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THE WHITE HOUSE

WASHINGTON

March 25, 1992

MEMORANDUM FOR THE PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY

FROM: D. ALLAN BROMLEY DAB

SUBJECT: MATERIALS FOR APRIL PCAST MEETING

I am attaching the following draft reports for your consideration before the next meeting of the Council on April 2-3, 1992:

(1) Draft report from the High Performance Computing and Communications Panel

(2) Draft report from the Megaprojects in the Sciences Panel

(3) Draft report entitled "Biological Diversity: Options for UNCED" from Tom Lovejoy

Please note that these three reports are the first drafts to be presented to the Council, and I would like everyone to be prepared to discuss them in detail on Thursday afternoon (see attached agenda).

In addition, I expect that a draft report outline and draft "charge" to FCCSET for the Health of U.S. Colleges and Universities project will be faxed to you on Thursday, March 26. The revised Panel report on Technology and the American Standard of Living will be included in the briefing book that you will receive at the meeting.

If you have any questions or need additional information prior to the meeting, feel free to contact Alicia Dustira at (202) 395-4692.

Attachments: draft reports (3)
draft meeting agenda

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March 25, 1992

PRESIDENT'S COUNCIL OF ADVISORS
ON SCIENCE AND TECHNOLOGY

APRIL 2-3, 1992
AGENDA

OPEN SESSION 9:00 AM - 11:00 AM
THURSDAY, APRIL 2, 1992
CONFERENCE ROOM
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, NW

8:30 - 9:00	ARRIVAL AND COFFEE	
9:00 - 9:15	OPENING REMARKS	D. ALLAN BROMLEY
9:15 - 9:30	HEALTH OF U.S. COLLEGES AND UNIVERSITIES PROJECT	D. ALLAN BROMLEY
9:30 - 11:00	ISSUES REGARDING U.S. ECONOMIC COMPETITIVENESS	GEORGE FISHER
11:00 -	CLOSING REMARKS OPEN SESSION ENDS	D. ALLAN BROMLEY

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THURSDAY, APRIL 2, 1992 (Continued)

11:00 - 11:15	COFFEE BREAK	
11:15 - 11:45	DISCUSSION	D. ALLAN BROMLEY
11:45 - 12:00	MOVE TO WHITE HOUSE MESS	
12:00 - 1:00	LUNCH WARD ROOM WHITE HOUSE MESS	

CLOSED SESSION - 1:00 PM TO 4:00 PM
ROOM 472
OLD EXECUTIVE OFFICE BUILDING

1:00 - 1:30	FIRST PRESENTATION OF DRAFT PANEL REPORT ON HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS	SOL BUCHSBAUM
1:30 - 2:00	FIRST PRESENTATION OF DRAFT PANEL REPORT ON MEGAPROJECTS IN THE SCIENCES	JOHN MCTAGUE
2:00 - 2:30	FINAL REPORT ON TECHNOLOGY AND THE AMERICAN STANDARD OF LIVING	RALPH GOMORY
2:30 - 3:00	DISCUSSION	D. ALLAN BROMLEY
3:00 - 3:15	COFFEE BREAK DR. BROMLEY'S OFFICE, OEOB ROOM 358	
3:15 - 3:45	BIOLOGICAL DIVERSITY AND THE U.N. CONFERENCE	TOM LOVEJOY
3:45 - 4:00	OTHER BUSINESS AND CLOSING REMARKS	D. ALLAN BROMLEY

COCKTAILS AND DINNER
WHITE HOUSE MESS

5:30 - 6:00	COCKTAILS
6:00 -	DINNER

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FRIDAY, APRIL 3, 1992

CLOSED SESSION - 9:00 AM TO 12:00 NOON
ROOM 476
OLD EXECUTIVE OFFICE BUILDING

8:30 - 8:50	ARRIVAL AND COFFEE (Dr. Bromley's office, OEOB Room 358)	
8:50 - 9:00	MOVE TO ROOM 476	
9:00 - 9:15	OPENING REMARKS	D. ALLAN BROMLEY
9:15 - 10:00	DISCUSSION OF APRIL AGENDA AND OTHER BUSINESS	D. ALLAN BROMLEY
10:00 - 11:30	DISCUSSION OF HEALTH OF U.S. COLLEGES AND UNIVERSITIES PROJECT	DAVID PACKARD HAROLD SHAPIRO
11:30 - 12:00	CLOSING REMARKS	D. ALLAN BROMLEY

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BIOLOGICAL DIVERSITY: OPTIONS FOR UNCED

by Thomas E. Lovejoy

1. The importance of biological diversity. While biological resources have always been of importance to society and a renewable source of wealth, biotechnology is today opening the possibility of a significant new source of wealth drawn from the variety of nature. For example, much diagnostic and forensic medicine, and indeed much biotechnology itself, relies on the discovery of a heat resistant enzyme in a Yellowstone hotspring. This enzyme, from a single species, is producing annual economic growth in the tens of billions of dollars. The pharmaceutical industry as noted recently in the New York Times business section, is turning increasingly to nature to find chemicals of value to human health. Similarly, waste cleanup is increasingly dependent on the use of microorganisms to remove toxic or unsightly substances from the environment.

