SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

Subcommittee on Science, Technology, and Space

Witness List*

Hearing on
the High Performance Computing and Communications Program and
Uses of the Information Highway

Thursday, May 4, 1995; 10:00 am
in Room SR-253 of the Russell Senate Office Building

PANEL I:

Mr. John Toole, Director, National Coordination Office for High Performance Computing and Communications, National Library of Medicine, Bethesda, Maryland

PANEL II:

Dr. Richard Gowen, President, South Dakota School of Mines and Technology, Rapid City, South Dakota

Dr. Steven Running, School of Forestry, University of Montana, Missoula, Montana

Mr. Bill Burrall, Moundsville Junior High, Moundsville, West Virginia

*Not necessarily in order of appearance.

Statement by

JOHN C. TOOLE

Director, National Coordination Office for High Performance Computing and Communications

Chairman, High Performance Computing, Communications, and Information Technology Subcommittee, Committee on Information and Communications, National Science and Technology Council

Before the

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

May 4, 1995

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Federal High Performance Computing and Communications (HPCC) Program
May 4, 1995

Introduction

Good morning Mr. Chairman, Members of the Subcommittee, and staff. I am pleased to appear before this subcommittee and have the opportunity to describe the accomplishments, plans, and directions of the Federal High Performance Computing and Communications (HPCC) Program. I am very honored to have taken responsibility as Director of the National Coordination Office (NCO) for HPCC in March from Dr. Don Lindberg, who served concurrently as Director of NCO and as Director of the National Library of Medicine from September 1992 until March 1995.

After serving the past 9 years at the Advanced Research Projects Agency, I am now the first full-time Director of the NCO. I believe we have an unprecedented opportunity for establishing the foundation for America's information future and would like to talk to you about that today.

Information technology is central to our national security and to our society, both economically and socially. US leadership has resulted from an extraordinarily complex and fruitful long-term partnership among academia, industry, and government. Today's initial National and Global Information Infrastructures are based on technologies emerging from the computing and communications research that has been underway for many years; however, the dreams of tomorrow will rest upon the investments we make in research today.

The Federal HPCC Program has been a model "virtual agency" since its inception, with unprecedented collaboration among the (currently) 12 Federal organizations concerned with HPCC R&D. The Program has maintained an important balance between very long term science and engineering, and the most advanced computing and information technologies possible -- all directed at the collective mission needs of the respective agencies. Agencies have strongly supported the program because it is a complex field in which advancements are in their strategic best interests, and the most effective leverage possible grew out of this collaboration.

As we look to the future of information technology in the United States, I would like you to consider the recent study by the National Research Council, *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*. This is a major study requested by Congress. In addition to looking at the HPCC Program in detail, the NRC committee of distinguished researchers from academia and industry studied the long term investments made by government and industry. This committee concluded that the government's investments in information technology have made a significant impact over the long term. The HPCC Program is the most critical part of that investment today.

In the short time I have today, I'd like to focus on three topics:

- Examples of key Program accomplishments that highlight new science, national capabilities, and future infrastructure,
- A brief synopsis of our FY 1996 plan, and

- Future anticipated activities.

Program Accomplishments

I am pleased to provide the committee copies of the report, *High Performance Computing and Communications: Foundation for America's Information Future*, which can also be viewed on-line via the World Wide Web. This report, prepared by the HPCCIT Subcommittee of the National Science and Technology Council's Committee on Information and Communications R&D (CIC), describes in detail the Program's significant accomplishments and outlines the breadth of the program. Although we have produced such reports every year, this year's report includes on-line links to many of the highlighted research projects, providing even more detail for the American public. I'll use a couple of examples to highlight some of the key investments that have been made since the Program's formal authorization in FY 1992.

The spectacular images transmitted around the world of the recent collision of the Shoemaker-Levy 9 comet fragments with the planet Jupiter illustrate the impact of HPCC technologies across multiple Federal agencies. It is an example of enabling new scientific computational models, run on a new generation of scalable computing systems, communicated almost instantaneously on a web of networks, that made possible the use of the NASA's Hubble space telescope in unforeseen ways. NSF's Pittsburgh Supercomputing Center and DOE's Sandia National Laboratories accurately foretold the event using new computational techniques that depend very much on high performance computing technology. These models provided the information for space scientists to point the Hubble telescope in the correct direction to observe first hand these unique events. Without the modeling efforts, a once-in-a-lifetime observational astronomy event would have been lost.

