FY 2007

The Networking and Information Technology Research and Development Program

Supplement to the President's Budget

February 2006

SUPPLEMENT TO THE PRESIDENT'S BUDGET
FOR FISCAL YEAR 2007

THE NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT PROGRAM

A Report by the
Subcommittee on Networking and Information Technology
Research and Development

Committee on Technology
National Science and Technology Council

FEBRUARY 2006

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, **D.C. 20502**

MEMBERS OF CONGRESS:

I am pleased to forward with this letter the annual report on the interagency Networking and Information Technology Research and Development (NITRD) Program. This Supplement to the President's Budget for Fiscal Year 2007 describes activities funded by Federal NITRD agencies in advanced networking, high-end computing and information technologies. Innovations in science and technology derived from NITRD investments contribute substantially to strengthening the Nation's economy. Cyber security and information assurance research and development in the NITRD Program are enhancing the future security of the Nation's information infrastructure.

The President's 2007 Budget provides an increase of eight percent for the NITRD Program as a whole, recognizing the important contribution of information technology research and development to the Nation's competitiveness. I am particularly pleased to be able to draw attention to the effect that the President's American Competitiveness Initiative (ACI) has had on the NITRD Program. The 2007 Budget proposes an increase for NITRD-related funding within the three agencies highlighted in the ACI (the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology) of 17 percent over 2006 levels.

Tools and capabilities that result from NITRD investments propel advances in nearly every area of science and technology, and enhance the Nation's competitiveness. Agencies participating in the NITRD Program actively coordinate both the planning and execution of their research programs, avoiding duplication and making these programs more productive. This Budget Supplement provides details of such interagency coordination for the NITRD Program.
I am pleased to provide you with this timely report.

Sincerely,

John H. Marburger, III
Director

National Coordination Office for Networking and Information Technology Research and Development
The annual NITRD Supplement to the President's Budget is prepared and published by the National Coordination Office for Networking and Information Technology Research and Development (NCO/NITRD). The NCO/NITRD supports overall planning, budget, and assessment activities for the multiagency NITRD enterprise under the auspices of the NITRD Subcommittee of the National Science and Technology Council (NSTC).

To Request Additional Copies
To request additional copies of this Supplement to the President's FY 2007 Budget or other NITRD Program publications, please contact: NCO/NITRD, Suite II-405, 4201 Wilson Boulevard, Arlington, Virginia 22230; (703) 292-4873; fax: (703) 292-9097; e-mail: nco@nitrd.gov. Electronic versions of NITRD documents are also available on the NCO Web site: http://www.nitrd.gov.

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Executive Summary

This Supplement to the President's Fiscal Year (FY) 2007 Budget provides a technical summary of the budget request for the Networking and Information Technology Research and Development (NITRD) Program, as required by the High-Performance Computing Act of 1991 (P.L. 102-194) and the Next Generation Internet Research Act of 1998 (P.L. 105-305). 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. The NITRD enterprise is an Administration interagency R&D budget priority for FY 2007.

The Supplement to the President's Budget for the NITRD Program describes current technical and coordination activities and FY 2007 plans of the 12 Federal agencies in the NITRD budget crosscut, as well as those of other agencies that are not part of the formal crosscut but participate in NITRD activities. In the NITRD Program, the term "agency" may refer to a department, a major departmental subdivision, or a research office or laboratory. NITRD activities and plans are coordinated in eight Program Component Areas (PCAs): high-end computing infrastructure and applications; high-end computing research and development; cyber security and information assurance; human-computer interaction and information management; large-scale networking; high-confidence software and systems; social, economic, and workforce implications of IT and IT workforce development; and software design and productivity. Agency R&D program managers in each PCA meet monthly in an Interagency Working Group (IWG) or Coordinating Group (CG) to exchange information and coordinate technical plans and activities such as workshops and joint solicitations. Overall NITRD Program coordination is carried out by the Subcommittee on Networking and Information Technology Research and Development, under the aegis of the Committee on Technology of the National Science and Technology Council (NSTC).

Changes within the NITRD Program that are highlighted in the FY 2007 Supplement include the chartering of the High End Computing CG as an IWG, which reports to the NITRD Subcommittee, and the chartering of the Cyber Security and Information Assurance (CSIA) IWG, which reports to both the NSTC's NITRD Subcommittee and its Subcommittee on Infrastructure. This IWG succeeds the IWG on Critical Information Infrastructure Protection (CIIP), which had been chartered in August 2003 and reported to the Subcommittee on Infrastructure of the NSTC's Committee on Homeland and National Security. This year's NITRD budget also includes for the first time reporting by the High Performance Computing Modernization Program Office (HPCMPO) in the Office of the Secretary of Defense (OSD) and Department of Defense (DoD) Service research organizations.

The Administration's recently announced American Competitiveness Initiative, which calls for a doubling over 10 years of the investment in several Federal agencies that support basic research in the physical sciences and engineering, also contributes to the NITRD Program FY 2007 budget. NITRD agencies NSF, DOE/SC, and NIST show budget increases that exceed the base percentage increase in the overall Program budget (for details, please see the NITRD Program Budget Analysis beginning on page 21).

For each PCA, the NITRD Budget Supplement presents strategic priorities underlying the FY 2007 budget request, highlights of the request, ongoing and anticipated interagency planning and coordination activities, and additional technical activities, by agency. Agencies that are engaged in cited activities as funders, performers, in-kind contributors, and participants in focused coordination activities are identified, with funders and performers listed first and, following the word "with," the in-kind contributors and participants. When applicable, lead agencies are listed first. Some large-scale activities may be listed in more than one PCA because they involve R&D efforts in a variety of technologies. In such cases, agencies report the portion of program funding in each relevant PCA. Additional agency activities are reported with NITRD member agencies listed first, followed by participating agencies.

High End Computing (HEC) Infrastructure and Applications (I&A)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DOE/SC, NASA, NIST, DOE/NNSA, NOAA, EPA

HEC I&A agencies coordinate Federal activities to provide advanced computing systems, applications software, data management, and HEC R&D infrastructure to meet agency mission needs and to keep the United States at the forefront of 21st century science, engineering, and technology. HEC capabilities enable researchers in academia, Federal laboratories, and industry to model and simulate complex processes in biology, chemistry, climate and weather, environmental sciences, materials science, nanoscale science and technology, physics, and other areas to address Federal agency mission needs.

President's 2007 Request

Strategic Priorities Underlying This Request

Supporting Federal agencies' science, engineering, and national security missions and sustaining U.S. scientific leadership require ongoing investment in Federal HEC facilities as well as in advanced computational and data-intensive applications. HEC I&A strategic priorities to address these needs include:

Production-quality HEC resources: Increase resources to meet expanding Federal agency mission needs

Federal HEC acquisitions: Reduce time and cost by improving benchmarking and procurement coordination

Productivity: Collaborate on new assessments that more accurately predict computing system performance on diverse scientific problems, total time to solution, and total cost of ownership

Science and engineering applications: Develop more detailed and accurate applications for next-generation HEC platforms

Access to leadership-class systems: Provide access for the broad academic, industrial, and government R&D communities through peer-reviewed processes

Access to Federal HEC resources: Expand access for leading researchers to develop and execute HEC science and engineering applications that address Federal agency mission needs. This includes access to HEC capability and capacity systems for researchers associated with agencies that do not have HEC facilities.

Highlights of Request

Acquisition of prototype leadership-class and production R&D systems

NSF: Five-year High Performance Computing System Acquisition: Towards a Petascale Computing Environment for Science and Engineering program for deployment and support of world-class HEC resources for academic research; new platform expected in 2006 and petascale resources by 2010

DOE/SC (ORNL): Upgrade ORNL's Leadership Computing Facility (LCF) to over 250 TF, enabling more capability for use across Federal agencies

DOE/SC (ANL): Diversify LCF resources through acquisition of 100-TF BlueGene/P

DOE/SC (LBNL): For National Energy Research Scientific Computing Center (NERSC), acquire next-generation computational platform, the NERSC-5 (100-150 TF)

NASA (Headquarters): Establish a central HEC office under agency-wide "Shared Capability" theme

NASA (ARC): Continue enhancing Columbia supercomputer's quality of service for science and engineering users and prepare for transition to next-generation computational platform

NASA (GSFC): Acquire next-generation platform for Earth and space science research

Applications

NSF: New Office of Cyberinfrastructure to enable exploration of both emerging and established science and engineering applications through new uses of balanced HEC computing, storage, software, services, and other resources for advanced academic research

DOE/SC: Re-competition of modeling and simulation applications in Scientific Discovery Through Advanced Computing (SciDAC) program, to extend SciDAC's multidisciplinary, multi-institutional teams of computer and disciplinary scientists developing advanced applications in physical and biological sciences

DOE/SC: Competition to select small number of university-based SciDAC institutes to become centers of excellence in high-end computational science in areas critical to DOE missions and HEC software centers

DOE/SC: Expand 2005 Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program to include all major DOE/SC platforms through open call for proposals from agencies and industry

NASA: Through National Leadership Computing System call for proposals, open part of Columbia system to users outside of NASA who present the most demanding science and engineering challenges

DOE/NNSA: Develop verification and validation methodologies for weapons simulations including quantification of margins and uncertainties

NOAA, NSF: Improve capabilities for dynamic data assimilation

Planning and Coordination Supporting Request

Access to leadership-class computing: Coordinated efforts by agencies to make their most powerful HEC resources more widely available through open calls for proposals – DOE/SC, NASA, NSF