2. The accelerating loss of biological diversity. At the very time science is beginning to develop truly significant ways to turn the variety of life into economic return, unprecedented numbers of species are being lost. This is principally, but not exclusively, because the tropical forests, which contain over 50% of all species in the 7% of the dry land surface of the earth they occupy, are being destroyed at a rate approaching 100 acres per minute. While there is a normal rate of extinction, usually involving replacement by a new species such that there is no net loss, it is estimated that current extinction rates are 1000 times normal. (??Do we want to express it this way or is it better just to leave people with the sense of magnitude??). Professor E.O. Wilson estimates species loss at 50,000 per year, a rate that would result in 25% of all species lost by 2040.

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3. The need for inventory. A great deal of the problem arises from the relatively superficial knowledge of the flora and fauna. Science is not capable of saying within a factor of ten how many species there are. Basically until we know what there is and where it is, it is impossible to avoid unnecessary extinction by a combination of proactive conservation and thoughtful guidance of development. OPTION: Call for an agreement of all nations to inventory their biological resources (something of this sort is included somewhere in Agenda 21). Different nations have taken different approaches. President Salinas has created a National Commission on Biological Diversity reporting directly to him (this occurred around March 13, 1992). Costa Rica has started a National Institute of Biological Diversity (INBIO). There has been discussion in this country of a National Center for Biological Diversity.

4. The state of natural history institutions. Most of the great institutions of natural history are in the northern countries (i.e., the Smithsonian, the Royal Botanic Garden at Kew). While they have not been strongly funded in recent decades, they are nonetheless critical because they hold the bulk of the reference collections. Once national inventories get underway, there will be immense pressures on these institutions. OPTION: Prepare a plan to strengthen the ability of these institutions to respond to the needs arising out of accelerated inventory activity. This could be done by a block of northern countries. OPTION: Help developing nations develop their own capacity by strengthening existing institutions and creating new ones where necessary. Where discounted debt is available, debt swaps could be a useful financing mechanism.

5. Lack of trained manpower. The number of trained systematists in the world is small, and in many instances there may be only one or two specialists in the entire world capable of identifying certain groups (i.e., marine invertebrates, soil

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organisms). OPTION: Provide increased training opportunities for systematists in the United States. OPTION: Help set up training opportunities for systematists in developing countries. OPTION: Provide training at lower levels of education to create a cadre of paramedic equivalents to systematists. This has already been done in Costa Rica.

6. Intellectual Property Rights/Technology Transfer. Developing countries have often provided genetic material almost gratis and profits have accrued (after much investment in R & D to industrialized country industries). Tropical nations are beginning to think of genetic diversity in intellectual property right terms. At the same time they are interested in technology transfer (not recognizing that the rights exist largely in the private sector), so they can realize some of the benefits accruing from the interaction of biological diversity and biotechnology. U.S. industry is interested in access to the genetic material. This is likely to take a long time to negotiate the principles. In the meantime, private industry is taking the lead in deals which implicitly recognize the rights on both sides. OPTION: Encourage deals like that between Merck and Co., Inc. and Costa Rica's INBIO, where Merck gets screening rights for useful chemicals and if anything useful is developed, the revenue is shared. OPTION: Encourage the establishment of joint laboratories and production facilities in the nations harboring the greatest riches of biological diversity.

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President's Council of Advisors on Science and Technology
High Performance Computing and Communications Panel Report
3/17/92

Introduction

In FY92, a presidential initiative was launched, aimed at securing US preeminence in high performance computing and related communication technologies. The initiative, entitled High Performance Computing and Communications (HPCC), is one of five initiatives coordinated by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) process. Nine federal agencies are currently involved, with the Defense Advanced Research Project Agency, the Department of Energy, the National Aeronautics and Space Administration, and the National Science Foundation providing the principal program funding and direction. Lesser but important roles are being played by the National Oceanic and Atmospheric Administration, the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Education, and the National Institutes of Health.

The stated goal of the initiative is threefold: extend U.S. technological leadership in high performance computing and computer communications; provide wide dissemination and application of the technologies; and spur gains in U.S. productivity and industrial competitiveness, all within the context of the mission needs of federal agencies. The strategy for accomplishing the goals and the program components are highlighted in the report "Grand Challenges: High Performance Computing and Communications," published as a supplement to the fiscal year 1992 and 1993 budgets.

Because of the importance of the HPCC program to the national well-being, especially its potential implication for industrial competitiveness, the Assistant to the President for Science and Technology has asked that the President's Council of Advisors in Science and Technology (PCAST) establish a panel to advise PCAST on the strengths and weaknesses of the HPCC program. The Panel, which includes two PCAST members and experts drawn from industry and academia, has conducted several fact finding meetings, interviewed HPCC program managers from the key participating agencies, and was briefed by the Computer Systems Policy Project, a private sector organization representing all the major American computer and information systems corporations. On this basis, the Panel offers the following observations and recommendations.

Panel Observations and Recommendations

The Panel believes that, in general, the program has important objectives and is structured to achieve the objectives. The Panel also finds that the HPCC program is making excellent progress towards achieving the program objectives.

The Panels observations and recommendations relate to the following issues: the program **strategy**; the program **balance** among technology, applications, and infrastructure; the program **management**; and the program **vision.**

Strategy

The HPCC program has certain explicit technology goals. The two best known goals are to implement by 1995 a tera-ops (10^{12} operations per second) computer and a skeletal gigabit (10^9 bits per second) National Research and Education Network.