Interdisciplinary Grand Challenge R&D projects -- computationally-intensive applications -- have led to new science and engineering techniques in a wide range of disciplines. By modeling air flow and turbulence around aircraft, properties of their engines, combustion, the oceans, the atmosphere, the weather, pollution, climate, groundwater, earthquakes, vegetation, the human body, proteins, enzymes, the human brain, materials, chemicals, structural dynamics of car crashes, and the evolution of galaxies, innovation in high performance computing and communications techniques have brought the Nation new knowledge and new capabilities.

Research in computational modeling is starting to pay off, for example, in the US aeronautics industry. A comprehensive new engine modeling system called the Numerical Propulsion Simulation System, was developed under NASA using these techniques. It has resulted in engineering productivity improvements that enabled one of our premiere aircraft engine companies to cut design time in half for high-pressure jet engine compressors which are used in the Boeing 777. This new design also reduces fuel consumption -- saving billions of dollars in fuel cost over the life of the fleet and reducing environmental impact.

In the future, we can expect that scientific results developed as part of the Grand Challenges, combined with National Challenges -- information-intensive applications impacting US competitiveness and societal well being -- will greatly enhance the quality of life for Americans. Weather forecasting and medical information are two good examples. NOAA has developed a hurricane prediction system, using modern techniques requiring high performance computing, that can more accurately predict the path of a hurricane, provide earlier warning, and, in turn, save lives. In the medical field, application of telemedicine is bringing the physician

instantly in contact with remote locations using advanced computer networks. Digital models of human anatomy are being developed to provide a new education tool for researchers, health care providers, students, and the general public.

Internetworking has been an important component of the HPCC Program, and will determine the future of the NII. The success of the Internet is widely known, beginning with ARPA-funded research in the 1960's and continuing to the NSF's privatization of the Internet today. For the research community and individuals across the Nation, the Internet ties people and places together to work on future challenges. It is providing public access to an incredible wealth of information some of which you will see demonstrated here today. HPCC research in networking is working to address the future capabilities, such as technical approaches for performance, scale, and security.

A major activity has been the six gigabit testbeds jointly funded by HPCC agencies to demonstrate the uses of high performance communications technology in actual agency missions. Nine Federal agencies, thirteen telecommunications carriers, twelve universities, eight corporations, and two state supercomputer centers have participated in these six testbeds that connect 24 sites. Asynchronous Transfer Mode (ATM) and Synchronous Optical Networking (SONET) technologies, developed rapidly in these collaborative projects, and prototype switches and protocols were developed to address issues at very high speed that would have taken many years longer without the HPCC Program. In many cases, science and technology has created opportunities for industry to open unforseen markets and be at the forefront of technology in the 21st century.

High performance computing systems have been essential to National Defense, NASA, NSF, and Department of Energy Scientists. The HPCC program has funded research to explore new systems approaches and scalable techniques for a wide class of problems. For example, while we acknowledge the impressive world records in computation speeds, such as Sandia's 281 gigaflops linear algebra benchmarks performed on the Intel Paragon computers, research has been on-going on high performance backplanes, operating systems, embedded systems, networks of workstations, and new algorithms.

Software technology has always lagged hardware development. It is challenging to write complex computational models for many different machine architectures; however, languages such as High Performance FORTRAN and High Performance C++, along with software tools to support them, are available for use in new computational experiments. Software tools are now available to the public over the National HPCC Software Exchange, an activity supported by the HPCC Program to ensure rapid dissemination of advanced software to researchers throughout the US. Associated with the software development activities are new visualization techniques, such as the Cave Automatic Virtual Environment, which allows a user to explore new design approaches and unique ways to visualize the massive amounts of data today's researcher has available.

The HPCC program added a fifth component in FY 1994, Information Infrastructure Technology and Applications. In the past two years, the Program has supported R&D for the enabling information infrastructure, and exploited the experience base that has grown from related research in high performance computing and communications. One of the most notable achievements are the "Web browsers" used to retrieve vast amounts of information available all around the world. Based on the Mosaic system developed at the National Center for Supercomputing Applications, funded as part of NSF's HPCC program, already more than 1 million copies of public domain Mosaic software have been obtained through NCSA; more than 10 instantly in contact with remote locations using advanced computer networks. Digital models of human anatomy are being developed to provide a new education tool for researchers, health care providers, students, and the general public.

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Applications programs as part of HPCC refer to the experimental use of advanced information technology research and development applied to real problems in innovative ways. These applications drive the HPCC technology development. By engaging in Grand and National Challenges in the HPCC Program, agencies have a unique opportunity to accelerate this critical technology into their mainstream. For example, the four-year digital library research being jointly supported by HPCC agencies will lead to new ways to store, retrieve, search, and process masses of information being gathered by weather satellites, census surveys, and many other type of relevant information. Health care, national security, energy management, aeronautical design, public health, and education all benefit from the technologies of the HPCC program.