Benchmarking: Measuring HEC system performance on a broad range of applications – DARPA, DOE/SC, EPA, NASA, NOAA, NSF, OSD

Acquisition coordination: Information sharing, procedural streamlining, and collaborative analysis of total cost of ownership – DOE/SC, EPA, NASA, NOAA, NSF, OSD

Cooperative platform development: Design collaboration on systems for a common set of applications – DOE/NNSA, DOE/SC, NSA

Modeling of infectious disease: NSF providing Extensible Terascale Facility (ETF) resources and expertise for NIH large-scale Models of Infectious Disease Agents Study (MIDAS) – NSF, NIH

SciDAC program: Re-competition of applications and infrastructure components – DOE/SC, DOE/NNSA

Shared infrastructure for climate and weather modeling: Module interface standards for software interoperability – DOE/SC, EPA, NASA, NOAA, NSF (NCAR), OSD

Air quality modeling: Atmospheric dispersion models and other simulation techniques used in assessing source impacts and control strategies – EPA, NOAA

Additional 2006 and 2007 Activities by Agency

NSF: Continue ETF, core centers (SDSC and NCSA), and middleware initiative in support of academic science and engineering activities

OSD (HPCMPO): HEC capabilities and services; HEC software development and life cycle support; expert computational consulting services for DoD laboratories from the academic community; develop future HEC workforce through fellowships, internships, and workshops; keep HEC systems current; recapitalize 25 percent of systems; HEC system security

NIH: NIH Roadmap National Centers for Biomedical Computing (NCBCs); Cancer Imaging and Computational Centers; P41 Computational Centers; NLM information and analysis servers; international networks for biomedical data and software sharing; bioinformatics resource centers for emerging and re-emerging infectious disease; proteomics and protein structure initiatives

DOE/SC: LCF at ORNL – X1e (18 TF), XT3 (25 TF), expansion in 2007; LCF at ANL – BlueGene/L (5 TF), expansion in 2007; NERSC – NERSC-4 SP3 (9 TF), NCS-A, Infiniband cluster (3 TF), NCS-B capacity system (7 TF) available to users in 2006, NERSC-5 initially available to users in 2007; expansion of SciDAC applications and infrastructure across DOE/SC and including DOE/NNSA, NSF participation in 2006 and 2007; applied mathematics research for computational science including multiscale mathematics

NASA: Columbia system (62 TF) at NASA ARC, with 2,048-processor shared memory environment and integrated support model, to aggressively scale application codes for rapid mission impact; NASA GSFC acquired system (7 TF) for Earth and space science research

NIST: Parallel and distributed algorithms such as for computational nanotechnology; interoperable MPI standards; virtual measurement laboratory immersive visualization; fundamental mathematical tools

DOE/NNSA: Develop, deploy, and maintain weapons and engineering codes; provide production-quality computational environment for the ASC Purple system; build common capacity computing environment across three labs; re-compete Alliance Centers program; develop and improve verification and validation methods for scientific simulations

NOAA: Integrated acquisition of next-generation R&D HEC systems for all of NOAA; integrated management and allocation of HEC resources; modeling frameworks for WRF and ESMF; grid technologies

EPA: HEC capabilities for GEOSS demonstrations; air quality algorithm enhancements; computational toxicology for faster, more accurate, less expensive analysis; grid services deployment

High End Computing (HEC) Research and Development (R&D)

NITRD Agencies: NSF, OSD and DoD Service research organizations, DARPA, DOE/SC, NSA, NASA, NIST, DOE/NNSA, NOAA

HEC R&D agencies conduct and coordinate hardware and software R&D to enable the effective use of high-end systems to meet Federal agency mission needs, to address many of society's most challenging problems, and to strengthen the Nation's leadership in science, engineering, and technology. Research areas of interest include hardware (e.g., microarchitecture, memory subsystems, interconnect, packaging, I/O, and storage), software (e.g., operating systems, languages and compilers, development environments, algorithms), and systems technology (e.g., system architecture, programming models).

President's 2007 Request

Strategic Priorities Underlying This Request

Sustain U.S. leadership in HEC: Develop new generation of economically viable, high-productivity computing systems to meet Federal agencies' HEC needs, which will require managing rapidly increasing volumes of data and integrating multiscale (in space and time), multidisciplinary simulations

Hardware and software: Integrate innovations, especially language and development environments, to reduce barriers to use of systems that may have tens of thousands of processors and to increase the productivity of end-user applications

System prototypes: Develop, test, and evaluate robust, innovative HEC systems and software to reduce industry and end-user risk and to increase competitiveness. Industries using HEC include aeronautics, automobile, biomedicine, chemicals, petrochemicals, and pharmaceuticals.

Research pipeline: Continue HEC University Research Activity (HEC-URA) to help refill the workforce pipeline with highly skilled researchers who can develop future-generation HEC systems and software

Highlights of Request

HEC-URA: New R&D in file systems and I/O – NSF, DARPA, DOE/NNSA, DOE/SC, NSA

High-Productivity Computing Systems (HPCS) Phase III: Final phase of program to develop economically viable prototypes for national security and industrial user communities, to address all aspects of HEC systems (packaging, processor/memory interfaces, networks, operating systems, compilers, languages, and runtime systems) – DARPA, DOE/SC, DOE/NNSA, NSA, with NASA, NSF, OSD, other agencies

Advanced capabilities for scientific research: Expand SciDAC-enabling organizational resources including centers, institutes, and partnerships – DOE/SC, DOE/NNSA

Prototype research and evaluation: Prepare users for future generations of high-end systems and reduce procurement risk – DOE/SC

Vector processor system: Continue cooperative development – NSA, with other NITRD agencies

Quantum computing program: DARPA, NIST, NSA

Software environments: Develop common system software and tools for high-end systems – DOE/NNSA, DOE/SC, NSF, OSD

Weapons applications: Sustain advanced systems development effort to meet programmatic needs for increased productivity – DOE/NNSA

Planning and Coordination Supporting Request

Planning

Technical and planning workshops: HPCS Productivity Workshops, Storage and I/O Workshop to coordinate new HEC-URA file systems and I/O effort, HEC Requirements Workshop supporting new NSF HEC initiative – DARPA, DOE/NNSA, DOE/SC, NASA, NIH, NSA, NSF, OSD

Council on Competitiveness HPC Initiative: Fund studies, conferences, and educational activities to stimulate and facilitate wider usage of HEC across the private sector to propel productivity, innovation, and competitiveness – DARPA, DOE/NNSA, DOE/SC, NSF

Open-source software: Research to enable users to read, modify, and redistribute source code, fostering more efficient development and increased collaboration to improve software quality – DOE/NNSA, DOE/SC, NASA

Systems architecture

HEC hardware and software testbeds: Facilitate access, share knowledge gained and lessons learned – DOE/SC, NASA, NIST, NOAA, NSF, OSD

HPCS Phase III: DARPA, DOE/SC, DOE/NNSA, NSA, with NASA, NSF, OSD

Black Widow performance reviews: Assess progress on developmental milestones – NSA, with DARPA, DOE/NNSA, DOE/SC, NASA, NSF, OSD

Quantum information science: Study information, communication, and computation based on devices governed by the principles of quantum physics – DARPA, NIST, NSA, NSF

Systems software development

HEC-URA: Coordinate research in operating/runtime systems, languages, compilers, libraries – DARPA, DOE/NNSA, DOE/SC, NSA, NSF

HEC metrics: Coordinate research on effective metrics for application development and execution on high-end systems – DARPA, DOE/SC, NSF, with DOE/NNSA, NASA, NSA, OSD

Benchmarking and performance modeling: Collaborate on developing measurement tools to help improve the productivity of HEC systems – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

File systems: Coordinate R&D funding based on a national research agenda and update agenda on a recurring basis – DARPA, DOE/NNSA, DOE/SC, NASA, NSA, NSF, OSD

Additional 2006 and 2007 Activities by Agency

NSF: University-based research on formal and mathematical foundations (algorithmic and computational science); foundations of computing processes and artifacts (software, architecture, design); emerging models for technology and computation (biologically motivated, quantum, and nanotechnology-based computing and design); distributed systems and next-generation software; data-driven science including bioinformatics, geoinformatics, and cognitive neuroscience; infrastructure development (create, test, and harden next-generation systems); and software and tools for high-end computing

OSD: Software Protection Initiative research in protection of critical defense software; applications software profiling and development; extend benchmarking and performance modeling to support system acquisitions and applications software development

DARPA: Architectures for cognitive information processing program – a new class of processing approaches, algorithms, and architectures to efficiently enable and implement cognitive information processing; begin transition of polymorphous computing architectures to DoD and commercial products; networked embedded systems technologies

DOE/SC: Research in programming models, performance modeling and optimization, software component architectures; development time and execution time productivity (with HPCS); data analysis and management, interoperability, software development environments

NSA: Eldorado – work with vendor on XT3 modifications, fully funding development in 2005-2006, available in 2006-2007

NASA: Participate in interagency coordination of architectures, testbeds, and system performance assessment

NIST: Architectures and algorithms for quantum computers; secure quantum communications

DOE/NNSA: Platforms; problem-solving environments; numeric methods; re-compete Alliance Centers program; user-productivity baseline in context of weapons simulations

Coordinated Implementation of the *Federal Plan for High-End Computing*

In 2003, the High-End Computing Revitalization Task Force (HECRTF) was chartered under the National Science and Technology Council (NSTC) to develop a plan for undertaking and sustaining a robust Federal high-end computing program to maintain U.S. leadership in science and technology. The *Federal Plan for High-End Computing*, released in May 2004, offers a vision for a proactive Federal effort that advances high-end computing technology to address many of society's most challenging large-scale computational problems and, in doing so, strengthens the Nation's global leadership in the sciences, engineering, and technology.