The Panel finds the strategy of using scalable, massively parallel architectures to achieve the tera-ops goal convincing. Evidence to-date lends credence to the viability of the approach. An essay discussing the potential of the scalable, massively parallel architecture is located in Appendix A.

The National Research and Education Network (NREN) approach of coupling diverse existing networks, for example, the DARPA, NSF, and DOE networks, is also proving to be effective. The Panel supports the strategy of making NREN both an infrastructure goal and a testbed for technology development.

The integration of computing and communication as manifested in the program is viewed by the Panel as a critical part of its strategy. It will do much to accelerate the Nation to a "digital society." An essay on new challenges created by the integration of computing and communication, titled Harvesting Knowledge from Super Databases, is presented in Appendix B.

An effort should be made to encourage additional federal agency participation in the program. The participation of the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the National Institute for Standards and Technology, the National Institutes of Health, and the Department of Education is important, and their role should be continually expanded. Appendix C contains a related essay titled Increased Agency Participation in the HPCC Initiative.

The purpose and scope of NREN have often been misinterpreted. Its purpose is to provide a high speed data communication service for the research and education community, and in so doing serve as a testbed for the development of network technologies and services. Here, the meaning of "network" is functional, not physical. The optical-fiber physical medium and broadband switches will be owned by common carriers, and the "network" will be implemented by purchasing services from common carriers and other commercial vendors of communications services. Because of this close relationship with the private sector, there is a special opportunity to stimulate commercial exploitation of products and services developed in conjunction with the NREN program. A comprehensive study should be made on the technical, financial, legal and regulatory problems associated with the commercialization of a nationwide high-speed network to maximize the catalytic effect of NREN. An essay on the Network Aspects of the High Performance Computing and Communication Program is found in appendix D.

The panel believes that in the future, most of our workforce will have available for its use the tools developed through the HPCC program. Some members of our future workforce will program scalable, massively parallel computers to solve complex problems, but the majority of the workforce will use such systems transparently to solve problems of a general nature. Therefore, to fully exploit the competitive advantage of the HPCC tools, an emphasis must be placed on all aspects of workforce education. An essay describing some of the many educational requirements, titled Human Resources Infrastructure, is located in Appendix E.

A dialogue between the HPCC program and industry is essential to the success of the initiative. Without program acceptance by the various industrial constituencies, the results of the program will have little impact. Acceptance by industry depends on strong industrial participation. The HPCC program has successfully included input from industry to date, and the panel recommends that the dialogue between the HPCC program and industry be continued and strengthened as the program evolves.

Balance

Comments on the distribution of funds among the four program components are limited by the Panel's inability to discriminate between hardware purchases and other program tasks. Furthermore, since the program is in the early stages of implementation, it is expected that significant funds earmarked for Advanced Software Technology and Algorithms (ASTA) and Basic Research and Human Resources (BRHR) are being used for one time purchase of hardware. Therefore, the Panel's comments do not address the balance of spending between the various program components.

The panel believes that the High Performance Computing Systems (HPCS) component overemphasizes processing speed over other computing needs, for example, memory storage, visualization, and user interface. These technologies enable the user to manipulate the vast amount of information generated by the enhanced computational capabilities of scalable, massively parallel computers. Steps should be taken to ensure that all computing components receive adequate emphasis to allow for the full exploitation of the tera-ops processing capability.

Some agencies may be overemphasizing support for existing constituencies over program objectives. Optimal achievement of program objectives should be the primary determinant of implementation tactics.

In particular, the Grand Challenges should drive the technologies. Agencies should be encouraged to choose Grand Challenges and support them to ensure success. Because the implementation of the Grand Challenges will uncover program deficiencies, this data should be used to assist in the redirection of the program objectives, in particular, with the HPCS and NREN components. Indeed, several of the panelists believe that the successful realization of the Grand Challenges constitute a more important goal than the development of the supporting technologies.

Management

The Panel believes that the level of coordination during the planning phase of the initiative was commendable. For example, the HPCS technology development effort, jointly implemented by DARPA, DOE, NASA, and NSF has very little overlap and is effectively addressing the major problems in a coherent manner.

It is the Panel's view that there are no formal structures to expedite program review and to discuss program changes during the implementation phase. Program execution is not reviewed collectively to permit timely program modifications. An effort should be made to implement the level of program coordination during implementation that was achieved during program planning.

The Panel suggests, as a test case to foster more tightly coordinated execution, that each agency could contribute a small portion of their budget, perhaps five percent, toward the funding of a single, coherently-managed project. The project should be well-defined, and in support of a highly visible Presidential initiative, e.g., a model of ozone degradation for the Global Change initiative.

Vision

The panel believes that, successfully implemented, the HPCC initiative will significantly accelerate the advance toward a "digital information society" in which computing and communications are combined in a seamless manner to change our lives in profound ways. The panel believes that this vision has a good chance of being realized. This vision is widely shared even among those who do not understand the technical details, and accounts for the strong interest and support that HPCC enjoys.

A unification of computing with communications is inherent in the HPCC strategy. In NREN, networking makes the power of a single computing resource available to many users. In massively parallel computing systems, speed is achieved by making it possible for many processors to work on a single problem in an efficient way through sophisticated inter-processor communication. Thus, computing is made available in both "one for many" and "many of one" modes of operation, thanks to effective communication technology.