Educational resources and the computational tools that have emerged from the HPCC Program are an important result of this scientific investment. Students, including K-12, undergraduate, graduate, and post-graduate students, are now approaching these difficult scientific and engineering tasks with a new set of computational tools that were previously not available. These researchers, for example, are now capable of studying the human genome structure, the evolution of galaxies, and the design of new materials, by the use of computational modeling. Many of us believe that this Program is fostering a revolution in the way we do science, the way we learn, and the way we share information. Projects supporting the classroom, such as NASA'a Classroom of the Future in West Virginia, provide a new generation of educational modules and teacher support, using remote sensing databases over the Internet.

Even though some of the innovative computer manufacturers in the dynamic and highly competitive market of high performance computing and communications may fail, their insight into the nature of parallel computational algorithms and the structure of future computational systems did not fail. Indeed, they brought new knowledge and insight into the field of high performance computational science and engineering.

Finally, the HPCC Program has helped support a world-class network of research facilities that are reaching out to the states, communities, and individuals. I call your attention to the descriptions of the High Performance Computing Research Centers described in the FY 1996 Supplement to the President's budget that I have provided for you today. These Centers are actively engaged in research, education, outreach to minority institutions and rural areas, and training our next generation students throughout the US.

FY1996 Plan

In FY 1996, 12 Federal departments and agencies will participate in the HPCC Program by coordinating their R&D activities and accelerating technology transfer into key computationally intensive and information-intensive application areas. The estimated FY 1995 HPCC Program budget for the nine participating Federal organizations was $1,038 M. For FY 1996, the President requested $1,143 M for the 12 organizations. Projects are competitively selected and include academia, industry, and government labs. In FY 1994, for example, approximately 55% of the program moneys went to academia, 20% to industry and 25% to government labs/not for profits.

For FY1996, each Agency's detailed program is submitted and briefed to their respective committees. In addition to the supplement, a detailed HPCC *FY 1996 Implementation Plan,* to be published this month, will provide a coherent overview of the detailed projects included across the 12 HPCC Agencies. While enormous progress is now visible in high performance computing and communications in the first four years of the Program, much remains to be done. Across the entire program, several new directions are being taken in FY 1996, based on research that has been on-going in the program:

First, increased emphasis will be placed on research for all aspects of software for parallel, scalable computing systems, including software tools, compilers, operating systems, languages, development environments, and programming libraries. This will enable a new generation of application software developers, encourage independent commercial software developers, and stimulate new applications to meet mission needs.

Second, emphasis in the networking research areas will address new high performance protocols, "services" imbedded in the network, and ways to achieve an "open data network," as described in a recent report by the National Research Council. This will stimulate interoperable systems capable of interacting across the nation for many user's needs, and provide greater diversity among communications media, such as "wireless" and interactive cable systems for schools, libraries, health care facilities, and homes.

Third, research on innovative approaches to security, privacy, vulnerability, and reliability will be emphasized to enable information access and commerce. This includes all aspects of the system, as well as the critical networking areas.

Fourth, the Program will include demonstrations of advanced applications, combining the best of Grand and National Challenges. As we have begun to show, new discoveries in science and engineering are emerging, along with the infusion of this technology into the science and engineering base of the nation. In addition, capabilities of the future information infrastructure are already being demonstrated. Applying these technologies to our Nation's most important problems, in conjunction with other National programs, is a mechanism to achieve enormous leverage of Federal funding of R&D while advancing our overall quality of life and our country's economic competitiveness for the 21st Century.

Future Anticipated Activities

The importance of information technology to everyone in the US has become evident, but the real information revolution is yet to come. Capabilities double every 18 to 24 months, thanks to the enormous progress in microelectronics and components. These, in turn, fuel new system approaches and breakthroughs that open up entirely new possibilities.

The HPCC program began during the Bush Administration and received strong bipartisan support in both the Senate and the House. Since its beginning in FY 1992, the current Administration has made it a priority for our long term science and technology investment, providing long term capability for the next wave of information technology while exploiting high performance computing and communications across the globe. The National Coordination Office, which I now direct, was created to coordinate the Federal HPCC Program across the Federal government.

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As part of the National Science and Technology Council (NSTC), the Committee on Information and Communications R&D (CIC) was established under the leadership of the Honorable Anita Jones, Director of Defense Research and Engineering and CIC Chair, and the Honorable Lionel S. Johns, Office of Science and Technology Policy, CIC co-chair. The CIC, which consists of senior representatives from R&D Agencies, has developed and published a strategic implementation plan titled *America in the Age of Information*. This plan outlines several strategic focus areas designed to focus fundamental information and communications research and to accelerate development in ways that are responsive to NSTC's overarching goals, agency mission goals, and our Nation's long term economic and defense needs. The strategic focus areas are: global-scale information infrastructure technologies, high performance/scalable systems, high confidence systems, virtual environments, user-centered interfaces and tools, and human resources and education.