The HEC IWG is implementing this Plan through the coordination of high-end computing policy, strategies, and programs across NITRD member and participating agencies. Emphasis is placed on identifying and integrating requirements, conducting joint program planning, and developing and implementing joint strategies. Coordination activities encompass fundamental and applied research and development, technology development and engineering, infrastructure and applications, demonstrations, and education and training. The coordination is carried out through monthly HEC IWG meetings, agency-sponsored workshops, technical forums, and a variety of focused multiagency activities. The following list highlights some of these multiagency activities:

High-End Computing University Research Activity (HEC-URA): Beginning in 2004, NSF, DARPA, DOE/SC, and NSA engaged in joint planning and expanded funding for university research in operating systems, languages, compilers, and libraries, and in software tools and development environments. Beginning in 2006, NSF and other agencies will expand funding for research in file systems, storage, and I/O.

DARPA High-Productivity Computing System (HPCS) Program: The DARPA HPCS Program was initiated in 2001 to develop a new generation of high-end computing systems providing leap-ahead advances in performance, robustness, and programmability. Since then, DARPA has expanded its HPCS collaboration with other agencies to now include NSA, DOE/SC, DOE/NNSA, NASA, and NSF. Starting in 2006, HPCS enters Phase III, which will involve active collaboration with these agencies through such mechanisms as funding, participation in review panels, and requirements analysis.

Leadership Systems: The *Federal Plan* advanced the concept of "leadership high-end computing systems" to offer leading-edge computing facilities to enable breakthrough computational science and engineering for problems important to Federal agency missions and to the Nation. Today, this concept has been implemented by DOE/SC at four of its national laboratories through its INCITE program and by NASA through its National Leadership Computing Systems (NLCS) initiative. The two agencies either are completing or have completed solicitations for leadership-class computing resources, and they plan to conduct additional solicitations on a recurring basis. Other agencies are planning similar procurements of leadership-class systems in the near future.

System Performance Assessment: One of the major challenges in guiding research, development, and procurement of high-end computing systems is to measure, compare, and assess system performance. Currently, DOE and DARPA, in collaboration with other agencies, are developing methods to measure both execution performance and ease of programming. This includes novel work in combining software engineering experiments customized to high-performance computing. In addition, OSD (HPCMPO), DOE/SC (NERSC), and NSF are sharing selected benchmarks and procurement practices in order to streamline and improve the effectiveness of high-end computing systems procurements.

These examples illustrate the collaborative efforts underway in implementing the *Federal Plan for High-End Computing*. These and other HEC activities are described in further detail in the HEC I&A and HEC R&D sections of this Supplement.

Cyber Security and Information Assurance (CSIA)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DARPA, NSA, NASA, NIST
Other Participants: CIA, DHS, DOE (LLNL), DOJ, DOT, DTO, FAA, FBI, State, Treasury, TSWG

CSIA focuses on research and advanced development to prevent, resist, detect, respond to, and/or recover from actions that compromise or threaten to compromise the availability, integrity, or confidentiality of computer-based systems. These systems provide both the basic infrastructure and advanced communications in every sector of the economy, including critical infrastructures such as power grids, emergency communications systems, financial systems, and air-traffic-control networks. These systems also support national defense, national and homeland security, and other vital Federal missions, and themselves constitute critical elements of the IT infrastructure. Broad areas of concern include Internet and network security; confidentiality, availability, and integrity of information and computer-based systems; new approaches to achieving hardware and software security; testing and assessment of computer-based systems security; and reconstitution and recovery of computer-based systems and data.

Incorporation of the CSIA Program Component Area and the CSIA Interagency Working Group (IWG) into the NITRD Program

In August 2005, the NSTC chartered the Cyber Security and Information Assurance (CSIA) IWG. This IWG succeeds the IWG on Critical Information Infrastructure Protection (CIIP), which had been chartered in August 2003 and reported to the Subcommittee on Infrastructure of the NSTC's Committee on Homeland and National Security. The CSIA IWG reports jointly to the Subcommittee on Infrastructure and the NITRD Subcommittee. This change facilitates better integration of CSIA R&D with NITRD activities and reflects the broader impact of cyber security and information assurance beyond critical information infrastructure protection.

The first steps in integrating CSIA R&D into NITRD activities involve incorporating the budget associated with the CSIA PCA and the coordination by the CSIA IWG into the NITRD Program, and completing and releasing the Federal Plan for CSIA R&D (described below). Future steps will include roadmapping CSIA R&D and adjusting the activities in NITRD PCAs in light of the Program's expanded scope. Selected areas requiring cross-PCA coordination are described below.

President's 2007 Request

Strategic Priorities Underlying This Request

Fundamental and applied research for CSIA: New knowledge, technologies, and tools to achieve significantly improved security for the computer-based systems that support national defense, national and homeland security, economic competitiveness, and other national priorities. Key research areas include:
- **Network security:** New communications protocols, especially for wireless networks and mobile ad hoc networks, required to effectively secure networks and the data that travel over them (with LSN)
- **Dependable systems:** Systems with characteristics that include fault tolerance, reliability, safety, and security (with HCSS)
- **Situational awareness and response:** Data fusion and forensics, security visualization, and security management
- **Secure distributed systems:** Ability to function as network-centric multi-domain enterprise with ubiquitous secure collaboration

Infrastructure protection: Computer-based systems that function as intended, even in the face of cyber attack, and that are able to process, store, and communicate sensitive information according to specified security policies (with HCSS)

Infrastructure for R&D: Testbeds, tools, platforms, standards, and data collection and sharing to enable academic, industry, and government researchers to effectively conduct CSIA R&D

Industry outreach and technology transfer: Effective transition and diffusion of R&D results into mainstream products and services and improved practices; increased coordinated industry outreach and technology transfer

to aid timely transition of existing and newly created CSIA R&D to practice, including standards, guidelines, metrics, benchmarks, and best practices

Highlights of Request

Cyber Trust: Academic research in foundations, network security, secure systems software, security of information systems – NSF, DARPA

Testbeds: Development, testing, and evaluation of testbeds for the DETER, EMIST, and GENI projects – NSF, DHS

Datasets: Complete secure, trusted data-sharing infrastructure and initial data collection and sharing – NIST, NSF, DHS

Internet infrastructure security: Domain Name System (DNS) security roadmap, testing, guidance, and routing protocol security – NIST, DHS

Planning and Coordination Supporting Request

Federal Plan for Cyber Security and Information Assurance Research and Development

The CSIA IWG was charged with developing an interagency Federal Plan for CSIA R&D. This forthcoming document, which represents a collaborative effort by the CSIA IWG members, provides a baseline framework for coordinated, multiagency CSIA R&D. The Plan is currently in final clearance.

The Federal Plan resulted from a process in which CSIA R&D needs were identified, analyzed, and prioritized. Part I of the Federal Plan includes sections on:

- Technology Trends
- The Federal Role
- Types of Threats and Threat Agents
- Threat and Vulnerability Trends
- Recent Calls for CSIA R&D
- Strategic Federal Objectives
- R&D Technical and Funding Priorities
- Top Technical and Funding Priorities
- Findings and Recommendations

Part II of the Plan contains commentaries on technical topics. Each commentary includes a definition of the topic and discussions of its importance, the state of the art, and capability gaps requiring R&D. The technical topics are grouped in the following eight broad R&D categories identified in the CSIA IWG's analysis: functional cyber security; securing the infrastructure; domain-specific security; cyber security characterization and assessment; foundations for cyber security; enabling technologies for CSIA R&D; advanced and next-generation systems and architecture for cyber security; and social dimensions of cyber security.

Other Interagency Planning and Coordination Activities

Roadmapping: Develop an initial roadmap that provides a timeline for activities needed to implement the Federal Plan for CSIA R&D – CSIA IWG

Cyber security R&D:

- **System resilience:** Intrusion tolerance, self-regenerating systems, dynamic quarantine of worms, detection and containment of malicious code – DARPA, DoD (AFRL)
- **Adaptive quarantine:** Development of adaptive quarantine to prevent and preempt active, passive, novel insider and outsider cyber attacks against safety-critical and mission support networks and systems enterprise-wide – DTO, FAA
- **Intrusion detection:** Intrusion detection and monitoring, cyber attack detection, traceback, and attribution – NSA, DoD (AFRL), DTO
- **Countermeasures:** Flash ROM countermeasures tool and technologies that address identity theft and fraud detection – TSWG, FBI
- **Power grid:** Trustworthy cyber infrastructure for the power grid – DHS, NSF, DOE
- **Election systems:** Trustworthy election systems – NIST, NSF

Grants and proposals: Collaborate/coordinate on solicitations and evaluations – DARPA, NSA, NSF, DHS, DTO

National Plan for Research and Development in Support of Critical Infrastructure Protection: Provide input to the NSTC Subcommittee on Infrastructure on cyber aspects of critical infrastructure protection – CSIA IWG

INFOSEC Research Council *Hard Problem List*: Support the preparation of the *Hard Problem List* released in November 2005 – Multiple agencies

Cyber Security: A Crisis of Prioritization: Respond to the PITAC report's recommendations – CSIA IWG

Improving Cybersecurity Research in the United States*:* Continue support for National Academies study – DARPA, NIST, NSF