Communication, unlike computing is an inherent component of our culture. Therefore, this initiative will have a major impact on our society, but in a manner that is difficult to predict. Whatever form the impact will ultimately take, it is likely to transform our society.

APPENDICES

A. National Scale Computing

B. Harvesting Knowledge from Super Databases

C. Increased Agency Participation in the High Performance Computing and Communications Initiative

D. Network Aspects of the High Performance Computing and Communications Initiative

E. Human Resources Infrastructure

Appendix A

National Scale Computing

HPCC has given birth to an entirely new information tool: a truly *national-scale* computing system. Called a massively parallel supercomputer (it is also referred to as a "Tera-ops" computer), it is roughly as powerful as all the computers in America today. The existence of this tool opens important new doors for America.

A national-scale computer is a computer so powerful that it can deal with the whole nation's data in a particular area. For example, a national-scale computer is big enough to treat the entire federal budget as an integrated spreadsheet, and to compute the impact of a change in one line item on all the others. It is big enough to connect every public school in America with every on-line data base. It is big enough to absorb every health care transaction in America, and reduce this data to summary form. And it is potentially big enough to model complex systems which have defied analysis by the biggest traditional supercomputers. These massively parallel computers are the first that are truly powerful enough to harness a flood of data and reduce it into useful information.

An important characteristic of these new national-scale computers is that they are made out of the same technology as the personal computers now in our schools and the workstations now in our hospitals. Traditional supercomputers were made from exotic technology that bore no resemblance to what the rest of the world used. But these new national-scale computers, which are made up of thousands of the same microprocessors that are in personal computers and workstations, can directly absorb the nation's data, over the national data network. They will be able to run the same software, but do it a thousand times faster. And they pool their manufacturing economies: every time someone buys a work station, it drives down the cost of a massively parallel supercomputer and vice versa.

In short, these national supercomputers can address information handling problems that were beyond our reach until now. The challenge for America is to awaken to these possibilities, not just in science but in *all* the segments of our society that deal with large amounts of information. America's scientists have already started. Under the leadership of the Office of Science and Technology Policy, they have defined a set of "Grand Challenges," critical scientific problems that were hopeless until national-scale computers became available. Soon there will be a national-scale computer designing new materials, another analyzing potential changes to the climate, etc.

America just as urgently needs a national-scale computer consolidating information about the detailed behavior of the economy. It needs a national scale computer absorbing the country's health care transactions, allowing analysts to look for ways to provide the same level of service more efficiently. It needs a national scale computer taking in requests from every elementary school child in America and providing them, overnight, with a customized package of information to browse through and learn from the next day. And America needs the computing capacity to deal with a national emergency, such as an epidemic that requires scientists to attempt a new drug design in months instead of years or decades. In short, America needs a set of "Grand Understanding" computers for society just as much as it needs a set of "Grand Challenge" computers for science.

Historically, there has been a split between information processing computing (the kind commonly needed by society) and mathematical computing (the kind commonly needed by science). These new national-scale computers, which are equally suited to both kinds of computing, can bring these constituencies back into better balance. The Federal Government should aggressively sponsor the introduction of massively parallel Grand Understanding systems. It should actively seek out the most promising areas of social application, just as it sought out the most promising areas of science with the Grand Challenges. It should deploy these national-scale systems for society just as aggressively as it deploys systems for science.

Appendix B

Harvesting Knowledge From Super Databases

The decade of the 1990s will see a vast increase in the production of scientific data along with an ever-increasing demand by researchers in academia, industry, and government for instant access to that data. The fundamental engine driving the increase in data is the computer. When computers are coupled with modern sensors in spacecraft, laboratory instruments, or medical scanners, "supersensors" are created. By the end of the decade, those supersensors will be pouring out fresh data at a rate exceeding a terabyte per day. Supercomputers are used to simulate physical systems such as drug molecules, manufacturing processes, or the evolution of severe storms. With the acceleration provided by the HPCC initiative, supercomputers by the mid-decade will be capable of producing a trillion numbers per second. These numbers will be assembled into digital artificial realities which are, in essence, large scale databases. The scientific and technical literature itself has reached a reductio ad absurdum in its current analog form. Digital libraries, accessible over the National Research and Education Network (NREN), will contain the sum of past human knowledge and the explosion of new literature in a computer-searchable form that will contain terabytes of knowledge.

Thus, one of the greatest challenges facing the United States as the HPCC program unfolds will be to devise an easy-to-use software interface to the national information infrastructure which will allow researchers, from their desktops, to readily access and digest information from any of these sources, regardless of its geographic location. Not only will this create a grand challenge in information science technologies, but it will create a new mode of scientific inquiry, namely scientific discoveries made in information space rather than in the physical space of current scientific laboratories.