Using this strategic implementation plan as a guide, we are engaging academia, industry, and government to define the investments beginning in FY 1997 that will lead us into the information future. You will see this emerge in two ways -- first as each Agency submits their respective implementation plans and budgets and, secondly, as part of the CIC planning activities, which are now supported by the NCO.

Sustained investment over the long term is essential, particularly with the inherent shorter term focus of industry. It is hard to predict which new ideas and approaches will succeed, since the exact course of exploratory research cannot be planned in advance, and progress in the short term is difficult to quantify. Furthermore, the industrial R&D investment, although much larger than government investment, is very different in nature, necessarily focusing primarily on shorter term product development cycles. The rationale for government investments in this crucial area are developed in detail in the NRC HPCC study and the other documents cited.

US strength in information technology - economically and scientifically - is due in part to the aggressive federal research investment in computing, communications, and mission applications of the Agencies. HPCC is the initiative that has yielded leverage through cooperation, but the basic long-term investment by the government in this area is of vital importance to our future.

Summary

Mr. Chairman, I am acutely aware of the budget issues facing this committee and the need to reduce our deficit spending sharply. I also believe, however, that information technology is our future, and government investments we make in computing and communications will help shape our long term ability to succeed. I personally would not have taken this job if I didn't believe so strongly that our investments, coupled with the brilliant skills of academia and industry, are so critical to our future.

I know I have only given you some of the highlights of the program, but welcome any questions or comments from the Committee. Thank you for this opportunity.

Presented to the Subcommittee on Science, Technology and Space
on the Committee on Commerce, Science and Transportation

The High Priority Connection Network - Technology for Rural America

by
Dr. Richard J. Gowen
President
South Dakota School of Mines and Technology
on May 4, 1995

Introduction: Mr. Chairman, Members of the Committee, I am Dr. Richard J. Gowen, President of the South Dakota School of Mines and Technology located in Rapid City, South Dakota. Thank you for the opportunity to tell you how we are using the nation's information highway to help the people of rural America compete in the global marketplace. We have developed the High Priority Connection Network (HPCNet) to link the businesses and industries across the heartland of America with the products and services needed to produce the highest quality products at competitive prices.