Additional 2006 and 2007 Activities by Agency

NSF: Team for Research in Ubiquitous Secure Technology (TRUST) to transform the ability of organizations to design, build, and operate trustworthy information systems for critical infrastructures; industry/university cooperative research centers in information protection, computer systems, and identification technology; Scholarship for Service program; advanced technology education

OSD (ODDR&E): Through the High Performance Computing Modernization Program, adapt network intrusion detection and analysis tools to improve collective analysis of multiple sensor inputs and to support IPv6

DARPA: R&D in security-aware systems

NSA: Cryptography, cryptographic infrastructure; high-speed security solutions, security-enhanced operating environment, secure wireless multimedia; authentication, privilege management; attack-sensing warning and response, insider threat, and network dynamics

NASA: Next-generation HEC perimeter protection architecture and system for Columbia supercomputer (a possible model for HEC system security at other agencies), including a new security approach for network-intensive applications and the coupling of two-factor authentication to unattended file transfers

NIST: FISMA standards and guidelines; state and local municipality outreach; secure OS and application configuration specifications, identity management, smart-card interoperability specifications, conformance testing; cryptographic standards, guidelines, tool kit, module validation; PDA forensics guidelines and computer forensics tool effectiveness testing; access control, policy management modeling and prototypes; technology-specific security guidelines (e.g., RFID, Web services, Wi-Max); remote authentication methods; wireless/PDA security protocols, mechanisms, and seamless/secure mobility; automated combinatorial testing; National Vulnerability Database

DHS: Vulnerability prevention, discovery, and remediation; cyber security assessment; security and trustworthiness for critical infrastructure protection; wireless security; network attack forensics; technologies to defend against identity theft; continued support for the Process Control Systems Forum

DOE (LLNL): R&D on extracting novel forensic information from hostile scan data and developing statistical and trending analysis for cooperative protection program data

DOJ: Common solutions to security requirements to achieve cost efficiency through broad implementation; incident response and situational awareness

DOT: Secure aircraft data networks and applications; security testing and penetration testing methods; biometrics and access control security for aircraft cockpits and aircraft; risk assessment methods; credentialing; advanced wireless technologies

FAA: Rapid quarantine capability; test biometrics single sign-on; test behavior-based security; enterprise architecture based on the DoD architecture framework; information systems security architecture as enclave with demilitarized zone; integrity and confidentiality lab to test wireless systems security; validate Web data mining that uses concept chain graphs to find vulnerabilities

FBI: Advanced visualization concepts for analyzing various data media types; state-of-the-art integrated analytical tools that support law enforcement investigations; cyber-capabilities-driven enterprise architecture as a business and management tool

TSWG: Secure ground-to-air data communications; automate cyber assessment at the Nuclear Regulatory Commission; develop commercially viable cyber security testing; establish cyber security training center; assess state of the art in infrastructure modeling capabilities

Human-Computer Interaction and Information Management (HCI&IM)

NITRD Agencies: NSF, DoD Service research organizations, NIH, DARPA, NASA, AHRQ, NIST, NOAA, EPA
Other Participants: GSA, NARA

HCI&IM R&D aims to increase the benefit of computer technologies to humans, particularly the science and engineering R&D community. To that end, HCI&IM R&D invests in technologies for mapping human knowledge into computing systems, communications networks, and information systems and back to human beings, for human analysis, understanding, and use. R&D areas include: cognitive systems, data analysis in fields such as human health and the environment, information integration, multimodal and automated language translation, robotics, and user interaction technologies.

Highlights of the President's 2007 Request

Strategic Priorities Underlying This Request

HCI&IM capabilities support key national priorities including large-scale scientific research, national defense, homeland security, air-traffic control, emergency planning and response, health care, space exploration, weather forecasting, and climate prediction. To advance these priorities, HCI&IM R&D is needed in:

Information accessibility, integration, and management: Next-generation methods, tools, and technologies to make it possible to access, integrate, analyze, and efficiently manage massive stores of widely distributed, heterogeneous information (e.g., science and engineering research data, Federal records). These capabilities will help human analysts make better use of all available information resources in the pursuit of new knowledge. The initial focus is on domain-specific collections, with the long-term goal of developing techniques that can be generalized across domains. Needs also include:
- **– Federal information management architecture testbeds:** To evaluate issues in petascale collections of information governed by differing requirements (e.g., national security, personal privacy)
- **– Long-term preservation:** Maintenance of and access to long-lived science and engineering data collections and Federal records

Multimodal devices and interfaces: Human-computer interaction capabilities enabling rapid, easy access (e.g., without a keyboard) to and communication and understanding of heterogeneous information (e.g., audio and text in diverse languages, video, images) for national security applications as well as for assistive devices

Systems that know what they are doing: Cognitive systems able to "learn," adjust to change, and repair themselves, to enhance battlefield capabilities, overall system security, and deployability of robotic devices in emergency-response and hazardous environments

Highlights of Request

Cognitive systems: Continue programs in learning, reasoning, and integrated cognitive systems – DARPA

Global Autonomous Language Exploitation (GALE): New program expanding on Translingual Information Detection, Extraction, and Summarization (TIDES) effort, to reduce the need for linguists and analysts by automatically and rapidly providing translated, distilled information that is relevant and useful to military personnel – DARPA, with NSA, NIST, DLI, CENTCOM, other agencies

Multimodal language recognition and translation: Improved performance and evaluation of human language technologies, including speech-to-text, text retrieval, document summarization, automatic content extraction, speaker and language recognition, dialogue and conversation understanding and summarization, meeting room transcription and summarization, question answering, and machine translation; interactive systems, multimodal user interfaces, and usability – DARPA, NSA, NSF, NIST, DTO, with NARA, other agencies

Data security and data analysis methods: New focus on information privacy and security; research in analysis of digital images and videos; research in methods for computational analysis of data collected in the observational sciences; Office of Cyberinfrastructure strategic plan component for sharing science and engineering data – NSF

Data-intensive discovery and design environments: Interdisciplinary team environments leveraging hyperwalls (wall-size high-resolution tiled display systems) for terascale/petascale data exploration, analysis, and understanding, including concurrent visualization (e.g., real-time rendering, computational steering, and remote access to ongoing computations) and algorithms and tools – NASA

Remote Sensing Information Gateway: Global Earth Observation Systems of Systems (GEOSS) demonstration project to share and integrate Earth observational data with initial applications to support air quality goals – EPA, with NASA, NIH, NOAA

Text Retrieval Conference (TREC): Continue evaluations of information-discovery technologies with tracks on Web retrieval, retrieval of documents for genomics research, question answering, personalized retrieval, and a new legal track – DTO, NIST, NSF, with NARA

Planning and Coordination Supporting Request

National workshop on information integration R&D: Identify key issues for coordinated research such as interoperability, privacy, security, and standards to advance utility of heterogeneous, multimodal information environments – NSF, AHRQ, DoD (ONR), EPA, NARA, with NIST, GSA, other HCI&IM agencies

Drug information and standards: Build system to obtain drug information with standardized definitions and in standardized formats from manufacturers, approve and transmit the information to Federal Web sites, including mapping clinical vocabularies and coding systems to clinical reference terminology adopted by HHS, VA, and DoD, and metadata registry of data standards terms – AHRQ, NIH, NIST, FDA, HHS (CMS), other agencies

Earth System Modeling Framework: Information interoperability and reuse in Earth science applications – NASA, DOE/SC, NOAA, NSF, OSD and DoD Service research organizations, other agencies

Eco-Informatics: Workshop and plans for possible second joint solicitation – NSF, NASA, EPA, other agencies

Health informatics: Planning for collaboration to include workshop(s), joint program – NSF, NIH

Additional 2006 and 2007 Activities by Agency

NSF: University-based research in science and engineering informatics; information integration; data mining, information retrieval; knowledge management; human-computer interaction, universal access, digital government; intelligent robots, machine vision technologies; automatic multilingual speech-recognition toolkits

DoD (ONR): New program in human-robot interaction and collaboration; continue programs in persistent surveillance including autonomous systems (e.g., robots, unattended vehicles) and information exploitation; information integration including multiple sources, disparate data types, and shared analysis tools; human factors and organizational design; portable bi-directional language translator

NIH: Curation and analysis of massive biomedical and clinical research data collections; tools to manage and use new databases; tools for building, integrating ontologies; software tools for visualizing complex datasets; curation tools; build nationwide support for standard vocabularies; information integration

NASA: Continue efforts on agency-wide data exploration architecture with centralized data repository; mobile autonomous robots and intelligent systems; speech-based human-computer interaction; wind down space exploration systems projects, including team-centered virtual adaptive automation, automated design of spacecraft systems, some robotics applications, and decision support system for health management

AHRQ: Continue health IT patient safety/quality improvement program including focus on reducing medical errors in ambulatory care settings and promoting safe use of medications, personal safety, and care delivery that achieves the highest-quality outcome; patient safety health-care IT data standards program; and rural/non-rural/regional projects including health information exchange and state information networks

NIST: Evaluation and standards for biometrics including fingerprint, face recognition, multimodal biometrics for identification and verification; evaluation methodology for multimedia, including video retrieval, motion image quality, video analysis, and content extraction and standards for multimedia (MPEG-7, JPEG); usability of interactive systems and user interfaces for mobile robots, human-robot interaction (HRI); usability and accessibility of voting systems; standards for software usability reporting, IT accessibility; measuring performance of smart systems; ontologies for information integration in manufacturing, commerce; developments in the semantic Web and health-care informatics

NOAA: Technologies for disseminating weather and climate data in multiple formats to professionals, academia, and the public; management of very large datasets, use of metadata, and development of decision support tools for knowledge discovery and data display

EPA: Tools and approaches exploring potential linkages between air quality and human health; integration of search and retrieval techniques across environmental and health libraries; evaluation and investigation of the distribution, integration, management, and archiving of models and datasets

NARA: Advance decision support technologies contributing to high-confidence processing of large collections (e.g., collections of Presidential records)

Large Scale Networking (LSN)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DARPA, DOE/SC, NSA, NASA, AHRQ, NIST, DOE/NNSA, NOAA
Other Participants: USGS

LSN members coordinate Federal agency networking R&D in leading-edge networking technologies, services, and enhanced performance, including programs in new architectures, optical network testbeds, security, infrastructure, middleware, end-to-end performance measurement, and advanced network components; grid and collaboration networking tools and services; and engineering, management, and use of large-scale networks for scientific and applications R&D. The results of this coordinated R&D, once deployed, can assure that the next generation of the Internet will be scalable, trustworthy, and flexible.

