Statement of Dr. George O. Strawn
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Networking and Information Technology Research and Development Program,
to the Subcommittee on Research and Science Education of the
Committee on Science, Space, and Technology
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I am George Strawn, Director of the National Coordination Office (NCO) for the Networking and Information Technology Research and Development Program (NITRD). With my colleague, Dr. Farnam Jahanian of the National Science Foundation (NSF), I co-chair the NITRD Subcommittee of the National Science and Technology Council's Committee on Technology. I want to thank Chairman Brooks, Ranking Member Lipinski, and members of the Subcommittee for the opportunity to come before you today to discuss the role of the NITRD Program in helping the United States maintain leadership in networking and information technology (NIT).

Prior to coming to the NCO for NITRD in 2009, I was at the National Science Foundation (NSF) and had taken part in NITRD activities as an NSF staff member since 1995. The positive impression I formed about NITRD during those years led me to apply for my current position and adds to my appreciation of this opportunity to testify before you today.

NITRD Overview

The NITRD Program has been authorized under three legislative acts. The first, the High Performance Computing Act of 1991 (Public Law 102-194), established the Program, setting forth a framework that combined research goals with specific provisions for interagency cooperation, collaboration, and partnerships with industry and academia. Two additional acts – the Next Generation Internet Research Act of 1998 (Public Law 105-305) and the America COMPETES Act of 2007 (Public Law 110-69) – reauthorized the Program and extended its scope in various ways.

As the NITRD Program this year celebrates its 20th anniversary, I hope the members of this Subcommittee and its parent Committee share the NITRD community's pride that our multi-agency framework has truly met the test of time. Over the course of two decades, the authorizing legislation has enabled the NITRD enterprise to evolve and expand to address increasingly rapid technological shifts and new responsibilities.

The framework of the NITRD Program provides for coordination across the Government's portfolio of unclassified investments in fundamental, long-term research and development (R&D) in advanced networking and information technology (NIT). NITRD research supports both the missions of our Federal agencies and the Nation's broader goals such as

homeland and national security, economic competitiveness, energy independence, environmental stewardship, affordable health care, and science and engineering leadership.

All of the research reported in the NITRD portfolio is managed, selected, and funded by one or more of the 18 NITRD member agencies (listed on page 14) under their own individual authorizations and appropriations. The Program's major research areas (termed Program Component Areas [PCAs] in the 1998 reauthorization legislation) currently include:

1. Cyber security and information assurance
2. High-confidence software and systems
3. High-end computing
4. Human-computer interaction and information management
5. Large-scale networking
6. Social, economic, workforce implications of IT and workforce development
7. Software design and productivity

We have also launched some exciting new ventures that are highlighted below.

NITRD research is performed in universities, Federal research centers and laboratories, Federally funded R&D centers, private companies, and nonprofit organizations across the country. The synergy exhibited by the NITRD member and participating agencies (listed on page 15) - is accomplished through interaction across the government, academic, commercial, and international sectors using cooperation, coordination, information sharing, and joint planning. Collaborative activities are focused on selected areas where the agencies can identify technical challenges that multiple agencies face and address them together to leverage each other's activities. These targeted collaborations enable the agencies to maximize resource sharing, minimize duplication of effort, and partner in investments to pursue higher-level goals.

Structure of NITRD Coordination

The Subcommittee on Networking and Information Technology Research and Development of the National Science and Technology Council's (NSTC) Committee on Technology (CoT) serves as the internal deliberative organization for NITRD policy, program, and budget guidance and direction within the Executive Branch. The NITRD Subcommittee interacts with Federal agencies that need advanced networking or information technology to identify networking and information technology research and development needs. Its high-level goals are to help assure continued U.S. leadership in networking and IT, satisfy the needs of the Federal government for advanced IT capabilities, and accelerate development and deployment of new technologies. Subcommittee members include senior R&D managers from each of the member agencies and representatives from the Office of Management and Budget (OMB), Office of Science and Technology Policy (OSTP), and the NCO. The Subcommittee interacts with Congress, OMB, OSTP, the NSTC, the CoT, other Federal agencies, and private-sector and international organizations on behalf of the NITRD Program.