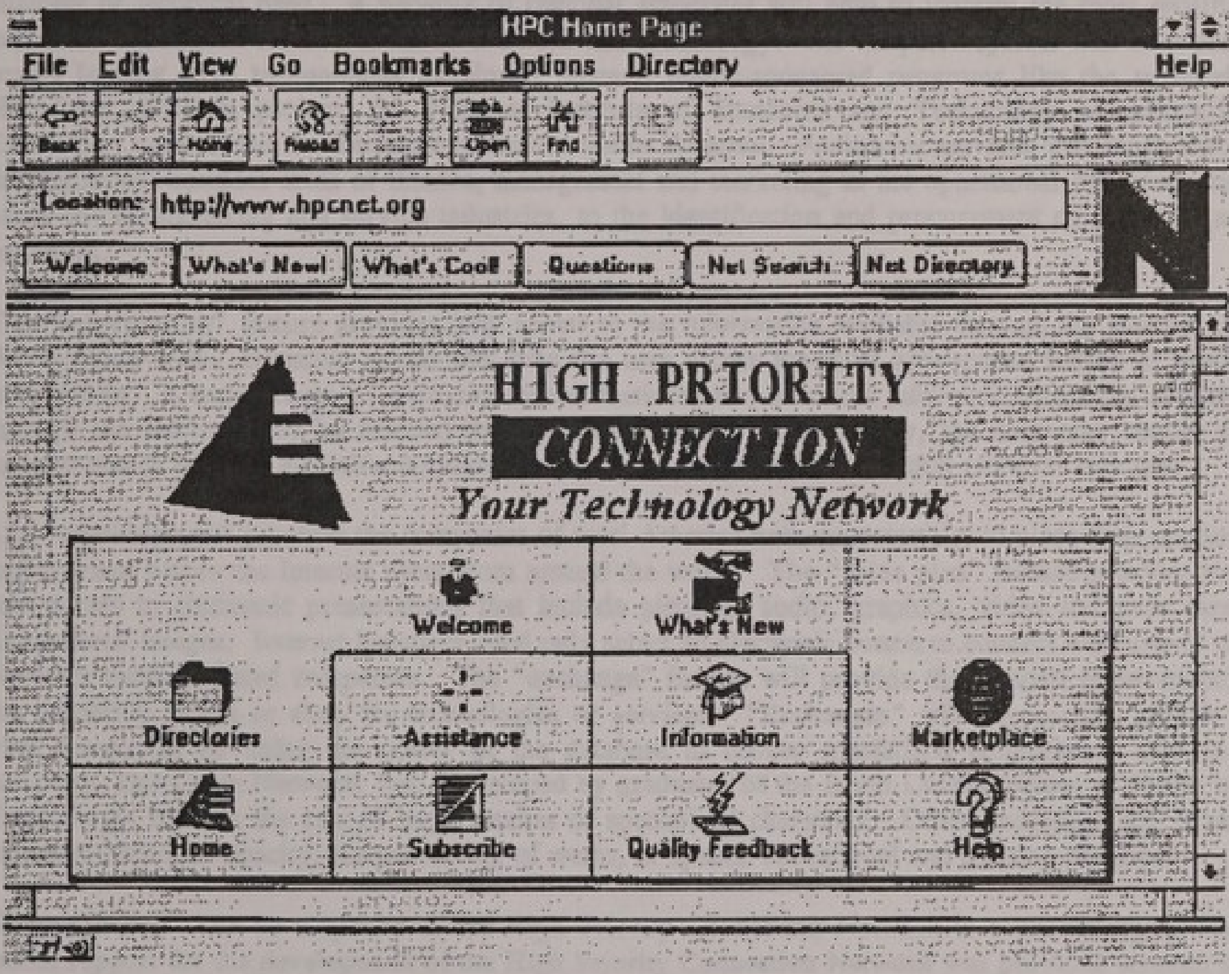
Network Overview: The High Priority Connection is an electronic network that uses the Internet to bridge the distances of rural America and deliver the information and assistance necessary to support the growth of jobs in our many small companies. Much as the interstate highways of yesterday made it possible to efficiently link companies of hometown America, the Internet provides the electronic highway for today's commerce. The High Priority Connection Network is the electronic equivalent of yesterday's long haul tractor-trailer. Through the High Priority Connection Network we are able to deliver to the small companies of our rural towns services that are equivalent to those available to their global competitors.

History: The concept for the High Priority Connection Network evolved from the efforts of the South Dakota School of Mines and Technology, working closely with the South Dakota Governor's Office of Economic Development, to tap the resources of the university and create new jobs. During the past seven years, 66 technical assistance partnerships were formed to join the resources of industry, the state, and the university to resolve a specific technical need of a company. Our university made available the resources of faculty, students, and facilities. The Governor's Office of Economic Development joined with industry and our university to fund these partnership teams. These technical assistance partnerships helped to create products and services that range from diamond-tipped surgical knives to an advanced composite material platform used for cleaning crop spray planes, to high performance computer software.

As we worked with the industries of our region, we became aware of needs that were beyond our immediate resources. While there is a great richness of assistance available from companies, government agencies, federal laboratories, universities and economic development groups, a person in a small company often finds it difficult to find or judge the value of such assistance. Some suggested that we create the equivalent of the agricultural extension agent to help companies locate sources of assistance. However, the great distances between our manufacturing companies makes a system of such technology extension agents impractical. Instead, we chose to develop our electronic delivery capability using "smart" systems to connect companies with needed business and technical assistance. The resulting High Priority Connection Network combines the excellent presentation capabilities of the Internet's Mosaic software with the search and retrieval capabilities of a high performance relational database.

Technical Challenge: Our design requirements for the High Priority Connection Network placed special emphasis on the value of a "user friendly" approach to connecting companies with needed assistance. Early tests using the Internet and World Wide Web were described as trying to find information in the largest library imaginable without access to a catalog. We adopted the goal that the High Priority Connection Network should be designed to be so intuitive that even the CEO or President of the company, and in my case, President of the University, could successfully link to needed assistance without help or the need to read a user's manual.

HPCNet Structure: The High Priority Connection Network uses "electronic buttons," as shown below, to link to its four major features; **directories, assistance, information, and marketplace.**



The **"directories"** feature of the High Priority Connection Network provides the user with access to over 18,000 commodities and products through a menu of choices based on the Standard Industrial Classification (SIC) Codes. Through these menus users gain access to information about the products, services, key personnel, and unique capabilities of a company. The user will also have access to graphical and multi-media presentation of the products and services offered through the company. Additionally, the user is provided information to contact the company or the opportunity to send an electronic message requesting additional information or a follow-up contact. A significant aspect of the

High Priority Connection Network is the identification of the number of items available in the database as classified with its corresponding SIC code.

