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On High-Performance Computing Research and Development

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Mr. Chairman and members of the Subcommittee, I am pleased to have been invited here today to discuss with you the role of the Federal government in funding high-performance computing research and development (R&D), and to place these investments in the broader context of global competitiveness.

The Federal Networking and Information Technology Research and Development (NITRD) Program, was established by the High-Performance Computing Act of 1991 (P.L. 102-194) and further elaborated upon by the Next Generation Internet Research Act of 1998 (P.L. 105-305). Federal networking and information technology research and development, which launched and fueled the digital revolution, continues to drive innovation in scientific research, national security, communication, and commerce to sustain U.S. technological leadership. The NITRD Program, now in its 15th year, represents the coordinated efforts of many Federal agencies that support R&D in networking and information technology.

I am the Director of the National Coordination Office (NCO) for Networking and Information Technology Research and Development. The NITRD National Coordination Office is responsible for supporting technical and budget planning and assessment activities for the NITRD Program. The interagency coordination of NITRD activities takes place under the auspices of the National Science and Technology Council (NSTC), and more specifically through the NSTC's Networking and Information Technology Research and Development Subcommittee, and several interagency working groups and coordination groups that operate under this Subcommittee. The collaborative efforts of the interagency NITRD community increase the overall effectiveness and productivity of Federal networking and information technology R&D investments.

Today I would like to discuss three different aspects of high-performance computing: (1) high-performance computing as a priority in the overall Federal R&D portfolio, (2) the impact and success of interagency coordination in the area of high-performance computing, and (3) U.S. leadership in high-performance computing in the context of global competitiveness in information technology and its applications.

High-Performance Computing as a Priority in the Federal R&D Portfolio

Fifteen years ago, what is now the NITRD Program was established in legislation as the national High Performance Computing and Communications Program, having at that time a narrower focus on R&D in high-performance computing technologies and high speed networks. Today, investments in high-performance computing support a variety of important Federal agency missions, including national security; climate modeling and weather prediction; modeling and simulation in biology, chemistry, materials science, nanoscale science and technology, and physics; and others. Over the years, the program evolved in scope into one that covers information technologies more broadly, including not only high-performance computing and advanced networking, but also cyber security and information assurance, human computer interaction and information management, software design, high confidence software and systems, and other important areas. Through this evolution, high-performance computing not only remains the dominant element of the NITRD Program, but has been cited on a recurring basis as a high priority within the Federal R&D portfolio.

The Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) annually issue a joint memorandum on the Administration's R&D budget priorities. In the past four years, high-end computing has been identified as one of those priorities. These memoranda set the stage for significant focused interagency coordination by Federal agencies, which I will discuss further shortly, from the establishment in 2003 of the High End Computing Revitalization Task Force that led to the development of the *Federal Plan for High End Computing* in 2004, to directing agencies to "aggressively focus on supercomputing capability, capacity and accessibility issues," in accordance with that plan.

The Administration's support has led to significant investments in high-performance computing. In 2002, the funding for high-performance computing in the NITRD Program was less than $0.8 billion. In five years, that budget grew by over 65 percent to a fiscal year 2007 budget request of over $1.3 billion for high-performance computing R&D, R&D infrastructure, and applications. The National Science Foundation, the Department of Defense, and the Department of Energy together account for over $1 billion of that investment (see Table 1). In the Administration's FY 2007 budget, high-performance computing accounts for over 40 percent of the $3.1 billion NITRD Program budget request, and accounts for more than half of the increase in the NITRD Program budget from the previous year.

The President's emphasis on science and technology, which is in part embodied in the American Competitiveness Initiative (ACI), is further contributing to the development of world-leading high-end computing capability and capacity, which is identified as a key goal for ACI research. The three agencies that are part of the American Competitiveness Initiative – the National Science Foundation (NSF), the National Institute of Standards and Technology (NIST), and the Department of Energy's (DOE's) Office of Science – are all members of the NITRD Program, and all fund high-performance computing investments.

Table 1: Largest Government funders of high-performance computing R&D, R&D infrastructure, and applications

NITRD Agency	FY 2007 Budget Request ($M)
NSF	**337**
DoD	**375**
OSD and DoD Service organizations	195
DARPA	118
NSA	62
DOE	**329**
Office of Science	296
NNSA	33

As a result of the ACI, the high-performance computing budget at NSF is expected to increase by more than $53 million above its FY 2006 level, enabling NSF to pursue the goal of a petascale computing environment and resources by 2010. Similar investments at DOE's Office of Science are expected to increase by more than $82 million above their FY 2006 levels due to the ACI, which will make possible upgrades and diversification of existing high-performance computing platforms and the acquisition of a next-generation platform, at various DOE National Laboratories. NIST's investments are supporting the development of high-performance computing tools, standards, and algorithms, as well as research on quantum computing and secure quantum communications. The Defense Advanced Research Projects Agency (DARPA), though not part of the ACI, is another key supporter of high-performance computing R&D, an area in which its budget is increasing by over $23 million above FY 2006 levels.[1]

High-performance computing has been and continues to be a funding priority within the Federal R&D portfolio. Together, the guidance, leadership, and past and future investments in high-performance computing have demonstrated and solidified the Administration's commitment to U.S. leadership in this area.