The NCO facilitates the activities of the NITRD Program (see list immediately below), and the office serves as the hub of public information about the Program. The NCO's technical, administrative, NIT services, and administrative support staff provide program and financial management services; technical and subject-matter expertise in facilitation, strategic planning, technical writing, networking and IT services; and administrative staff support for the NITRD Subcommittee and the IWGs, CGs, SSGs, Teams, and other NITRD subgroups. The cost of operating the NCO is shared by the NITRD member agencies in proportion to their NITRD budgets. The NCO also supports the President's Council of Advisors on Science and Technology (PCAST), under Executive Order 13539. The NCO Director reports to OSTP, works closely with OSTP and OMB, and attends OSTP technical-staff meetings. NSF serves as the host agency for the NCO. The NCO maintains the NITRD Web site (www.nitrd.gov) and prepares and archives NITRD publications.

Supported by the NCO's staff and services, the NITRD Program uses the following general mechanisms to pursue its coordination mission:

- Monthly meetings of its Interagency Working Groups (IWGs), Senior Steering Groups (SSGs), Coordinating Groups (CGs), Teams, and Subgroups (SGs). These regular interactions among representatives from many agencies enable participants to exchange information and collaborate on research plans and activities such as standards development, testbeds, research workshops, cooperative solicitations, and sharing operational best practices for Federal NIT, such as in the annual DOE High Performance Computing (HPC) Best Practices Workshop.[1] Also as a result of these exchanges, NITRD representatives frequently serve on grant review panels and participate in principal investigator meetings of other agencies.
- Formation of new coordination activities as needed to address national priorities. These are described under "New NITRD Ventures" below.
- Workshops, which typically include academic and industry participants from across the country as well as Federal representatives.
- Formal reports, including the annual NITRD Supplement to the President's Budget, strategic planning documents, and workshop reports. These documents all play an important role in helping set national agendas in research areas of critical interest.
- Support for external studies and assessments
- Outreach to the Federal and private sectors

New NITRD Ventures

Cybersecurity SSG

In 2008, as part of a mandate to improve coordination of Federal cybersecurity R&D under the Comprehensive National Cybersecurity Initiative (CNCI), the NITRD agencies developed a plan calling for the establishment of a new kind of coordinating group under NITRD. An interagency Senior Steering Group (SSG) for cybersecurity R&D was

[1] http://www.nersc.gov/events/hpc-workshops/

established whose members included Federal managers with budgetary responsibilities. This group was in addition to our cybersecurity PCA. A key goal of the SSG concept was to facilitate moving strategic cybersecurity R&D approaches developed by the NITRD agencies into programmatic activities. The Cybersecurity SSG has proven effective and we have adopted the same model to establish other NITRD SSGs.

Like the Cybersecurity SSG, the new SSGs enable NITRD to broaden its focus from established NIT R&D categories to ones that address new opportunities and critical national priorities for the United States. These SSGs, and a new venture in the education arena, are described in the following sections. The participating agencies for each of the SSGs can be found on pages 16-17.

Big Data SSG

Most of the world's information is now "born digital," and legacy texts, images, sounds, videos, and films as well are being digitized around the clock. Typical estimates put the amount of digital data generated annually at many orders of magnitude greater than the total amount of information in all the books ever written, and the total is expected to continue growing exponentially. In the sciences alone – a central concern of our Federal science agencies – the proliferation of ultra-powerful and distributed data-collection instruments and experimental facilities has turned the conduct of leading-edge research into a global-scale, data-intensive enterprise. Together, the Federal agencies in the NITRD Program generate exabytes of research data annually. Financial, commercial, communications, and Web-based enterprises likewise generate vast amounts of new digital information on a moment-by-moment basis. However, our capacity to create electronic data is outpacing advances in the technologies needed to enable us to preserve, manage, access, and make effective use of society's data resources – the highly complex, ultra-large-scale data sets that we in NITRD refer to as "big data."

NITRD has a PCA for human-computer interaction and information management, but big data offers new possibilities and new challenges. Responding to a request from OSTP, NITRD formed the Big Data Senior Steering Group in January 2011. The Big Data SSG is charged with identifying current big data R&D activities across the Federal government, offering opportunities for coordination and collaboration, and considering what national initiatives on big data would be most useful. The science of big data begins with issues of scale, complexity, and heterogeneity encompasses the many significant challenges in turning data into knowledge, including search, discovery, mining and visualization of ultra-scale data; interoperability; and semantics. In their first months, the agencies participating in the Big Data SSG have identified four focus areas for their initial activities: core technologies, data projects, training, and competitions.