Our database currently contains information on 15,048 companies in South Dakota. In cooperation with the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), we are preparing to include over one million additional companies from the 18 EPSCoR states and the Commonwealth of Puerto Rico. Most of these companies are small and many share the same need to bridge great distances to obtain assistance.

The "assistance" feature connects users with state and federal assistance programs, economic development services, and sources of technologies. Users of the High Priority Connection Network will have access to specialized assistance brokers to provide guidance in locating a solution to a business or technical need. A network of regional associates will help to identify the most qualified assistance brokers in the key areas of business and technology. An "expert" system will help users access leading edge technologies developed through public-sponsored programs like the successful NSF-State EPSCoR project, the National Institute of Standards and Technology Manufacturing Extension Centers, and the Technology Reinvestment Program. Assistance services will range across the traditional business areas of finance, management and marketing to the operational and production needs in manufacturing and service industries, to the identification and procurement of materials and resources.

The "information" feature provides easy access to the information available through the Internet and World Wide Web. Dynamic menus will help the user access the most appropriate source of needed information. A broad range of state and federal business and technical information services available through the Internet may be reached through these menus. Additionally, the user may choose the assisted search services available through libraries and commercial information retrieval services.

The "marketplace" provides the companies of rural America with opportunities to place their products and services before the Internet users from around the world. The "value plus" feature provides low-cost access to electronic presentations that include pictures, audio, graphics, video and even three-dimensional images. Internet browsers need only select an electronic button to connect with one of our Network database-listed companies. The "exchange" feature will provide the Internet browsers with the capability to list or shop for technologies or services. "Exchanges" will support the growth of vital companies by using the power of the database to broker specialized commerce. One such company, Eco-Chem Network, Inc., developed by graduates of the South Dakota School of Mines and Technology, brokers the sale of large batches of specialized chemicals. Other exchanges will broker excess production capacity, the processing of waste, or special educational and training programs.

Status Today: The development of the High Priority Connection Network is a continuing process. Initial support for the development of the High Priority Connection Network was provided through the South Dakota Governor's Office of Economic Development with the intent that the operation of the Network ultimately become self-supporting. A major goal of the initial design was to build a network that would expand the opportunities for commerce in rural America through electronic linkages between people with needs and people who provide solutions.

The basic design of the High Priority Connection Network is complete, and the Network is being extended to link users and providers in surrounding states. The National Science Foundation's EPSCoR program has funded the development of "smart" links for transferring the technologies developed by researchers to the companies within the EPSCoR states. Such development of links

between users and providers will lead to the rapid expansion of the services available through the High Priority Connection Network and increase the value of this Network to companies in rural America. Shortly, the High Priority Connection Network will be available to the world through the Internet. Subscribers will bridge the vast distances of rural America when they access the advanced support services available on the High Priority Connection Network.

WRITTEN CONGRESSIONAL TESTIMONY
by
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DIRECTOR, NUMERICAL TERRADYNAMICS SIMULATION GROUP
SCHOOL OF FORESTRY
UNIVERSITY OF MONTANA

BEFORE THE
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE
SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORATION

HEARING ON THE HIGH PERFORMANCE COMPUTING
AND COMMUNICATIONS PROGRAM

4 MAY, 1995

A tremendous synergism is evolving amongst the technologies of satellite remote sensing, computing and telecommunications for Earth sciences and natural resource management. When the first Earth Resources Technology Satellites were launched in 1972, the optical accuracy of the satellites was poor and uncalibrated, and the computer power to process the stream of digital imagery transmitted to Earth was primitive compared to todays capabilities. As the suite of Earth Observing System satellites are launched beginning in 1998, part of the NASA Mission to Planet Earth, an unprecedented array of satellite based information will become available. EOS will produce satellite data covering the globe at variable space and time detail with a consistency not now possible. Of equal importance will be the high precision of new EOS data resulting from sophisticated in-flight calibration of the sensors. The inhanced precision of EOS satellites will allow accurately measured land products, prototypes of which I will show today.

Fortunately, as satellite technology is evolving, computer technology is doing likewise, so the personal laptop computer I carry today is probably 1000 times more powerful than the university mainframe computer we used as graduate students at Oregon State University in 1972. The 1000GB/day processing planned by the EOS Data Information System would have been absolutely impossible 10 years ago.