One can already see this scientific methodology emerging in other major scientific initiatives of the government. The Human Genome program is accelerating the rate at which data bases of genetic information or protein structures are growing. Recently, a number of connections between previously unrelated proteins have been discovered, not in the test tube, but in searches of the national genome and protein databases. The Global Change Initiative is driving a research program which ties together the databases created by remote sensing satellites and the simulation databases which represent the Earth's weather, ocean currents, or climate as predicted by large scale numerical simulations run on supercomputers. Some of the most exciting papers to appear recently have resulted from these intercomparisons of large scale databases. The high resolution space and Earth-based telescopes of the next decade will be producing an unprecedented view of the heavens in a wide range of wavelength windows. One of the recommendations of a recent National Research Council study on the future of astronomy was to create a national distributed collection of databases for observational astronomy. Many discoveries of new objects and phenomena in the skies will be made by "observing" these databases. Finally, the Human Brain project which is emerging from a recent Institute of Medicine study, "Mapping the Brain and its Functions," foresees large distributed national databases of brain structures and functions mapped by a wide variety of imaging modalities as a comprehensive national effort toward deepening our understanding of the body's most vital organ.

The problem is that the underlying computer science structure of the software which is needed to support each of these national initiatives is very similar but, without a cross-cutting plan, each field will set out to develop its own database software. Just as the HPCC program realized that by focusing on generic supercomputing and networking software, a wide variety of application areas could be simultaneously impacted, a similar generic approach is needed for large scale databases.

This initiative would build on top of the successes of the HPCC program, which will have tied together millions of desktop computers with each other and with supercomputers and national data centers. However, by itself, the HPCC program will not create the software infrastructure which will be necessary to make routine use of the potentially invaluable knowledge which is hidden in the ever-expanding masses of data.

Such an initiative would again need to bring together computer scientists and engineers with computational scientists and engineers. It would require major advances in database structures, artificial intelligence, mass storage, robotics, visualization, networking, and user interfaces. Ideally, this initiative would be a bridge to the similar needs of corporations, libraries, and education. Many new information services would be prototyped, which would lead to new private sector companies to provide these services over the emerging national information network, which itself is being driven by the HPCC program.

Appendix C

Increased Agency Participation in the High Performance Computing and Communications Initiative

Rapid incorporation of evolving high performance computing architectures and networks into other mission oriented agencies will contribute to more effective approaches to problem solving, a higher quality of life, new products and services, and enhanced national competitiveness across broad sectors of the economy. There are pressing needs and opportunities within each agency which can advance through better use of the HPCC program. The following are several examples.

The National Oceanographic and Atmospheric Administration (NOAA) is preparing for a new generation of technology which will allow collection and prediction of weather with greater accuracy and for longer periods of time. Massive atmospheric data bases will be collected by satellites to supplement data collected by additional and more sophisticated ground based stations. As the global change program moves into mature phases, the physics which incorporates this data with the terrestrial and oceanographic boundaries will require far more computational capacity than is currently available at the National Center for Atmospheric Research (NCAR).

The Environmental Protection Agency (EPA) is formulating a process to address the over four million potential contamination sites, including superfund sites, identified by the National Research Council, which are characterized to varying degrees of accuracy and which will ultimately require containment or remediation. The groundwater aquifers neighboring these sites are relatively poorly known, but will be measured over the next few years because more than 50% of U.S. drinking water is derived from groundwater sources. While the boundary conditions for the aquifers are rather complex and chemical interactions add further complexity, the multiple coupled time dependent differential equations which describe the ultimate fate of pollutants can be addressed with high performance systems of the near future. Policy makers will need these projections if they are to properly prioritize sites for a systematic cleanup program.

The National Institute for Standards and Technology (NIST), in collaboration with the Department of Defense (DOD), has developed a Product Definition through Electronic Specifications which will form the basis for a paperless Computer Aided Logistic System (CALS). If fully adopted, future DOD procurement will be accompanied with an electronic data base which documents specifications and manufacturing information for part replacement or inventory replenishment. The extension of this system to the private sector via a high performance network could vastly improve the response time for the delivery of parts and ultimately improve the competitiveness of American manufacturers. The system will include massive data bases, electronic transmission of drawings to corporations throughout the country, and product analysis through finite element techniques. These computations can be so numerically intensive that high performance computers will be required for the prompt solution of problems.

The National Institutes of Health (NIH) is developing parallel technology for biomedical applications in computational chemistry that analyze complex proteins and in structural biology to reconstruct 3-D representations of large virus particles. These applications use signal-processing techniques on massive data sets produced in protein NMR spectroscopy to determine the distances between the nuclei of atoms and thereby reconstruct their geometric orientation in space and in time. With the assistance of electron microscopy, this technique provides a basis for the image reconstruction of entire viruses.

The Department of Education (DoEd) is sponsoring a number of precollege activities in each state to help achieve the President's goal of making U.S. students first in the world in Science and Mathematics. Most of these efforts include computational activities and many include multimedia exchange with other schools or television studios via a network. The potential demand of millions of students on such a network will be far larger than that of researchers envisioned in research universities which are currently served by the National Research and Education Network.

Extending U.S. leadership in HPCC will include increasing the dissemination and application of the technologies to disciplines involved with NOAA, EPA, NIST, NIH, and DoEd. The participation of these five agencies, as a percentage of the FY 1991 HPCC base funding for all Federal agencies, is 4.3%. While the FY 1992 increment for the five agencies is somewhat larger (6.3%) and the FY 1993 increment is larger yet (6.5%), the potential payoff for more significantly expanding the program into other mission agencies is great. While it was proper to initially fund NSF, DOE, NASA, and DARPA at higher levels in order to develop the technologies, it is now proper to disseminate the technologies to other agencies to effect their maximum adoption throughout society. In developing the FY 1994 budget, OMB should thus encourage NOAA, EPA, NIST, NIH and DoEd to more significantly build upon the expertise of NSF, DOE, NASA, and DARPA.