Health IT R&D SSG

The formation of NITRD's Health IT R&D SSG is our response to the American Recovery and Reinvestment Act of 2009 (Public Law 111-5), which called on NITRD to "have programs in Health IT R&D." We have always had mission agency members, but this is the first time that a formal NITRD activity is devoted to a mission programmatic goal – improving health and health care. Health IT R&D includes fundamental research, applied

R&D, technology development and engineering, demonstrations, testing and evaluation, technology transfer, and education and training.

The Health IT R&D SSG was launched in January 2010 after an initial NITRD planning activity on the topic. The agencies participating in the group are working towards a next-generation health information infrastructure that will provide universal, interoperable information systems for U.S. health care. R&D challenges include, to name just a few: universal data exchange language; security, privacy, and identity management; interoperable electronic health records (EHRs); personal health records (PHRs); devices/sensors; and further empowering of "e-patients." The SSG's interests also encompass: coordination of standards, implementation specifications, and certification criteria; maintaining frequent communication with, and serving as the liaison among, the SSG agencies, academia, and industry; and responding to U.S. national goals for health IT R&D and the health IT recommendations of PCAST in its 2010 report *Realizing the Full Potential of Health Information Technology to Improve Healthcare for Americans: The Path Forward.*[2]

The Health IT R&D SSG is developing a health information technology recommendations document that provides research directions for health IT R&D. In addition, the SSG has formed the Health Information Technology Innovation and Development Environments (HITIDE) subgroup, which is working on policy and governance issues for experimental testbed activities. Testbeds will enable our agencies to try out new health technology prototypes in realistic, real-time environments.

Wireless Spectrum R&D (WSRD) SSG

The Wireless Spectrum R&D SSG was established in November 2010 to coordinate spectrum-related research and development activities across the Federal government. WSRD's purpose is: to help coordinate and inform ongoing activities across Federal agencies; and to facilitate the identification of gaps in the Government's R&D portfolio with respect to technologies that allow a more efficient use of spectrum. These activities are consistent with the guiding principles of WSRD, which are transparency, smart investment, and the expansion of opportunities for technology transfer across and beyond the Federal government.

The WSRD members have developed a preliminary inventory of some 670 Federal wireless spectrum R&D activities and are preparing a gap analysis from the inventory and recommendations on Federal research that could advance the goals of the June 28, 2010 Presidential Memorandum: "Unleashing the Wireless Broadband Revolution," Section 3. In addition, WSRD will work with academia and the private sector to develop priorities, encourage private investment, and develop public/private partnerships when appropriate.

Cyber-Physical Systems

H.R. 2020 calls out cyber-physical systems (CPS) as a new area of national priority for NITRD activity. Cyber-physical systems are real-time, networked computing systems – interconnected software, microprocessors, sensors, and actuators – deeply integrated within

[2] http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-health-it-report.pdf

engineered physical systems to monitor and control capabilities and behaviors of the physical system as a whole. Such systems have become increasingly important to our society and are essential to the effective operation of: U.S. defense and intelligence systems; critical civilian infrastructures (e.g., air-traffic-control, power-grid, and water-supply systems), industrial-process control systems, and other large-scale civilian systems; as well as to smaller-scale systems that are vital for U.S. economic competitiveness (e.g., in airplanes, cars, robotic devices, and medical instruments and devices).

Much of the work of NITRD's High Confidence Software and Systems (HCSS) PCA over the past decade has been focused on CPS research and building a national CPS research community that engages multiple sectors and disciplines. Currently, we are considering augmenting this work with an SSG devoted specifically to CPS R&D. In addition to H.R. 2020, the last two PCAST reviews of our Program (*Leadership Under Challenge: Information Technology R&D in a Competitive World*,[3] August 2007, and *Designing a Digital Future: Federally Funded Research and Development in Networking and Information Technology*,[4] December 2010) concluded that improving the quality, capabilities, and trustworthiness of our life- and safety-critical information technologies, including cyber-physical systems, should be a key focus of Federal research.

Education and Workforce Activities

As employers with needs for all kinds of highly skilled scientific and technical NIT personnel, the NITRD agencies are acutely aware of some of the problems in our formal education system that limit the number of graduates adequately prepared to become part of the NIT workforce. To underscore their concern, in the draft strategic plan for NITRD the agencies highlight development of a "cyber-capable" U.S. population as one of three critical foundations for a bright national future. One immediate outcome of the strategic planning discussions has been the establishment of a new Team (called SEW-Education) under the auspices of NITRD's Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW) Program Component Area.