The final step in exploiting the vast information that will be collected by EOS is the distribution of that processed data to users. Distribution of these data to the global-scale research community will be fairly straightforward, as those scientists work at major universities or government research centers which will be linked by state-of-the-art network connections. I will show two examples of these global terrestrial science products that will be available from the EOS computer network. First will be a map of vegetation productivity useful for estimating forest, range and

crop productivity worldwide. The second image will be a map of global landcover change from human activities. Both of these satellite based products are important in representing the land surface in global climate models.

However, the utility of EOS and other advanced remote sensing products by the larger scientific and resource management community will hinge on their ability to access a regional subset of these global data in a timely fashion. In my demonstration today, I want to concentrate on the remote sensing based products that should prove particularly valuable for future natural resource management IF managers and land owners can receive the data quickly and easily. I will show samples of research products that have been developed over the last five years in the western United States, and discuss how these need to be delivered for optimal utility.

The single biggest factor in making these advanced remote sensing products truly useful to managers and land owners is near-real time delivery at low cost, and this is where the "information superhighway" is the critical final component. The best current example of near-real time satellite data use is the nightly weather forecasts we all watch on television, distributed by the National Weather Service, derived in part using the NOAA Geostationary Operational Environmental Satellites (GOES) data. I invision a new era of land management that can have weekly satellite data distributed to users in much the same way over the "information superhighway".

Some of these products are generated by incorporating topography, soils, daily weather information, and landcover maps integrated with advanced computer simulation models of biophysical and ecological processes. The final products give much more realistic and quantitative mapping of land surface activity than satellite data alone can provide. Here are some examples:

(1) Drought monitoring: This image shows the change in a Drought Index that was calculated from Spring to the Summer of 1990. Both visible light and temperature data from the NOAA AVHRR meteorological satellite are used for this index. This Drought Index could be computed and distributed weekly, but is currently only a research product developed at the University of Montana. Decisions on grazing concentration or irrigation timing are possible uses.

(2) Burning Index: This is a fire danger index map of Oklahoma that incorporates topography, ground fuels, daily weather data and satellite data into a mid-afternoon measure of the risk of wildfire ignition. This is a propotype for the next generation National Fire Danger Rating System of the US Forest Service, developed at the Intermountain Fire Sciences Lab in Missoula, and could be distributed daily. Mobilization of fire crews depends on these forecasts.

(3) Snow Cover: Accurate monitoring of spring snowmelt is essential in the Western United States for predicting flood events, summer irrigation supplies, and dam operations for hydroelectric power. This image from the NWS National Operational Hydrologic Remote

Sensing Center in Minneapolis used NOAA AVHRR data to map the snow cover change from February 19 to May 1, 1990. These snowcover maps could be distributed bi-weekly via computer network.

(4) Water quality: This image, from the University of Montana, shows water quality of Flathead Lake, in western Montana, on July 16, 1984 as measured by chlorophyll concentration. Satellite based water quality monitoring of freshwater and oceans will be done weekly with the new EOS sensors.

(5) Wildlife habitat: This image shows the vegetation cover of the Seeley-Swan, a mountain valley in western Montana, and the mountain goat habitat of that area. Topographic and habitat preference factors are merged with satellite data into this analysis of wildlife habitat, done at the University of Montana as part of the U.S. Dept. of Interior, Fish and Wildlife Service GAP analysis program.

(6) Forest/Range/Crop productivity: The seasonal production rate of crop, range and forest land can be followed by integrating NOAA AVHRR satellite Greenness Index data with daily surface weather data. This image is an example, sponsored by the State and done at the University of Montana, of a system to calculate the productivity of forested land using satellite data. Decisions on range cattle allotments or forest harvesting are examples of land management that could benefit from these data. These Production Indices could be computed and distributed weekly nationwide.

Of course there are many other interesting projects using satellite imagery in innovative ways elsewhere in the world, such as mapping malaria outbreak potential or grasshopper population dynamics in Africa. These examples highlight activities I am involved with in the western United States only. All of the above products have been developed and tested by various research groups and agencies in the last five years. All of them could be used by landowners and managers if they could get access to the datasets quickly with low cost computers and network connections. In each case the primary remaining hurdle is to provide the networking that can allow this information transfer, particularly to rural agency offices and landowners.

The Earth Observing System program is concentrating on a Data Information System to transmit processed satellite data to users. The EOS Data Information System is a cooperative activity of NASA, the Dept. of Commerce (NOAA), the National Science Foundation, the Dept. of Defense, the Dept. of Interior (USGS), and the Dept. of Energy. However, the computer network facilities to reach beyond the science community to land managers in rural parts of the United States, require more than EOS program responsibility alone. Advances in land management in the western United States will rely on high speed telecommunications to use the types of new information shown today. I encourage the continued devlopment of the "information superhighway".