Appendix D

Network Aspects of the High Performance Computing and Communications Initiative

The strength of the U.S. economy and the standard of living of its citizens critically depends on the quality of the evolving nationwide information networking infrastructure that undergirds virtually all personal, business, and national endeavors and aspirations. The vision is of a future infrastructure that will enable people and their machines to communicate easily and securely, any time, anywhere, and in any medium -- voice, data, facsimile, image, and video -- and at acceptable cost.

The infrastructure will be able to cater to the needs of all users, from the most mundane needs to the most sophisticated, from the needs of individual homes and residences, and small businesses as well as large, to national needs such as defense, advanced health care delivery services, educational systems, and others.

To meet these evolving needs and opportunities, a nationwide high performance information networking infrastructure will be necessary. It will embrace high performance computers, high performance terminals and work stations, and extensive databases and other information bases, all linked together by high performance networks. Such an infrastructure will facilitate new as well as traditional work styles and lifestyles. It will facilitate great improvements in the operational efficiencies of both service and manufacturing industries, and it will make possible distributed work places, work-at-home or telecommuting, a richer variety of social and personal interactions, and personal access to health, educational, and a growing range of information services. In short, the information infrastructure can perhaps be regarded as the key enabling technology for the nation's prosperity, health and happiness.

The high performance infrastructure cannot happen on a nationwide scale overnight, however. First, many technical questions have to be solved before such an infrastructure can be regarded as technically viable. The High Performance Computing and Communications Program (HPCC) is providing a major boost to ensuring that some of these technical questions get addressed expeditiously. It will also shed light on the question of how to ensure that a widespread high performance infrastructure might become economically viable in the commercial sense as soon as possible.

Regarding the technical programs, it is fair to say that the emphasis so far under the HPCC, as is appropriate, has been to explore and assess selected approaches to high performance computing, especially using massively parallel architectures. Likewise, high performance networking explorations are being developed, particularly through the cooperative programs with industry that have been organized by the non-profit Cooperation for National Research Initiatives (CNRI). As is to be expected for exploratory technical programs, the experimental systems are very much stand-alone and not necessarily easily or economically integrated into public networks. In general, the public networks will have to be considerably upgraded, especially the local distribution networks, before they can handle the broadband services that the high performance infrastructure will demand. Nevertheless, the public networks do provide an existing technical and operational foundation on which to build a high performance infrastructure. It would be short-sighted, and particularly for the National Research and Education Network (NREN), not to take advantage of the expertise in all the operations domains -- financial, legal, regulatory, as well as technical -- that the common carriers possess.

In actual fact, the total conversion of the public networks to all-digital systems, in the local exchange areas as well as interexchange, is already well along and in addition, most of the public carriers are developing deployment plans for fast packet services (up to speeds of 45 Mbits/sec and multiples thereof) over optical fiber systems. Thus, the technologies of the public communications networks and private computing networks are converging and becoming increasingly compatible with each other. In many respects, the network becomes a vast distributed computer; the computer becomes the network.

Transforming the common carrier networks into the <u>ubiquitous</u> infrastructure capable of supporting broadband services poses many severe technical challenges, principally because of the inevitable heterogeneity in equipment and communications control protocols that the nationwide communications industry scene now presents. It is anticipated that under the HPCC program more attention will have to be paid to the operating systems and protocols necessary for providing advanced broadband services across heterogeneous networks. If this is not done, there is the danger that a largely private, high performance computing and communications network will evolve tuned to meet the needs of researchers and other leading-edge users, but it will be very much separate from public, or common carrier networks and may require continued subsidy by the federal agencies. Furthermore, if such a separate development were to occur, many of the benefits of a high performance information infrastructure would be delayed, or even prevented indefinitely, from reaching most of U.S. business and society. It is much the better course for the high performance infrastructure to evolve along with the public networks rather than separate from them.

Upgrading the nations information infrastructure will clearly be a massive financial undertaking, spread over many years, that will involve all segments of the information industry. It is critically important, therefore, to be paying attention to ways in which the common carrier industry can be involved <u>now</u> along with all the other players, in planning how to help a nationwide high performance information infrastructure become effective and commercially viable as soon as possible.

The HPCC program anticipates that the high performance technological elements it is currently supporting will perform nucleating roles for the nationwide, public high performance infrastructure; in other words, technology transfer from the government sector to the private sector will take place on a grand scale. But as countless lessons from industrial innovations show, for technology transfer to occur effectively and rapidly, the "receiving" organizations have to be involved early in the process with the "sending" organizations. Simply tossing a semi-completed product or system "over the wall" into the private sector is not likely to work, either technically or economically. The receiving organizations need to be involved early on in planning how the high performance elements of the infrastructure will be technically coupled with, or integrated into the public networks, and how the transition phase will be financed. In particular, it will not simply be enough for the HPCC program to support the development of selected elements of a high performance infrastructure without providing some support also to the issues raised, financial as well as technical, in transferring the advanced technology into the public network sector.