The SEW-Education team is seeking ways to promote the integration of instruction about the science of computing throughout the K-12 curriculum. Indeed, the former co-chair of the NITRD Subcommittee, Dr. Jeannette Wing (now back at the computer science department at Carnegie-Mellon University), introduced the concept of "computational thinking for everyone." She spearheaded NSF initiatives to support development of innovative ways to familiarize students at all levels with the fundamental concepts of computation, such as algorithms, and how they can be applied to solve problems in every domain – just as students now learn fundamental concepts in mathematics and other sciences in grade-appropriate curricula starting at the elementary level.

In national public forums we held in 2008 and 2009 to inform NITRD strategic planning, academic computer scientists and K-12 educators told us that few, if any, K-12 schools had a curriculum in computer science (CS). According to these experts, computer science teaching was limited to an introductory high-school course in programming, offered by

[3] http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-07-nitrd-review.pdf
[4] http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd-report-2010.pdf

only 65 percent of high schools in 2009 and taken by a small percentage of students. In lower grades, they said, teachers informally helped students use computer applications but there was virtually no instruction about the science of computation. In a society increasingly dependent on complex digital systems, the NITRD agencies believe, the gaps in K-12 students' knowledge and experience, and in the availability of skilled CS teachers, are worrisome and need to be addressed through grade-appropriate computer science curricula.

At the same time, the demand for NIT workers is growing. A 2009 study conducted for NITRD by SRI[5] notes that two NIT-related occupations – network systems and data communications analyst, and computer applications software engineer – are among the five fastest-growing in the U.S. economy, and are the only two of the five to require a college degree. According to U.S. Bureau of Labor Statistics projections in 2010, there were 7.6 million STEM workers in the United States, representing about 1 in 18 workers. STEM occupations are projected to grow by 17.0 percent from 2008 to 2018, compared to 9.8 percent growth for non-STEM occupations. STEM workers command high wages, earning 26 percent more than their non-STEM counterparts, more than two0thirds of STEM workers have a least a college degree, compared to less than one-third of the non-STEM workers, and STEM degree holders enjoy high earnings, regardless of whether they work in STEM or non-STEM occupations.

Furthermore, labor-market projections for the NIT workforce do not capture the reality that a very broad range of occupations increasingly involves applications that require NIT knowledge and skills. Nor can statistical projections serve as a guide for assessing the adequacy of the educational system to prepare a workforce that leads the world in advanced innovation.

The managers of the NSF programs targeting the K-12 problem participate in the SEW-Education group and are helping develop its action plan. The first NSF effort, Computing Education for the 21st Century (CE21), is focusing special attention on the middle-school through early-college levels, with the goals of: increasing the number and diversity of students and teachers who develop and practice computational competencies in a variety of contexts; and increasing the number and diversity of postsecondary students who are engaged and have the background in computing necessary to successfully pursue degrees in computing-related and computationally intensive fields of study.[6]

The second NSF activity, CS 10K (which stands for 10,000 Computer Science teachers in 10,000 high schools), aims to increase the effectiveness of computing education in high school through the introduction of an entirely new curriculum (based on a proposed, new Advanced Placement course) concomitant with the preparation of teachers prepared to teach it by 2015.[7]

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[5] Commissioned by the NITRD Subcommittee in response to Recommendation 2.1 (page 23) of *Leadership Under Challenge,* the 2007 PCAST report on its review of the NITRD Program.

[6] http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503582

[7] http://www.computingportal.org/cs10k

A three-year, $14.2 million effort initiated in 2010 by SEW-Education participant and NITRD member DARPA is also directed to the middle- and high-school levels of the K-12 system. Citing the decline in CS college graduates and the growing need for computer scientists and engineers, the agency's solicitation asked for innovative proposals to: combat young people's misperception that the "dot.com" bust eliminated all CS jobs; excite middle- and high-school students about CS and STEM careers; provide means of retaining the excitement of extracurricular activities, such as NASA's Space Camp, in the regular curriculum; and offer plans for institutionalizing the new approaches over the long term.[8]