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May 1, 1995

Honorable Senator Conrad Burns and members of the committee,

It is an honor to have been asked to give testimony to issues concerning the "affordable school/library telecommunications access" amendment.

As a classroom teacher, I have been utilizing telecommunications and online services in the classroom arena for the past thirteen years. Our classroom connection has evolved from the 300 baud modem to 56 kilobit frame relay access which supplies us, at present, with a high-speed connection to the Internet. The level of access we presently possess, provides my students with a window to the world and places at their fingertips, a world of learning opportunities never before thought possible. Connectivity such as this becomes a most important issue for schools such as ours, located in rural America. Presently, only three percent, or one out of every four schools in our country have classroom access to the Internet at varying levels of connectivity. To ensure equal opportunity to all students and citizens, I cannot emphasize enough the importance and need for the government to expand and maintain the transport medium and ensure affordable access to educational institutions and libraries across the country.

According to Information Week, in the past ten years alone, the use of electronic mail has grown from 300,000 users to over 6 million. Prodigy and America OnLine are registering record numbers of new users, all wanting access to lanes on the Information Superhighway. Elimination of vital funding sources for the nation's educational infrastructure would seriously impair our ability to prepare our students for the 21st century. In short, our nation's children stand to lose a great deal in respect to their future. This loss of opportunity to become productive citizens will also impact future generations in respect to the stability of our nations retirement system.

The three R's have now evolved into the four R's with the addition of information "Retrieval" as a most important skill necessary for survival in today's competitive marketplace. Information retrieval skills become even more important when one looks at the global picture. Equitable and affordable access to the Information Superhighway will assure that our nation is providing unprecedented learning opportunities for our children in a society that requires its citizens to be technologically literate as they compete in a highly competitive global marketplace.

I have experienced, firsthand, students and colleagues that have had their lives greatly enhanced and become more effective learners through the use of online services. My students have become members of the global community with their electronic visits to classrooms throughout the United States and around the world. Throughout the past two weeks we have been interacting with a school in Oklahoma City and receiving candid accounts from a teacher whose assistant principal's husband is still one of the missing. Realtime learning through technology! We have hosted numerous collaborative learning projects and participated in global events, such as the recent World Summit for Social Development in Denmark in which my students sent essays to world leaders. Over the years from our classroom in rural West Virginia, we have visited and worked cooperatively with students in Japan, Germany, Korea, The Netherlands, Bermuda, and even the remote town of Akutan, Alaska...population ninety-five. The Akutan example solidifies the point that universal access is of paramount importance to ensure that all students in the K-12 arena have such opportunities. On a remote island in the Aleutian chain, telecommunications became a vital link in the lives of those students and residents and literally brought the world to their classroom and community.

It was through online services that my students took their peers from across the country and in far off lands, behind prison walls to take a candid look at society's problems in a project that gained international acclaim and a place in the Smithsonian archives. In this project, students had the opportunity to ask questions to inmates incarcerated in our state maximum security prison. The results were dramatic and touched the lives of students, teachers, and communities in twenty-two foreign countries. One outcome of this project was the honor I received as 1993 National Technology Teacher of the Year. Collaborative classroom projects like these are taking place on a daily basis on the Internet and enable students and teachers to transcend the barriers of distance and time in creating new and exciting learning environments.

I have found that students who participate in online projects show a dramatic improvement in their reading and writing skills. When students write for a global audience, they seem to focus not only on what they say, but on how it is presented to their peers. Likewise, teachers who use information services also show enhanced professional development and enhanced teaching skills and strategies in integrating such technologies into the curriculum. Telecommunication technologies are enabling teachers to become the agents of change rather than the objects of change, and motivating students to take control of their own learning.

Although the Internet has been around for some twenty-five years, its evolution in the educational arena is in its infancy. I firmly believe that as it evolves, it holds the potential to be the single-most important teaching tool to ever arrive on the educational scene. It is changing and will continue to change the way teachers teach and the way students learn. Students and teachers alike now have access to world leaders, experts in their field, not to mention the wealth of informational databases that presently exist and continue to grow on the Internet daily.

It is of extreme importance that as students, teachers, and the entire educational community merge onto the superhighway, they do not encounter toll gates as a barrier to learning opportunities. Barriers which will further widen the gap between the have's and the have not's. To have access to the Information Superhighway is to have an open passport to travel the world, visiting libraries with a lifetime library card and no return date necessary. Loss of this opportunity for lifelong learning would be undoubtedly a great injustice to the educational community and the citizens of the greatest country in the world.

On behalf of students, educators, and communities across the country, I implore the leaders of our nation to continue support of telecommunications technology: a decision vital to our children's future.

Sincerely,

Bill Burrall