is best equipped to handle thousands of small proposals involving colleges, K-12, libraries, and similar NREN activities.

% Require accountability for NREN funds by NSF. NREN funds have few controls now, being split over four agencies. There is no direction or control in the implementation strategies among the four agencies, each of whom can spend it any way they wish. At the very least, agencies should be directed to report how the money was spent.

% Request that Dr. Wolff develop his "Yellow Stamp" program to distribute funds directly to institutions. America's libraries, colleges, secondary, and elementary educational institutions and non-profit research centers would then be able to use the funds solely to purchase internetworking services.

% Maintain "research funding" but do not confuse operational network access with network research. It is clear that the commercial marketplace is properly motivated to invest its own resources without government R&D subsidy. The government should limit its R&D scope to innovative industrial/academic research in high speed communications technologies and applications at the frontier.

Statement of Honorable Bob Traxler

Thank you very much, Mr. Chairman, for the opportunity to appear before your Subcommittee today. This hearing is an important step in the process of our fully understanding and appreciating the various factors that should be considered as we chart the future of computer networking in this country.

I appear before you today as Chairman of the VA-HUD and Independent Agencies Subcommittee of the House Appropriations Committee. My Subcommittee has jurisdiction over the National Science Foundation, an important player in the creation and nurturing of NSFNet. I want you to know that as Chairman of the Subcommittee that has recommended millions of dollars for the creation of our nation's six federally funded supercomputer centers and for NSFNet itself, I feel extremely proud of the way in which that network has evolved.

The litany of accomplishments of the NSFNet is long and impressive and, I believe, those accomplishments reflect exactly what the Congress and NSF intended when setting up the network. Virtually all observers agree that NSFNet has been a resounding success. It is a stellar example of cooperation between the federal government, the academic research community and the private sector.

It is a homegrown system, if you will, that has given the United States clear leadership in computing networking, while at the same time providing boundless opportunities for students, scientists, the business community--individuals from virtually every walk of life--to access resources ranging from electronic bulletin boards to supercomputers across this continent and around the world.

NSFNet links our nation's institutions of higher education, including some 65% of all universities, government and research laboratories, representing a significant portion of the larger Internet system, and also representing the forerunner for the National Research and Education Network (NREN). As such it has truly become an invaluable asset critical to our nation's competitiveness. NSFNet, however, is no monolith. Rather it is a "network of networks," with its backbone now being tied into by some 5,000 individual networks, an estimated 1,500 of them from outside the United States, linking us to 36 other nations in Europe and the Pacific Rim.

I am pleased with the evolution of NSFNet to date because I believe it has provided one of the most outstanding examples of inter-agency cooperation and it has thus effectively made maximum use of our increasingly scarce federal resources. Importantly, federal investment in NSFNet has leveraged private investment. Merit Network, Inc., through its corporate partners has invested four dollars for every federal dollar expended. The regional education networks have invested many times more. As a result, the network that has been created continues to grow and to spread into all sectors of our nation's daily commerce and educational experience.

I believe that through its practical development and demonstration of networking techniques and capabilities, NSFNet has put us many years ahead of where we otherwise would have been in this endeavor. It has opened numerous commercial opportunities and has paved the way for the day when a network of this enormity can in fact be sustained by the private sector. In fact, through the efforts now underway to develop and demonstrate networking technologies, business opportunities have been created and will continue to emerge as we move toward broader and broader "mass service" markets.

Are we there yet? I think that is one excellent question for your hearings today. My personal feeling is that, even as commercial opportunities grow, NSFNet has much work still to be done. I would hope that we can keep the momentum and the leadership we have in this area. I believe government involvement can and should continue to be used to insure that the breakneck pace of advancement in the field of computer networking can be marshaled to our further benefit.

Rather than impeding commercial opportunities, I believe NSFNet has fostered them. That is just what I believe the Congress intended. Likewise, I believe NSFNet is our best hope for staying at the leading edge of networking technology worldwide. Its work in creating networking standards and developing technology transfer systems will continue to stimulate new uses of the network and, therefore, further new commercial opportunities.

I congratulate you on your hearings today and I look forward to working with you on this critically important project and these important issues.

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