These efforts are complemented by the National Initiative for Cybersecurity Education NICE) led by NIST. This comprehensive program, to which many NITRD agencies are contributing, includes activities in four component areas: national cybersecurity awareness; formal cybersecurity education; cybersecurity workforce structure; and cybersecurity workforce training and professional development.[9]

SEW-Education also plans to coordinate its efforts with those of the new NSTC Committee on Science, Technology, Engineering, and Math Education (CoSTEM). The COMPETES Act of 2010 directed OSTP to set up this committee, which is co-chaired by OSTP and NSF, and gave it the following responsibilities:

- Coordinate the STEM education activities and programs of the Federal agencies
- Coordinate STEM education activities and programs with the Office of Management and Budget
- Encourage the teaching of innovation and entrepreneurship as part of STEM education activities
- Review STEM education activities and programs to ensure they are not duplicative of similar efforts within the Federal government
- Develop, implement through the participating agencies, and update once every 5 years a 5-year STEM education strategic plan

[8] http://www.darpa.mil/Our_Work/I2O/Programs/Computer_Science_in_Science_Technology_Engineering_and_Mathematics_Education_(CS-STEM).aspx

[9] http://csrc.nist.gov/nice/

Other Recent NITRD Highlights

In addition to the recent NITRD developments described above, I am pleased to report that we have welcomed four new agencies as members of the NITRD Program. Last spring, the Office of the National Coordinator (ONC) for Health Information Technology of the Department of Health and Human Services became a NITRD member. The ONC representative also serves as a co-chair of the Health IT R&D Senior Steering Group. We are also delighted that the Department of Defense's Service research organizations – the Air Force Research Laboratory (AFRL), the Army Research Laboratory (ARL), and the Office of Naval Research (ONR) have come onboard as NITRD member agencies. The Service labs have long been active participants in the Program's research groups, so it is gratifying to have the benefit of their contributions as Subcommittee members as well.

I want also to note briefly that the National Coordination Office is working on a prototype R&D dashboard that will provide greater access to NITRD funding data, enabling the public to explore the Program's research activities in greater depth. You can find our initial conceptual dashboard on the NITRD web site.[10]

Maintaining U.S. Leadership in Networking and Information Technology

Networking and information technology – computers, wired and wireless digital networks, electronic data and information, IT devices and systems, and software applications – today provide the indispensable infrastructure for activities across all facets of our society and our economy. Throughout the IT revolution, the United States has led the world in the invention and applications of these technologies. For well over six decades, ongoing Federal research and development to supply advanced IT capabilities for Government missions has fueled the creation of new ideas, innovators, and innovations addressing key national priorities, such as those cited above and repeated here for emphasis: homeland and national security, economic competitiveness, energy independence, environmental stewardship, affordable health care, and science and engineering leadership. In fact, the 2010 PCAST review of NITRD noted that "the Federal investment in NIT research and development is without question one of the best investments our Nation has ever made."

There is no doubt that the historic U.S. supremacy in NIT is under global challenge from aggressive competitors. We no longer manufacture all the components for the NIT products we use, and that pipeline is something we need to monitor carefully. However, we need to be mindful that the U.S. companies that so successfully built our country's multibillion-dollar NIT commercial marketplace are also becoming global enterprises. I believe that we remain the world's NIT leader, but continued innovation leadership is required to maintain our position.

I come to the NIT leadership question with the perspective of a computer scientist who has for many years been a student of the history of U.S. information technologies. Technology innovation proceeds in extended cycles. Big – usually unexpected – scientific discoveries

[10] http://itdashboard.nitrd.gov/

come first, followed by long periods of incremental innovations and commercialization of products developed out of the initial fundamental advances. In the field of networking and information technology in particular, the Federal government has historically been the sponsor of the fundamental scientific breakthroughs that spawned the information revolution. This history dates back to the 1800s. In the 1830s, the U.S. government supported Samuel F.B. Morse's development of the telegraph. In the 1890s, the U.S. Census Bureau supported the work of its employee, Herman Hollerith, in developing an innovative punch-card technology to record and store census data. Several decades later, the company Hollerith subsequently started became the International Business Machines Corporation (IBM). More recent examples include the Army-supported development of the electronic computer; DARPA's support for the ARPAnet followed by NSF's support for the NSFnet, which became the Internet; and NSF's support for the research that brought us the first Web browser and the Google Web search engine.