Impact and Success of Interagency Coordination of High-Performance Computing

I would now like to take the opportunity to highlight some of the success stories that have emerged from the interagency coordination activities of the Government's high-performance computing research community.

Until 2003, interagency coordination of high-performance computing activities took place through the NITRD Program's High End Computing Coordinating Group. It was then that a decision was made within the Administration to increase the Government's focus on high-

[1] Additional detail about high-performance computing budgets, technical activities, and coordination activities can be found in the *FY 2007 Supplement to the President's Budget for the Networking and Information Technology Research and Development Program* (http://www.nitrd.gov/pubs/2007supplement/).

performance computing. In April 2003, Dr. John H. Marburger, III, Science Advisor to the President and Director of OSTP, established the High End Computing Revitalization Task Force (HECRTF) and charged this group to develop a Federal plan that covered high-performance computing R&D; capability, capacity, and accessibility of high-performance computing resources; and procurement issues. The release of the *Federal Plan for High End Computing* in May 2004, and the increase in visibility through elevating the High End Computing Coordinating Group to an Interagency Working Group under the umbrella of the National Science and Technology Council, represented the start of a renewed emphasis on high-performance computing within the NITRD Program.

This cooperation, along with strong leadership from the OSTP and OMB, has resulted in unprecedented coordination on high-performance computing issues among Federal agencies. A few examples follow.

- *DARPA High Productivity Computing Systems (HPCS) Program:* DARPA's HPCS program was established in order to develop a new generation of economically viable high productivity computing systems for national security and industrial user communities by the end of this decade, producing substantial advances in the performance, programmability, portability, and robustness of these systems. Although initiated by DARPA, this program has garnered the support of over a half dozen Federal agencies which have contributed to HPCS technical planning and coordination, and also of the broader multi-agency research community.

  More importantly, as a result of recognition that this program is the Government's primary effort directed at next-generation high-performance computing architectures, several of these Federal agencies have contributed their own funding to the program, thereby increasing the leverage of DARPA's investments. The HPCS program is close to entering its third phase, which is aimed at development and prototype demonstration. It is expected that the additional funding provided by other agencies will make it possible to fund more projects in Phase III than would have been possible with DARPA funding alone. This will increase the diversity of architectures that will be explored through this program, thereby expanding the pool of concepts available on which to build next-generation systems in the future, and helping to cement U.S. leadership in this critical technology area.

- *High-End Computing University Research Activity (HEC-URA):* HEC-URA is a program for funding university research that has been supported by interagency planning. A group of NITRD agencies has been collaborating since 2004 to identify research needs for high-performance computing, and to develop programs to meet those needs. Most recently, following a pair of workshops held last year, a solicitation was released by NSF this year to fund university research in file systems and storage technologies for high-performance computing systems. Though led by NSF, three other Federal agencies contributed funding to support HEC-URA file systems and storage projects that have direct relevance to their agency missions, helping to ensure the availability of research results that would not necessarily have emerged from their own agencies' research programs.

- *High-performance computing benchmarks, performance metrics, and performance modeling:* The use of benchmarks, performance metrics, and performance modeling are key to a variety of high-performance computing issues, ranging from guiding decisions on which architectures to invest in at research stages, supporting procurement decisions by providing consistent bases for comparing alternative systems, and predicting the performance of various types of systems on different classes of computing applications. Because of the importance of these issues and their broad relevance to needs that are shared by multiple agencies, over a half dozen Federal agencies have been collaborating on the development of performance metrics, measurement tools, and benchmarks, with several of these agencies providing funding to support related research.

In my preceding discussion, I have highlighted several examples of high-impact results of interagency coordination. These are just a few of the many instances of the cooperation that is taking place across Federal agencies and the positive effects that these collaborative efforts have produced. Numerous other examples are identified in the *FY 2007 Supplement to the President's Budget for the NITRD Program*, which I referred to earlier. I would now like to close my remarks with a brief discussion of U.S. leadership in high-performance computing technologies.

U.S. Leadership in High-Performance Computing in the Context of Global Competitiveness

I described earlier the establishment of the High End Computing Revitalization Task Force that led to the development of the *Federal Plan for High End Computing*. Agencies are now working together to implement that plan, focusing on R&D programs for hardware, software, and systems, the different technical elements of the roadmap laid out in the plan. Distinctions between different classes of machines (capability machines, also referred to as leadership class machines, versus capacity machines intended to provide the high-performance computing capacity needed to meet government agency needs), and collaborative funding of programmatic activities such as those I described earlier, have helped make better use of Federal R&D investments in high-performance computing.