President's 2007 Request

Strategic Priorities Underlying This Request

Large-scale data transfers: Enable near-real-time petabyte and above data transfers, by 2008, to support science cooperation and modeling in high-energy physics, bioinformatics, weather, astrophysics, and other areas, overcoming scalability limitations of current technology and the Internet Protocol (IP)

New architectures: Develop future Internet architectures that are flexible, trustworthy (secure, reliable, ensuring privacy), and able to support pervasive computing using wireless access and optical light paths, networked sensors, and innovative applications (e.g., applications on the fly and large-scale information dissemination)

End-to-end performance measurement: Develop visibility into the interior of networks to enable optimization of application performance over networks; implement standard measurement boxes, standard protocols, and cooperation across domain boundaries to allow end-to-end application performance tuning

Highlights of Request

Optical network testbeds (ONTs): NSF's CHEETAH and DRAGON networks, DOE/SC's UltraScience Net; coordinate with OMNInet, OptiPuter, NationalLambda Rail, and regional ONTs; develop GMPLS, QoS, agile circuit-switching, and interdomain control plane protocols, tools, services, and management (e.g., resource reservation, security) – DARPA, DOE/SC, NASA, NSF

Innovative network architectures: Global Environment for Network Investigations (GENI) support of R&D for a large-scale testbed for new scalable, flexible, usable new Internet architectures – NSF with DARPA, DOE/SC, NASA, NIST

Network security research: Provide more trustworthy networking – DARPA, DHS, DOE/SC, NSF, NIST, OSD

End-to-end agile networking, QoS, GMPLS: Develop robust capability and technologies to provide on-demand networking and assured bandwidth for advanced networking applications – DARPA, DOE/SC, NASA, NSF, other agencies

Wireless and sensor networking: Advance capabilities for highly distributed, ubiquitous networking – DARPA, NIST, NSF, other agencies

Large-scale data flows: Infiniband and single-stream flows over WANs – DOE/SC, NASA, NSF, DoD (NRL)

High-speed transport protocols: Develop protocols to move massive amounts of data – DOE/SC, NSF

IPv6 and cyber security implementation: Rollout of IPv6 into research networks in response to OMB requirements – All

End-to-end network performance monitoring and measurement: Identify intrusions and bottlenecks and isolate faults – DARPA, DOE/SC, NSA, NSF, OSD (HPCMPO)

Network backup: Provide alternative capacity during network outages, stress, or national crises – DOE/SC, NASA, OSD (HPCMPO)

International coordination: Leverage investments in federated security regimes and optical networking transparency – DOE/SC, NSF

Planning and Coordination Supporting Request

Co-funding: NSF networking research projects receive support from DARPA, DOE/SC, NSA, DHS

Workshops: Annual government/private sector ONT workshops to provide input into coordinated Federal activities for R&D and promote technology transfer; NSF GENI workshops to coordinate research on new

architectures, experimental infrastructure, and control plane technology; academia/industry/government workshop to identify networking R&D needs – Multiple agencies

Coordination by LSN Teams:

- **– Joint Engineering Team (JET): DOE/SC, NASA, NIH, NIST, NOAA, NSA, NSF, OSD (HPCMPO), USGS, with participation by academic organizations (CAIDA, CENIC, Internet2, ISI, MAX, NLANR, StarLight), national labs (ANL), supercomputing centers (ARSC, MCNC, PSC), universities (FIU, IU, UIC, UMd, UNC, UW), and vendors –** ONTs; engineering research networks (JETnets); security best practices; applications testbeds (IPv6, IPv6 multicast, performance measurement); metrics and monitoring: interdomain, end-to-end, internal network visibility; tool sharing and data exchange; 9,000-byte MTU recommendation; international coordination; transit and services cooperation
- **– Middleware and Grid Infrastructure Coordination (MAGIC) Team: DOE/SC, NIH, NIST, NOAA, NSF, with participation by academic organizations (EDUCAUSE, Internet2, ISI, UCAR), national labs (ANL, LANL, LBL, PNL), universities (UIUC, UMd, UNC, UWisc), and vendors –** Middleware and grid tools and services; applications; coordinated certificate authorities for security and privacy; collaboration infrastructure; standards development; international coordination (e.g., federated certificate authorities under Americas Policy Management Authority)
- **– Networking Research Team (NRT): DARPA, DOE/SC, NASA, NIST, NSA, NSF –** Basic research (technology and systems); prototyping and testing of optical networks (dynamic provisioning, GMPLS-based control plane); applications; wireless, nomadic (ad hoc, mobile) networking; education and training

Information exchange: Multiagency LSN participation in review panels, informational meetings, principal investigator (PI) meetings; tactical coordination among program managers with common interests; coordination of JET meetings with DOE ESSC and Internet2 Joint Techs Meetings; GMPLS forum coordinating development of interdomain signaling in agile optical networks

Additional 2006 and 2007 Activities by Agency

NSF: Support university-based fundamental networking research in trust, pervasive computing; innovative research in architectures, algorithms, protocols, sensor network programming, hardware/software, and privacy/security; programmable wireless networks; network measurement; CAREER awards for networking research; infrastructure research (create, test, harden next-generation systems); middleware development and dissemination

OSD (HPCMPO): IP end-to-end performance measurement, network monitoring tools, IPv6 pilots and IPv6 multicast, network security (IPsec, VPN portals, attack detection tools, filters, encryption), automated management, disaster recovery planning, research network broadband access to Hawaii and Alaska

NIH: R&D on data and computational grids in support of biomedical research, including Biomedical Informatics Research Network (BIRN) and cancer Biomedical Informatics Grid (caBIG); focus on QoS, security, medical data privacy, network management, and collaboratory infrastructure technologies

DARPA: Network-aware control plane; connectionless sensor networks minimizing energy consumption; Situation-Aware Protocols In Edge Network Technologies (SAPIENT); optical data router for >100 Tbps bandwidth

DOE/SC: Middleware and network research (security, data management, standards-based protocols, advanced reservation and scheduling); Open Science Grid (operational infrastructure for large-scale applications); UltraScience Net (research and engineering prototype); connectivity (ESnet, MANs, collaboration services, trust federations and authentication services)

NSA: Internet measurement; wireless networks (ad hoc sensor networks, wireless capacity enhancement, wireless in noisy environments, WLAN QoS, WLAN/WAN simulation); GMPLS evolution for optical networks

NASA: Real-time interactive and grid applications; Columbia supercomputer networking support; network security, data distribution, and real-time visualization

NIST: Internet infrastructure protection, quantum information networks, health-care networks, criminal-justice information systems, wireless ad hoc networks, public safety communications; standards and guidelines for management and assistance; and process control systems protocols and security

NOAA: Advanced networking infrastructure, including lambda-based networking, IPv6, distributed Web servers; computer and network security; applications (collaboration, grid computing (e.g., for storm-scale simulations), wireless, remote operation)

High Confidence Software and Systems (HCSS)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DARPA, NSA, NASA, NIST
Other Participants: DHS, DOE (OE), FAA, FDA

The goal of HCSS R&D is to bolster the Nation's capability and capacity for engineering effective and efficient distributed, real-time, IT-centric systems that are certifiably and inherently dependable, reliable, safe, secure, fault-tolerant, survivable, and trustworthy. These systems, which are often embedded in larger physical and IT systems, are essential for the operation and evolution of the country's national defense, key industrial sectors, and critical infrastructures.