The NITRD Program sustains this historic Federal role in discovery, in the 21st century's far more complicated global technological and economic environment. As noted above, our collaborative multi-agency framework has enabled the NITRD agencies to keep evolving their NIT activities to keep pace with the increasing pace of emerging technologies and applications. The portfolio of research and development activities sponsored by the NITRD agencies grows ever broader. I would argue that this portfolio is an invaluable resource for maintaining U.S. leadership in NIT because it is the Nation's only full-spectrum NIT R&D enterprise.

Thus the NITRD portfolio serves a unique purpose in what many term "the U.S. innovation ecosystem." Over the decades, the United States has developed a fluid, information-rich research and innovation environment that stretches from Federal programs and laboratories, across university campuses and research centers, to industrial R&D facilities and small business start-ups. As the National Academies and others have noted,[11] there are innumerable feedback loops in this ecosystem through which ideas and concepts travel, get transformed, fuel new directions, turn student experimenters into skilled technologists and keen entrepreneurs, and ultimately produce path-breaking innovations. The NITRD research performed in universities, Federal research centers and laboratories, Federally funded R&D centers, and in partnerships with private companies and nonprofit organizations across the country generates continuous interaction, information exchange, and feedback in the ecosystem, providing new perspectives and insights to both Federal and private-sector stakeholders. Through its broad reach across the ecosystem, NITRD funding also supports the education and training of the Nation's next generations of NIT researchers, technical experts, entrepreneurs, and IT industry leaders.

The NITRD Program thus supports not only the vitality of the innovation ecosystem as a whole but the national NIT talent pool it nurtures. We are pleased that the PCAST, in its 2010 review of the Program, concluded that NITRD is widely and correctly viewed as

[11] See, for example, *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information infrastructure*, the National Research Council, National Academy Press, Washington DC, 1995; and *Assessing the Impacts of Changes in the Information Technology R&D Ecosystem*, National Research Council, 2009.

"successful and valuable," and we are working, as noted throughout this testimony, to address PCAST recommendations for ways to improve our efforts.

I will now turn to the other questions the Subcommittee posed that I have not yet addressed.

NITRD Objectives and Critical R&D Issues

While maintaining their mission focus, the NITRD agencies make every effort through their NITRD Program activities to grapple with the most critical NIT R&D problems. Although the NITRD collaborative umbrella enables only coordination – not prioritization – of agencies' mission activities, each agency faces and responds to the challenge of pushing the cutting edge of technological change. To cite just a few areas, the NITRD agencies individually and together are investigating the implications of cloud computing for data-intensive science and high-end computation. Our agencies are also leading the Government's major research effort to change the balance of power in cyberspace, so that legitimate uses are secure and malefactors can no longer attack at will. NITRD members are working on critical technical challenges at the upper limits of computing power and speed, such as energy conservation, nanoscale materials and techniques, and software architectures and applications for machines with hundreds of thousands of processors. The agencies are also pressing forward with improving software engineering for the long-lived, ultra-scale software-based systems that are the work horses providing many of the Nation's most vital capabilities across all sectors.

Amid the relentlessly accelerating rate of technological change of recent years, we in NITRD are also learning how to be more adept in adjusting our coordination emphases to be more responsive. The new ventures described above were created and became productive in record time for NITRD. Each of these is addressing significant national issues that require intellectual contributions from the NIT research community and advances in NIT R&D. The new SSGs and subgroups represent a different, more flexible model for NITRD collaboration – one in which collaborative groups are quickly formed to focus on emerging issues, do their work, and then may disband as their topical tasks conclude and new issues arise that need attention. NITRD's underlying PCAs will continue to exist, because they provide continuity in budget reporting over time. But shifting opportunities for short-term coordination activities are likely to be the new NITRD norm. These shifts align with the recommendations in the 2010 PCAST review of NITRD.

In my view, the value of the collaboration model in the NITRD Program, which involves both mission agencies focused on the "use value" of their missions and science agencies focused on "theory value," is illustrated by the political scientist Donald Stokes in his 1997 book *Pasteur's Quadrant.* Stokes defined a two-dimensional array of four types of R&D. His dimensions were "use value" and "theory value," and his point in making four quadrants was that high use value does not need to imply low theory value. And that high use-value science can generate high theory-value science, just as high theory-value science can generate high use-value science. Stokes pointed to the French scientist Louis Pasteur's groundbreaking work on causes and prevention of diseases as having high use value *and* high theory value (such research is said to lie in Pasteur's quadrant).