The focus of the Government research community on issues that extend beyond technical program planning is as noteworthy as the level of collaboration on R&D that I have described previously. In the area of benchmarking and performance metrics that I discussed earlier, agency sharing of technical results and best practices is already productively influencing the procurement of high-performance systems. The issue of accessibility of high-performance computing resources as a new Administration priority represents another important evolution in thinking within the government research community outside the direct scope of R&D investment. This issue emerged with the realization that the use of government high-performance computing resources should not be restricted only to the community of researchers directly funded by a given agency. With support from OSTP and OMB, agencies are now working to ensure that the use of computing resources they fund can also be used meet the needs of broader constituencies.

Two notable examples of the impact of this policy change are the DOE's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program, and NASA's National Leadership Computing System (NLCS). Both of these agencies opened up the use of their systems to users outside of their traditional user community, while still maintaining the high standards of merit-based peer review. As a result, DOE awarded millions of processor hours of supercomputing time to four industry research projects in the latest INCITE program cycle, and NASA awarded a million hours on a NASA supercomputer to the National Institute of Standards and Technology (NIST), an agency that has important problems that require high-performance computing to solve, but which does not procure its own dedicated high-performance computing systems.

In addition to making high-performance computing resources available to support private sector R&D, the Government is working more generally to foster the use of high-performance computing in the private sector. Several government agencies are providing funding for the Council on Competitiveness's High-Performance Computing Initiative. This initiative, undertaken by this well-known nonpartisan and nonprofit organization, is funding studies, conferences, and educational activities to stimulate and facilitate wider usage of high-performance computing across the private sector, in order to propel productivity, innovation, and competitiveness.

In March 2002, issues of innovation and competitiveness in the context of high-performance computing gained high visibility when Japan brought online a new supercomputer called the Earth Simulator, which became at that time the world's fastest supercomputer. Although people in some policy circles were caught by surprise by this development, the system had been publicly announced long in advance and its existence was known by experts in the research community. Many in the research community called for a tempered reaction, arguing that the leapfrogging by a Japanese supercomputer to the position of world's fastest machine was simply a result of the natural march of progress.

Three weeks ago, a new version of the Top500 Supercomputer Sites list was released.[2] This list, which surveys the world's 500 fastest supercomputers (excluding classified systems) as ranked by a well-known benchmark clearly confirms that the United States continues to hold a strong leadership position in the world of high-performance computing technologies. Some interesting statistics drawn from the latest Top500 list:

- The Earth Simulator, which held the number one position four years ago, now sits in the number ten position. Six of the nine machines above it are in the United States, including all of the top four machines.
- The U.S. dominates the list as a whole; 60 percent of the world's 500 fastest supercomputers are installed in the United States.
- U.S. vendors are the dominant suppliers of supercomputing systems in the world. The top three vendors of systems on the Top500 list are all U.S. companies, and account for nearly 75 percent of the systems on the list, including those outside the U.S.

[2] See http://www.top500.org/.

- Even foreign systems rely overwhelmingly on U.S. technologies. Of the top 20 non-U.S.-based systems, 15 were sold by U.S. companies. Of the remaining five that were built by foreign companies, a majority were built using high-performance microprocessors supplied by U.S. companies.

Looking back, we can now confidently say that while the clamor surrounding the launch of the Earth Simulator four years ago brought to the attention of policy makers the importance of supercomputing, it did not represent a pivotal crisis to U.S. global competitiveness. This is important to note in the context of recent announcements from Japan regarding an undertaking to develop a successor to the Earth Simulator, which will take place in phases over the next few years.

Conclusion

The fact that the U.S. currently holds the title of world's fastest supercomputer does not herald a *new* era in U.S. leadership in high-performance computing any more than the loss of the number one position implied a loss of leadership. High-performance computing has been – and will continue to be – a cornerstone in the Government's networking and information technology R&D portfolio.

The clearest demonstration of progress over the past four years, however, should not be viewed in terms of the raw speed of the world's fastest machine, but rather in the context of the growing focus on domestic high-performance computing policy, the unprecedented interagency coordination and collaboration on technical planning and implementation taking place within the Government research community, and the increasingly cooperative ties between the Government research community and the private sector. These latter attributes are not simply due to the march of technological progress, but are the result of focused efforts aimed at policy development, budget and technical planning, and the fostering of a vibrant Government research community consisting of dedicated individuals with shared priorities committed to working toward common objectives.

Once again, I thank you for the opportunity to be here today and would be happy to answer any questions.