President's 2007 Request

Strategic Priorities Underlying This Request

Demand for new classes of computationally enabled, adaptive, distributed, embedded, and real-time systems for mission- and safety-critical applications. Research is needed to develop:

Next-generation capabilities: Complex new capabilities and foundations for advances in physical and engineered systems for Federal missions and U.S. industrial innovation in key areas such as:
- **– Aerospace systems:** Aircraft autonomy, future airspace operations, human-rated space systems
- **– Automotive systems:** "Drive-by-wire" and intelligent vehicle and highway systems
- **– Critical infrastructure systems:** Beyond supervisory control and data acquisition (SCADA), power grid automation, water management, supply chain integration
- **– Defense systems:** Real-time, distributed, embedded systems in a highly network-centric environment for applications ranging from counterterrorism to ballistic and cruise missile defense
- **– Medical care:** "Operating room of the future," telemedicine, medical devices, paramedic support systems

New high-confidence enabling technologies: Revolutionary paradigms to replace today's operating systems (OSs), middleware (MW), and virtual machines (VMs) that integrate complex mechanisms and enable fault tolerance, dynamic adaptation, partitioning for fault isolation, real-time scheduling, and security

Assurance for complex, integrated systems: New systems built on a principled framework and a new computing technology base for integrating assured concepts that can replace today's inadequate technologies, which were designed for benign environments and noncritical applications and are underpinned by a fragmented collection of theories. Priority research topics include:
- **– Scientific foundations:** Software and systems assurance
- **– Design and engineering advances:** Model-based system design, formal methods, correct-by-construction techniques, and tools for designing, testing, verifying, and validating systems with software as key components, in part to expand the types of software-intensive systems that can be confidently deployed
- **– Assurance measures and metrics:** Ability to justify the degree of confidence in established properties

Highlights of Request

High-confidence, real-time operating systems (RTOS), MW, and VMs: Continue examination of adequacy of current real-time OS, MW, and VM technologies to identify R&D needed to achieve a next-generation high-confidence RTOS technology base; foster university/industry/government R&D partnership; launch a multiagency effort in high-confidence RTOS software, systems, and assurance – NSF, NSA, NIST, OSD (ODDR&E), DoD (AFRL), with NASA, DOE (OE), FAA, FDA, DoD (ONR, USASMDC/ARSTRAT)

Science of Design (SoD): Basic research in design of software-intensive systems that imports and adapts creative scientific ideas from other design fields (e.g., engineering, urban planning, economics, the arts) – NSF

Assured information systems: R&D toward an intelligent, secure flexible, self-protecting global infrastructure; robust protection mechanisms to support sharing of information across diverse communities; development of safe computing platforms that can securely isolate, measure, and attest to correct operations; cryptographic algorithms and engineering to protect the content of information systems – NSA

Verification Grand Challenge: Develop deployable high-assurance technologies for large-scale software systems; begin by convening panels of specialists (i.e., integrated verification systems, theory, system certification) to identify research directions, propose action plan, and suggest projects – NSA, NSF

Deployed and near-term SCADA and industrial control systems: Develop requirements, standards, software assurance metrics, and guidelines – NIST, DHS

Software assurance metrics, tools, evaluation, and databases – NIST, NSA, DHS

Planning and Coordination Supporting Request

High-confidence RTOS technology needs assessments and national roadmapping workshop: Non-disclosure briefings by technology development and systems integration vendors, academic researchers, and RTOS standards organization; initiate university/industry/government partnership; convene workshop(s) to roadmap RTOS R&D – NSF, DoD (AFRL), NIST, NSA, with DoD (ONR, USASMDC/ARSTRAT), OSD (ODDR&E), NASA, DOE (OE), FAA, FDA

High Confidence Medical Device Software and Systems: Ongoing national workshop series – NSF, NSA, with NIST, FDA

Software for Critical Aviation Systems: Begin workshop series – NSF, DoD (AFRL), NSA, with NASA, FAA

Beyond SCADA and Distributed Control Systems: Begin national workshop series on high-confidence devices and software to enable, protect, and evolve critical infrastructures – NSF, NIST, NSA, OSD (ODDR&E), with DoD (AFRL), DHS, DOE (OE)

Black boxes for medical devices: Preliminary study of the benefits of building data recording technologies into medical device systems to provide complete detailed records about their operation for analysis of processes and state prior to and during failures – NSF, with FDA

Open-source software for high-confidence medical devices: Exploration of future directions and practices for certification – NIH, NSF, FDA, other agencies

Sixth annual HCSS conference – NSA, with other HCSS agencies

National Voluntary Lab Accreditation Program (NVLAP): Calibration and/or test methods, protocols, and standards to meet accreditation needs for a variety of products and processes – NIST, NSA

Software Assurance Metrics and Tool Evaluation Workshops: Bring together users, developers of software assurance tools, compare effectiveness of tools and techniques, develop taxonomies of vulnerabilities and tools, and expand a software security assurance standard reference database – NIST, DHS, with other agencies

Sufficient Evidence? Building Certifiably Dependable Systems: Complete National Academies/CSTB study assessing current practices for developing and evaluating mission-critical software – NSF, NSA, DoD (ONR), FAA, with DARPA, DoD (ARO), NASA, NIST, FDA

Additional 2006 and 2007 Activities by Agency

NSF: Fundamental research in distributed, real-time, and embedded systems; operating systems; hybrid discrete and continuous control systems; formal methods for composition and verification; rigorous models of computation; compositional software methods; critical infrastructure component of Cyber Trust

DoD (AFRL): Technology for affordable, safe software; certification technologies for advanced flight-critical systems project; high-confidence design of distributed, embedded systems; advocate high-assurance security architecture for embedded systems

OSD (ODDR&E): Software Engineering Institute research – designs for networked systems that recognize, resist, and recover quickly from attacks; quality attribute reasoning; software architectures and practices that enable automated support, predict runtime behavior of software, and select software components based on certified properties and predicted contribution to assembly behavior; principles, methods, techniques for integration and interoperation across components, systems, systems of systems; model-based software engineering for real-time systems; methods for evidence-based assurance

NASA: Exploration systems – tools and techniques that support cost effective development and verification for autonomous and adaptive systems; aeronautics research – enabling technologies for integrated vehicle health management, integrated intelligent flight deck, and integrated resilient aircraft control sub-elements

NIST: Software diagnostic and conformance tests, tools, and methods; source code analysis tools; National Software Reference Library; voting accuracy standards; software engineering method development

FAA: Certifiably dependable systems, including software certification and incremental certification in traditional safety-critical systems; enhanced methods and standards for engineering security into products and improved continuous external monitoring of a system's internal vital signs; improved continuous security risk assessment in complex networked environment

FDA: Formal-methods-based design, including safety models, forensics, and design for infusion pumps, and blood bank regulatory policy models and certification; architecture, platform, middleware, and resource management, including plug-and-play in the operating room of the future

Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW)

NITRD Agencies: NSF, DoD Service research organizations, NIH, DOE/SC, DOE/NNSA
Other Participants: GSA

The activities funded under the SEW PCA focus on the nature and dynamics of IT and its implications for social, economic, and legal systems as well as the interactions between people and IT devices and capabilities; the workforce development needs arising from the growing demand for workers who are highly skilled in information technology; and the role of innovative IT applications in education and training. SEW also supports efforts to speed the transfer of networking and IT R&D results to the policymaking and IT user communities at all levels in government and the private sector. A key goal of SEW research and dissemination activities is to enable individuals and society to better understand and anticipate the uses and consequences of IT, so that this knowledge can inform social policymaking, IT designs, the IT user community, and broadened participation in IT education and careers.

President's 2007 Request

Strategic Priorities Underlying This Request

Interactions between IT and society: Develop new knowledge about and understanding of the implications of new technologies for economic, social, and technical systems, and their dynamic interactions

Public policy: Sponsor activities that bring SEW researchers and research findings together with policymakers to foster informed decision making

Federal information sharing: Implement a Data Reference Model for information sharing as part of the Federal Enterprise Architecture and e-government initiatives

Government IT practitioner communities: Build communities of practice across all levels of government and private-sector organizations in which practitioners, with support from researchers, can work collaboratively on issues associated with implementing emerging technologies to improve government services

IT education and training: Support innovative educational approaches to broadening participation in IT careers, and doctoral and post-graduate programs to expand the highly skilled workforce in such fields as bio-informatics and computational science

Highlights of Request

Ecology of IT: New program emphases on understanding the ecology of IT, knowledge creation, innovation, and intellectual property issues; information privacy and other human-centered computing priorities; continue broadening participation by underserved communities in IT activities – NSF

Computational Science Graduate Fellowship Program: Continue support for advanced computational science training activity at national laboratories – DOE/NNSA, DOE/SC

Collaborative Expedition Workshops: Continue monthly series of open workshops exploring cost-effective implementations of emerging technologies in delivery of public services at all levels of government, establishing "communities of practice" among IT implementers across government and the private sector, and evaluating Data Reference Model for interoperable Federal information sharing – CIO Council, GSA, NSF, with SEW

Planning and Coordination Supporting Request

SEW functions as a crossroads between the networking and IT R&D community and the larger arena of policymakers and IT implementers. SEW has developed a partnership with GSA and the Federal Chief Information Officers (CIO) Council that sponsors a monthly open workshop series – the Collaborative Expedition Workshops – to encourage collaboration among government and community implementers of IT and to demonstrate promising IT capabilities emerging from Federal research. NSF co-sponsors these events and invites researchers to give academic talks on selected topics in order to bridge gaps between research and policy. The workshops draw participants from Federal, state, and local government, academia, industry, and other communities. The focus is on emerging technologies for applications in such areas as emergency preparedness

and response, environmental protection, public health and health care systems, government information services for citizens, and agency projects under the Administration's Federal Enterprise Architecture and e-government initiatives. Examples of current activities include:

Communities of Practice (COPs): As of 2006, a dozen COPs have been established, including the Data Reference Model Forum, the Federal Data Repository Users Group, the Government Semantic Interoperability COP, Grants.gov COPs, a geospatial COP, the Interoperable Manufacturing COP, and the National Infrastructure for Community Statistics COP

Workshop co-sponsorship: Expedition Workshop held in early FY 2006 on information integration in environments with complex legal and access issues co-sponsored by the HCI&IM CG; other collaborations planned in FY 2006

Additional 2006 and 2007 Activities by Agency

NSF: Continue SEW-related R&D initiated under ITR and core research and education programs; socio-technical issues in intelligence informatics; computing education and the IT workforce; collaborations with the European Commission Information Society and Media Programme; expand opportunities for innovative education and curriculum development projects; participate in human and social dynamics program

NIH: Graduate and postdoctoral fellowship programs in bioinformatics

GSA: Explore emerging standards and technologies that improve interoperability, ease of use, and cost-effectiveness of Federal IT implementations; foster open COPs around application of emerging technologies to improve government services

Software Design and Productivity (SDP)

NITRD Agencies: NSF, OSD and DoD Service research organizations, NIH, DARPA, NASA, NIST, DOE/NNSA, NOAA
Other Participants: FAA

SDP R&D will lead to fundamental advances in concepts, methods, techniques, and tools for software design, development, and maintenance that can address the widening gap between the needs of Federal agencies and society for usable and dependable software-based systems and the ability to produce them in a timely, predictable, and cost-effective manner. The SDP R&D agenda spans both the engineering components of software creation (e.g., development environments, component technologies, languages, tools, system software) and the economics of software management (e.g., project management, schedule estimation and prediction, testing, document management systems) across diverse domains that include sensor networks, embedded systems, autonomous software, and highly complex, interconnected systems of systems.