Stokes's concept usefully describes the essentially multidimensional nature of activities such as NIT research. That is, NIT R&D properly involves high use and high theory value. Computer science theory can arise from applied science, just as science research can arise from computer science research results; it is the constant interplay between the pure and the applied R&D sectors that generates many of the innovations that astonish us. We need pure research (such as computational complexity) and we need use-inspired research (such as arises when a mission agency seeks solutions to its science problems).

Research Opportunities and Academic and Industry Inputs

The research communities in academia and industry contribute to NITRD activities in a variety of forms. For example, in the past 12 months the NITRD agencies have finished their work on two major strategic plans – a five-year strategic plan for NITRD and a strategic plan for game-changing R&D to secure cyberspace. We are pleased that our cybersecurity R&D strategic plan, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program* will soon be released to the public and the NITRD plan is under review. Throughout both development activities, the NITRD agencies reached out extensively to engage the private sector in workshops, Requests for Input, wikis, and other forums.

One of the results in moving to include flexible, topic-focused coordination groups is that the NITRD Program can more conveniently draw upon academic and private-sector expertise across disciplines, sectors, and research and engineering domains in order to turn research results into practical applications.

A different form of outreach to the private sector takes place under NITRD member DOE/SC's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program. Since 2003, INCITE has promoted transformational advances in science and technology by competitively awarding large allocations of time on the agency's most powerful computing platforms ("leadership class" systems), as well as supporting resources and data storage, to industrial, Federal, and academic researchers nationwide who lack access to such resources. For 2011, 57 INCITE awardees received a total of 1.7 billion processor hours.[12]

Importance of Federal NIT Investments

As discussed above, the history of NIT development has demonstrated the crucial role of Federal investments. The results of these investments have spawned a myriad of technological innovations, novel products and communications capabilities, and an entirely new, multibillion-dollar economic sector in NIT that has been responsible for significant expansion in well-paying job opportunities. The multiplier effects of Federal NIT R&D – on both innovation and employment – are widely documented, perhaps most famously in the National Research Council's "tire tracks" graphic illustrating how the feedback loops

[12] http://www.doeleadershipcomputing.org/wp-content/uploads/2011/07/INCITE_IR_FINAL_7-19-11.pdf

mentioned above operate over time to move research discoveries into the marketplace. [13] There is little doubt that our country and the world are moving rapidly into an increasingly digital future. We in NITRD concur with PCAST that Federal research leadership will continue to be an imperative if we are to sustain our preeminence in the networking and information technologies that we invented and developed.

Comments on H.R. 2020

The NITRD Program has benefited for 20 years from Congressional authorization and we look forward to this reauthorization. I believe that this draft legislation from the last Congress is well focused and will continue to aid our activities. Two small changes would, I believe, increase its value and focus.

A. The draft legislation currently calls for a three-year cycle for updating the NITRD strategic plan and a two-year cycle for advisory committee review. I respectfully suggest that if both activities were put on a three-year cycle, there would be better linkage between them. The same might be true of a two-year cycle, but the 50% increase in reporting activity would not, in my opinion, be offset by gains in value to the program.

B. A new section in the current draft legislation highlights cyber-physical systems and information management. As discussed above, we affirm the emphasis on cyber-physical systems. We respectfully suggest that, as also discussed above, "big data" is a better phrase than "information management" to characterize the advances required at this time.

These comments, I believe, are consistent with the findings of PCAST's 2010 review of NITRD.

Thank you very much for affording me the opportunity to provide testimony before the Subcommittee on Research and Science Education of the House Committee on Science, Space, and Technology. I will be happy to answer any questions you may have.

[13] In 2003, the National Research Council's Computer Science and Telecommunications Board (CSTB) updated the original 1995 tire tracks figure from the *Evolving the High Performance Computing and Communications* report in a new report, *Innovation in Information Technology that* summarized eight prior CSTB studies on the subject.