It is important to recognize that the common carriers are already supporting a number of relatively high performance network experiments. These include not only the broadband network experiments orchestrated by CNRI, but also local trials of high performance systems for serving the needs of hospitals, education systems, and home entertainment and information delivery. But these trials, though important, are a long way from becoming the ubiquitous high performance infrastructure that the HPCC program envisions. To close this gap and thereby bring the benefits of a high performance infrastructure to a much larger fraction of society calls for steady, determined cooperation between all parties involved.

It is critically important, therefore, for the key federal agencies, federal and state regulatory commissions, and leading-edge users of a high performance infrastructure to be working closely NOW with common carriers, both long-distance and local exchange carriers, to plan expeditious ways in which the public networks can be upgraded and support can be provided to meet the rapidly increasing demands of the Information Age for a high performance infrastructure.

Appendix E

Human Resources Infrastructure

By the standards of the twenty-first century, today's computing and communications will seem antiquated. The computational capacity of today's supercomputer will be available for most of our citizens, and high speed networks will be ordinary tools for communication. Most of the technical work force and much of the non-technical work force will be using these tools to their competitive advantage. That work force is in, or will soon pass through, our educational system. The existence of a computational infrastructure for our education systems will thus have a significant influence upon our ability to compete as a nation.

In order to position the United States to take advantage of computing and communications of the twenty-first century, we must develop a broad approach to the use of and familiarity with High Performance Computing and Communications (HPCC). In addition to the program of increased support for research and graduate education emphasized in the original HPCC program plan, the U.S. will need programs to foster the growth of computational science research and education. These programs will need not only to foster capability in traditional computer science, but also to stimulate the use of HPCC in the computational solutions to problems in science, engineering and other fields. In this endeavor, support for graduate education will, by itself, not be enough. New curricula emphasizing computational science will need to be developed and integrated into undergraduate programs in disciplines which today rely primarily upon experiment and theory. Building the right kind of curricula will require that computer scientists, mathematical scientists and computationally-oriented scientists and engineers actively collaborate. Support for interdisciplinary research and education is a good way to insure that this kind of collaboration is fostered.

Since parallel computation will be a principal method for achieving high performance in the near future, these curricula would include courses that teach the use of parallel algorithms as a natural way to solve computational problems. They should also integrate enough information about computer architecture to convey a deep understanding of the issues affecting computational performance. Because parallel computation is a new technology, problem solvers have often chosen to accept poorer performance of traditional computational approaches rather than revise programs which represent many years of invested time in their codes. The acceptance of parallel algorithms in the existing science and engineering community has thus been inhibited. If we are to accelerate the transition to parallel computation, we must initiate a program to bring existing computationally-oriented researchers up to speed on new parallel systems.

Effective programs can be initiated by existing and new high-performance computing centers, such as the NSF Supercomputer Centers, if the staff of the centers are upgraded and communications for outside users are significantly improved. Complementary programs to widely distribute parallel systems to universities and Federal laboratories, such as the DARPA and DOE Grand Challenge programs, will also breed familiarity among broad scientific communities.

A second major area of focus for human resources development in HPCC should be the education of the work force at the college, precollege and technical training levels. Here the emphasis should be placed on improving the general science and engineering curricula through the use of computers. High performance computing can be used in a transparent way to provide an electronic laboratory where students can learn about science by observing simulations of complex physical phenomena or access data bases collected by our most sophisticated technology, for example, accelerators, satellites, DNA sequencers, etc. By making these capabilities also accessible by our technical work force in business and manufacturing we can also stimulate research and development of services which will quickly impact our economic growth. Finally, by making computation a better teaching tool, we may be able to develop a non-threatening environment for more individual instruction which will stimulate interest in science and mathematics for the general populace, thereby improving scientific literacy.

THE WHITE HOUSE

July 15, 1992.

Dear PCAST member:

I shall welcome comments and suggestions in terms of follow up to Davids population initiative noted in the attached correspondence.

Best regards

Allan

Also copies to Associate/Assistant Directors

7911

DAVID PACKARD
26580 TAAFFE ROAD
LOS ALTOS HILLS, CALIFORNIA 94022

June 19, 1992

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Old Executive Office Building
17th St. & Pennsylvania Avenue, N.W.
Washington, D.C. 20506

Dear Allan:

I am very concerned about the President Bush campaign. Unless he can come out with some better issues he will certainly lose in California and probably not be re-elected.

I gave him a memo with some suggestions at the dinner out here last night. There was no opportunity to discuss the matter with him but I did discuss it with several of his aides, including Bob Teeter.

I am enclosing a copy of my letter. If you agree that something more imaginative must be done I think we should ask the PCAST members to help flesh out a recommendation.

I will discuss this matter with the members who will be at MIT next week.

For our get-away in August, I have decided that my Big Sur place would be the best choice. We can have accomodations for everyone there. I have discussed this with Alicia and I will be pleased to talk with you about it whenver you would like to do so.

I hope you are enjoying your vacation.

Sincerely,

Dave

David Packard

DP/gd

Enclosure

DAVID PACKARD
26580 TAAFFE ROAD
LOS ALTOS HILLS, CALIFORNIA 94022

MEMORANDUM

Date: July 14, 1992

To: Dr. D. Allan Bromley

From: David Packard

I am enclosing copies of my letter to President Bush and his reply. These are the documents I referred to in our phone conversation on Monday. I think it is very important that the President include in his statement much more than what is already being done through A.I.D. He should emphasize that it is within our ability to keep the world population below 10 billion, and in the several decades that follow, bring the world population back down to about the 5 billion level--and he is initiating the actions required to do this. This would make the environmental problems much more manageable.