President's 2007 Request

Strategic Priorities Underlying This Request

Improved software development methods: The overall cost – in time, money, and labor – of developing, upgrading, and maintaining software is the most difficult problem in IT deployment. Assuring the correct functionality, reliability, and security of products and processes that include software adds costs and delays implementation. SDP R&D focuses on cost-effective methods to solve these problems, which undermine overall advancement of IT capabilities. Priorities include:

- **– Frameworks and environments:** Advances that enable agencies to more efficiently develop and certify high-quality software that is critical to Federal agency missions
- **– Next-generation software engineering tools and techniques:** New approaches that reduce the cost, risk, and difficulties of software development; increase the reliability, security, interoperability, scalability, and reusability of software components; and enable software validation and verification

Seamless content interoperability: Software capabilities that enable diverse IT systems, software applications, and networks to exchange and use large volumes of data accurately, effectively, and consistently, both among agencies and between government and the private sector (e.g., data sharing by NASA, NOAA, and DOE/SC across the many interacting modules in the Earth System Modeling Framework (ESMF); availability of electronic health records for doctors, hospitals, and others in the health care industry; and DHS information sharing with 50,000 public-safety agencies)

Highlights of Request

Science of Design (SoD): Make creative scientific advances in the design of software-intensive systems through foundational ideas and theories, including approaches from other design fields; produce intellectually rigorous, analytical, formalized, and teachable body of design knowledge from empirical studies – NSF

Biomedical modeling tools: Develop and disseminate tools to enhance computational modeling of biological, biomedical, and behavioral sciences at scales ranging from the molecular to large populations – NSF, NIH

Collaborative research in computational neuroscience: Provide a theoretical foundation and technological approaches for enhancing understanding of nervous system function through analytical and modeling tools that describe, traverse, and integrate different organizational levels and span broad temporal and spatial scales and multiple levels of abstraction – NIH, NSF

Dynamic Data-Driven Applications Systems (DDDAS): Develop ability to dynamically incorporate additional data into executing applications and enable applications to dynamically steer the measurement process, creating new capabilities in a wide range of science and engineering areas – NSF, NIH, NOAA

Software technology transfer: Embedded Systems Consortium for Hybrid and Embedded Research (ESCHER) for transitioning government-sponsored research results into mainstream or commercial use, including through a quality-controlled software repository – DARPA, NSF

Interoperable biology databases: Develop data standards and ensure interoperability of Internet-based databases important to biotechnology, with emphasis on structural biology – DOE/SC, NIH, NIST, NSF

Software producibility: 2006 new start in building, assuring functionality of, managing, and sustaining software, including net-centric and systems of systems – OSD

Common software infrastructure for climate modeling: ESMF collaboration on building high-performance, flexible software infrastructure to increase ease of use, performance, portability, interoperability, and reuse in climate modeling, numerical weather prediction, data assimilation, and other Earth science applications – NASA, NOAA, DOE/SC

Open-source software: Research that enables users to read, modify, and redistribute source code, fostering more efficient development and increased collaboration to improve software quality – NSF, OSD

Planning and Coordination Supporting Request

Software interoperability workshop: To identify barriers to interoperability, centering on challenge problems whose solution requires new interoperability techniques – SDP CG

Large-scale implementation issues: Briefings by Federal IT user agencies with critical requirements for large-scale software applications to identify development issues and software engineering techniques – SDP CG

Software producibility: National Academies study – OSD, NSF

Additional 2006 and 2007 Activities by Agency

NSF: Software design methods; tools for software testing, analysis, and verification; semantics, design, and implementation of programming languages; scalable software architectures; techniques for handling complex combinations of requirements such as meeting real-time constraints and coordinating control in an embedded, failure-prone environment; compiler and runtime techniques for developing and controlling the execution of complex, dynamically changing applications; requirements for the design and construction of successful-by-design information systems; emphasis on interoperability, robustness, reliability, programmer productivity, maintainability, and software-intensive systems

OSD (HPCMPO): Applications software development in areas such as physics-based design, modeling, simulation, testing; institutes on battlespace topics; PET program tools and techniques for benchmarking, remote visualization, debugging and optimization, interactive computing environments for large datasets

NIH: National Centers for Biomedical Computing (NCBCs) to develop, disseminate, and train users of biomedical computing tools and user environments; encourage collaboration between big and small science at NCBCs; create and disseminate curriculum materials to embed quantitative tools in undergraduate biology education; cancer imaging and computational centers; modeling of infectious disease; bioinformatics resource centers for emerging and re-emerging infectious disease; proteomics and protein structure initiatives; interagency opportunities in multiscale modeling in biomedical, biological, and behavioral systems; individual grants in such topics as simulation and informatics, imaging tools

NIST: Integrated design, procurement, and operation through software interoperability; automated generation of test suites for integration standards; digital library of mathematical functions; ontology for mathematical functions; supply chain software interoperability; international testbed for business-to-business solutions; interoperability of databases for bioinformatics, chemical properties, properties of inorganic materials, and neutron research; ontological approaches to automate integration of supply chain systems; Units Mark-up Language; interface standards for manufacturing control systems; product representation scheme for interoperability among computer-aided engineering systems; standards for exchange of instrument data and chemical reference data; ontological methods for representation and exchange of mathematical data

DOE/NNSA: Provide a production-level, computational environment for ASC platforms, encompassing development tools, visualization and data analysis software, and networking and storage capabilities

FAA: Development of secure, dependable software-based systems in a timely, predictable, and cost-effective manner

Agency NITRD Budgets by Program Component Area

FY 2006 Budget Estimates
and
FY 2007 Budget Requests
(Dollars in Millions)

		High End Computing Infrastructure & Applications	High End Computing Research & Development	Cyber Security & Information Assurance[1]	Human-Computer Interaction & Information Management	Large Scale Networking	High Confidence Software & Systems	Social, Economic, & Workforce Implications of IT	Software Design & Productivity	
Agency		**(HEC I&A)**	**(HEC R&D)**	**(CSIA)**	**(HCI &IM)**	**(LSN)**	**(HCSS)**	**(SEW)**	**(SDP)**	**Total**
NSF	2006 Estimate	220.3	62.7	57.6	207.4	82.2	41.3	91.1	47.9	810.3
	2007 Request	**272.4**	**64.1**	**67.6**	**220.9**	**84.0**	**51.3**	**92.9**	**50.7**	**903.7**
OSD and DoD Service research orgs.[2,3]		214.6	9.8	0.6[4]	138.5	141.8	31.2	0.2	6.9	543.7
		186.0	**8.7**	**0.7[4]**	**135.6**	**130.7**	**29.1**	**0.3**	**6.8**	**497.8**
NIH[5]		198.5			188.7	74.9	8.4	12.3	17.9	500.6
		194.7			**183.2**	**74.6**	**8.3**	**12.2**	**17.7**	**490.7**
DARPA[3]			94.1	78.7	174.2	21.3				368.3
			117.7	**81.6**	**233.2**	**33.2**				**465.7**
DOE/SC[6]		104.4	109.1			38.9		3.5		255.8
		135.3	**160.4**			**45.0**		**4.0**		**344.7**
NSA[3]			89.2	14.1		1.0	36.2			140.5
			62.4	**13.3**		**2.3**	**39.9**			**117.9**
NASA		60.3		1.3	2.0	5.7	7.0		1.8	78.1
		63.9		**1.3**	**2.0**	**6.0**	**7.0**		**1.8**	**82.0**
AHRQ[5]					40.1	21.6				61.7
					37.3	**20.0**				**57.3**
NIST[7]		2.3	1.2	9.1	7.8	4.3	9.6		4.6	38.9
		2.3	**1.2**	**11.1**	**9.8**	**4.3**	**9.6**		**4.6**	**42.9**
DOE/NNSA[6]		10.0	15.9			1.6		4.6	3.3	35.4
		9.5	**23.4**			**1.6**		**4.6**	**2.8**	**41.9**
NOAA[7]		11.4	1.9		0.2	0.7			1.6	15.8
		16.4	**1.9**		**0.5**	**2.9**			**1.6**	**23.3**
EPA		3.3			3.0					6.3
		3.3			**3.0**					**6.3**
TOTAL (2006 Estimate)		825.0	383.9	161.3	761.9	393.9	133.6	111.6	84.0	2,855
TOTAL (2007 Request)		**883.8**	**439.9**	**175.5**	**825.4**	**404.5**	**145.2**	**114.0**	**85.9**	**3,074**

[1] The CSIA PCA budget should not be viewed as the total Federal investment in cyber security R&D. This figure includes only reporting for NITRD member agencies; it does not include investments at other agencies that support cyber security R&D, including DHS, DOJ, TSWG, non-NITRD-member organizations within DOE, and others. Furthermore, funding categorized under the HCSS PCA includes investments in various areas associated with secure and trustworthy systems. These investments are classified under HCSS – a PCA that has historically been part of the NITRD Program – but would be considered to fall within the generic scope of cyber security R&D if HCSS did not exist as a separate PCA.