NITRD MEMBER AGENCIES

The following Federal agencies, which conduct or support R&D in advanced networking and information technologies, report their IT research budgets in the NITRD crosscut and provide support for program coordination:

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)
- Department of Defense (DoD)
- Defense Advanced Research Projects Agency (DARPA)
- National Security Agency (NSA)
- Office of the Secretary of Defense (OSD) and Service Research Organizations
  - Air Force Research Laboratory (AFRL)
  - Army Research Laboratory (ARL)
  - Office of Naval Research (ONR)

Department of Energy (DOE)

- National Nuclear Security Administration (DOE/NNSA)
- Office of Science (DOE/SC)

Department of Homeland Security (DHS)

Department of Health and Human Services (HHS)

- Agency for Healthcare Research and Quality (AHRQ)
- National Institutes of Health (NIH)
- Office of the National Coordinator for Health Information Technology (ONC)

Environmental Protection Agency (EPA)

National Aeronautics and Space Administration (NASA)

National Archives and Records Administration (NARA)

NITRD PARTICIPATING AGENCIES

Representatives of the following agencies with mission interests involving networking and IT R&D and applications also participate in NITRD activities:

Department of Commerce (DOC)

- National Telecommunications and Information Administration (NTIA)

Department of Defense (DoD)

- Defense Information Systems Agency (DISA)

Department of Energy (DOE)

- Office of Electricity Delivery and Energy Reliability (DOE/OE)

Department of Health and Human Services (HHS)

- Food and Drug Administration (FDA)

Department of Interior

- U.S. Geological Survey (USGS)

Department of Justice (DOJ)

- Federal Bureau of Investigation (FBI)

Department of State (State)

Department of Transportation (DOT)

- Federal Aviation Administration (FAA)
- Federal Highway Administration (FHWA)

Department of the Treasury (Treasury)

- Department of Veterans Affairs

Director of National Intelligence (DNI)

- Intelligence Advanced Research Projects Agency (IARPA)

National Transportation Safety Board (NTSB)

Nuclear Regulatory Commission (NRC)

U.S. Department of Agriculture (USDA)

NITRD SSGs Participating Agencies

Cybersecurity

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)

Department of Defense (DoD)

- National Security Agency (NSA)
- Office of the Secretary of Defense (OSD)

Department of Homeland Security (DHS)

Director of National Intelligence (DNI)

Executive Office of the President

- Office of Science and Technology Policy (OSTP)

National Science Foundation (NSF)

Big Data

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)

Department of Defense (DoD)

- Defense Advanced Research Projects Agency (DARPA)
- National Security Agency (NSA)
- Office of the Secretary of Defense (OSD) and Service Research Organizations
- Air Force Research Laboratory (AFRL)
- Army Research Laboratory (ARL)
- Office of Naval Research (ONR)

Department of Energy (DOE)

Department of Health and Human Services (HHS)

- National Institutes of Health (NIH)

Director of National Intelligence (DNI)

Executive Office of the President

- Office of Science and Technology Policy (OSTP)

National Aeronautics and Space Administration (NASA)

National Science Foundation (NSF)

Health IT

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)

Department of Defense (DoD)

- Telemedicine and Advanced Technology Research Center (TATRC)

Department of Health and Human Services (HHS)

- Agency for Healthcare Research and Quality (AHRQ)
- Assistant Secretary for Preparedness and Response (ASPR)
- Centers for Disease Control and Prevention (CDC)
- Food and Drug Administration (FDA)
- Indian Health Service (IHS)
- National Institutes of Health (NIH) Office of the National Coordinator for Health Information Technology (ONC)

Department of Veterans Affairs (VA)

National Science Foundation (NSF)

Executive Office of the President

- Office of Science and Technology Policy (OSTP)

Wireless Spectrum Technologies

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)
- National Telecommunications and Information Administration (NTIA)

Department of Defense (DoD)

- Defense Advanced Research Projects Agency (DARPA)
- National Security Agency (NSA)
- Office of the Secretary of Defense (OSD) and Service Research Organizations
- Air Force Research Laboratory (AFRL)
- Army Research Laboratory (ARL)
- Office of Naval Research (ONR)

Department of Energy (DOE)

- Idaho National Laboratory (INL)
- Oak Ridge National Laboratory (ORNL)

Department of Homeland Security (DHS)

Department of Justice (DOJ)

Department of Transportation (DOT)

- Federal Aviation Administration (FAA)

Executive Office of the President

- National Economic Council (NEC)
- Office of Science and Technology Policy (OSTP)

Federal Communications Commission (FCC)

National Aeronautics and Space Administration (NASA)

National Science Foundation (NSF)