This will require major support to eliminate the diseases that are devastating the population in Africa. It would be a strong message of compassion for the plight of these people.

Members of PCAST understand this problem and can fill out the details for the President to make in his statement.

If you agree that this is a good course of action, it will be necessary to get some help from cabinet members and members of his election committee. I am sure we can do that but I want to have a more detailed plan that we can all support.

I have enclosed several copies of the letters but I suggest that you make more to provide each member of PCAST with a set.

Dave

DAVID PACKARD
26580 TAAFFE ROAD
LOS ALTOS HILLS, CALIFORNIA 94022

June 18, 1992

President George Bush
The White House
Washington, D.C.

Dear Mr. President:

Your meeting with Yeltsin with the agreement to make major reductions in nuclear weapons was a real ten-strike and it should help your campaign.

Your position on the environmental problem is not acceptable to a very large number of voters and I think you will not be re-elected unless you make a radical change in your position on this issue.

I understand your position on abortion and you clearly can not change that.

You can, however, come out with a strong position on population control. Abortion is not an indispensable element of population control. In fact, with an effective population control program in place, abortion will be unnecessary.

The most important factor for an effective population control program is the education of women on the use of contraceptive techniques and devices. There are a number of other population control actions that have been effective as well.

I realize you could not come out with a strong population control message in Rio. The Developing Nations were afraid that an extensive discussion of population control might result in their being blamed for all of the problems. They wanted the industrialized countries to be blamed so they would have a logical base on which to request financial support.

An effective population control program could keep the growth down to one-half or less than that which would result without one over the next few decades.

Population control will have a major impact on the preservation of rain forests. People living around them have to make the decision whether to starve to death or cut down some trees so they and their families can survive. High level agreements will have little or no effect on controlling people in this position.

There are valid reasons for going slow on actions to control the greenhouse effect. I am sure you understand these but I think a better case could be made to support your position on this issue.

I have not taken the time to provide numbers and data to support my recommendation. These are readily available and PCAST could prepare and document the case.

My comments so far relate to the international problems. I think a similar case could be made on the domestic problems and these will be the most important to many voters.

I strongly urge you and your advisors to come out quickly with a strong statement announcing and describing a policy along the lines I am suggesting.

I think this is the only choice you have to assure your re-election. If there is something I can do to be helpful in implementing these suggestions, please let me know.

Sincerely,

David Packard

GEORGE BUSH

WASHINGTON

June 26, 1992

Dear David:

It was good seeing you, and thanks once again for your magnificent support for me and for the Party. Because I, too, oppose abortion, some think I oppose family planning. I strongly favor family planning, and, indeed, our support for international family planning programs through A.I.D. is at an all-time high.

I agree with you on education involving family planning. What we should do, and what I will do as a result of your letter, is get out a strong statement of support for international family planning.

Thanks for the very helpful letter.

Sincerely,

The Honorable David Packard
26580 Taaffe Road
Los Altos Hills, California 94022

THE WHITE HOUSE

WASHINGTON

November 6, 1992

Dear Mr. President:

One of the most difficult issues facing both the federal government and the scientific community in this era of constrained budgets and boundless scientific opportunities is the question of how to proceed with the very large research projects, or megaprojects, necessary for further advances in many areas of science and technology. With this letter it is my pleasure to transmit to you a report on this subject from your Council of Advisors on Science and Technology.

We have concluded that science megaprojects are an integral part of the fabric of research that make possible the advances of many researchers working individually or in small groups. Nevertheless, a tension has arisen between megaprojects and "small science" investigators -- who continue to constitute the heart and backbone of science -- in part because an increasing fraction of the federal R&D budget has been devoted to the support of megaprojects. We have suggested a new approach to federal R&D budgeting -- the preparation of a scientific investment budget -- that would make explicit the balance and tradeoffs between megaprojects and individual investigator research.

We have also emphasized the need for the United States to maintain a leadership position in most fields of science because of the importance of scientific research in meeting national goals. To do so, we believe that the U.S. scientific community should engage in an extended discussion with government and other affected groups of what is needed, including the construction and operation of megaprojects, to maintain this leadership.

Finally, we have noted that megaprojects are becoming more international in character because of their increasing number and cost and because of the harmonious international relationships that your Administration has done so much to promote. To take full advantage of this trend, we have proposed the development of an international framework incorporating principles for international collaboration and cost-sharing. The scientific community and governments in all of the countries interested in megaprojects should be involved in this effort.

The President's Council of Advisors on Science and Technology (PCAST) is prepared to amplify any part of this report that may be of particular interest to you and, with your permission and following your review, would propose that this report be made public as a contribution to the growing international dialogue on this topic.

The Bush Administration has given very strong support to science and technology, support that will return benefits to this country for years to come. The recommendations contained in this report are designed to further strengthen this vital investment in our nation's future.

Sincerely yours,

D. Allan Bromley
The Assistant to the President
for
Science and Technology
and
Chairman, PCAST

The President
The White House
Washington, D.C. 20500