[2] The OSD budget includes for the first time this year funding from the DoD Service research organizations (Air Force, Army, Navy) as well as DoD's High Performance Computing Modernization Program Office (HPCMPO). Total NITRD budgets for the DoD Service research organizations are as follows: Air Force – $133 million (2006 estimate) and $139 million (2007 request); Army – $141 million (2006 estimate) and $120 million (2007 request), and Navy – $35 million (2006 estimate) and $33 million (2007 request). NITRD-related R&D budgets for HPCMPO are $203 million (2006 estimate) and $174 million (2007 request).

[3] Combined OSD, DARPA, and NSA agency totals supersede the Department of Defense total appearing in the President's 2007 Budget. Discrepancies result from rounding and late shifts in budget accounting.

[4] The share of DoD Service research organizations' NITRD funding reported in CSIA may increase in future years as some R&D currently reported in other PCAs may be reclassified as CSIA R&D, and other PCA reporting would decrease accordingly.

[5] Combined NIH and AHRQ agency totals supersede the Department of Health and Human Services total appearing in the President's 2007 Budget. Discrepancies result from rounding and late shifts in budget accounting.

[6] Combined DOE/SC and DOE/NNSA agency totals supersede the Department of Energy total appearing in the President's 2007 Budget. Discrepancies result from late shifts in budget accounting.

[7] Combined NIST and NOAA agency totals supersede the Department of Commerce total appearing in the President's 2007 Budget. Discrepancies result from rounding and late shifts in budget accounting.

NITRD Program Budget Analysis

2006 and 2007 Budget Overview

In general, differences between the President's Budget request for a given year and estimated spending for that year reflect revisions to program budgets due to evolving priorities, as well as Congressional actions and appropriations. While budget information reported on the preceding page includes such variations, several additional factors specific to the NITRD Program have led to substantial differences between the 2006 budget request and 2006 estimated spending. These include the addition of the CSIA PCA to the NITRD Program, new reporting of activities in response to evolving definitions of NITRD PCAs, and the addition of reporting from organizations that had participated in coordinated NITRD activities but had not previously been included in the NITRD budget crosscut. For example, OSD's High Performance Computing Modernization Program Office (HPCMPO) and DoD Service research organizations (Air Force, Army, and Navy) have been added to the crosscut. In addition, efforts at several agencies to improve the classification and characterization of agency activities have resulted in noteworthy changes in budget reporting ranging from additional reporting or removal of out-of-scope investments to shifts of funds between PCAs.

2006 Summary

The estimated 2006 NITRD budget is $2.86 billion, which is a $0.70 billion increase over the $2.16 billion 2006 request. Of this increase, approximately $0.08 billion represents actual increases in spending above 2006 requested funds. The remaining $0.62 billion increase is the combination of an additional $0.18 billion in newly reported funding due to the addition of the CSIA PCA and evolving PCA definitions, an increase of $0.52 billion due to the addition of OSD's HPCMPO and DoD Service research organizations, and a reduction of $0.08 billion due to improved classification and characterization of agency activities.

Changes to NITRD agency budgets are explained in detail in the Analysis by Agency section below. Due to these changes, the 2006 budget request published in last year's NITRD Budget Supplement no longer provides an effective baseline for comparison to the 2007 request and future budgets.

2007 Summary

The 2006 estimates and the 2007 budget requests in the table on the preceding page include reporting from the same agencies and make use of the same scope, definitions, and classification of investments. Thus, the 2006 estimates serve as an appropriate baseline for comparison with the 2007 requests and future budgets.

The President's 2007 Budget request for the NITRD Program is $3.07 billion, an increase of $0.21 billion over the $2.86 billion 2006 estimate. The 2007 budget requests funding increases above 2006 estimated spending for all eight NITRD PCAs. The high-end computing PCAs account for slightly more than half of the increase, and the HCI&IM PCA accounts for approximately another quarter of the increase.

The Administration's recently announced American Competitiveness Initiative has increased the NITRD budgets of agencies that are part of the Initiative. The Initiative calls for a doubling over 10 years of the investment in three Federal agencies that support basic research programs in the physical sciences and engineering. These agencies – NSF, DOE/SC, and NIST – are NITRD Program member agencies. All three received 2007 NITRD budget increases that exceed the percentage increase in the overall Program budget, as follows: NSF, 12 percent; DOE/SC, 35 percent; and NIST, 10 percent. The aggregated NITRD budget increase for these three agencies from 2006 estimates to 2007 request is $186 million (17 percent above 2006 estimates), which accounts for over 85 percent of the overall NITRD Program budget increase for 2007.

Budget numbers are rounded to the nearest million in the discussions that follow, and may result in minor discrepancies in sums due to rounding.

NITRD Program Budget Analysis by Agency

The following NITRD Program budget analysis by agency summarizes 2006 estimates and 2007 requests for each NITRD agency and provides explanations of significant[8] changes in budget – either differences between 2006 requested funding and 2006 estimated spending or changes between 2006 estimated spending and 2007 requests.

NSF

Comparison of 2006 request ($803 million) and 2006 estimate ($810 million): The increase in HEC I&A is due largely to pooling 2005 and 2006 funding to increase the size of a planned HEC system acquisition. Some HEC R&D funding has been moved to HEC I&A to better reflect the nature of work being done under certain HEC grants. HEC funding for work related to the collection and management of large datasets resulting from HEC applications has been moved to HCI&IM. The increase in HCI&IM is also due to increased R&D for better management of scientific data, as part of NSF's cyberinfrastructure investments. HCSS shows a decrease because some funding previously reported in HCSS is now reported under CSIA; however the sum of the CSIA and HCSS budgets has increased by $23 million due to greater investment in related areas. This increase is offset by decreases in the LSN and SDP budgets.

Comparison of 2006 estimate ($810 million) and 2007 request ($904 million): HEC I&A increases $52 million to support the acquisition of a petascale leadership-class HEC system. HCI&IM increases $14 million for cyberinfrastructure-related data and information management R&D. CSIA and HCSS each increase $10 million, reflecting continued emphasis on Cyber Trust and related high-confidence and information assurance research activities.

OSD and DoD Service research organizations

Comparison of 2006 request ($22 million) and 2006 estimate ($544 million): The NITRD budget includes for the first time this year funding from OSD (HPCMPO) and DoD Service research organizations, which is in addition to previously reported funding from OSD's Office of the Director, Defense Research and Engineering (ODDR&E). The 2006 estimate for HPCMPO is $210 million. The 2006 estimates for the DoD Service research organizations are $133 million for the Air Force, $141 million for the Army, and $35 million for the Navy.

The increase in the two HEC PCAs is primarily due to the addition of OSD's HPCMPO to NITRD Program reporting, with a small additional contribution due to the addition of DoD Service research organizations. The reporting of funding in HCI&IM is due to the addition of reporting by DoD Service research organizations, as is nearly all of the funding reported in LSN. To more accurately reflect the nature of the work being performed by OSD's Software Engineering Institute, the $18 million investment associated with this work was shifted from the SDP budget to the HCSS budget. The remaining increases in these two PCA budgets are due to the addition of the DoD Service research organizations.

Comparison of 2006 estimate ($544 million) and 2007 request ($498 million): The reduction in the HEC I&A budget is the result of reductions to the HPCMPO budget, as part of broader DoD funding reallocations. The reduction in the LSN budget is the result of reductions to the Army budget, as part of broader DoD funding reallocations.

NIH

Comparison of 2006 request and 2006 estimate (both $501 million): Nearly all NIH investments previously reported as HEC R&D have been reclassified as HEC I&A. This and other movements of funds from one PCA to another do not represent changes in programmatic investments, but have been made to better align the reporting of NIH investments with the definitions of the NITRD PCAs.

Comparison of 2006 estimate ($501 million) and 2007 request ($491 million): The overall agency budget reflects a two percent reduction in the NIH NITRD budget.

DARPA

Comparison of 2006 request ($176 million) and 2006 estimate ($368 million): The $13 million increase in the HEC R&D budget reflects the inclusion of the Architectures for Cognitive Information Processing program. The

[8] For the purpose of this analysis, budget differences that exceed $10 million for an agency within a single PCA are considered "significant" enough to warrant explicit explanation. For agencies with smaller overall NITRD budgets, explanations are provided for differences that account for significant percentages of an agency's PCA budget, even in instances where those changes are smaller than $10 million.

addition of the CSIA PCA to the NITRD Program resulted in $79 million of new reporting. The evolving definition of HCI&IM led to $100 million of new funding reported for that PCA, for DARPA's Learning, Reasoning and Integrated Cognitive Systems programs.

Comparison of 2006 estimate ($368 million) and 2007 request ($466 million): The $24 million increase in HEC R&D is for Phase III of the High Productivity Computing Systems program. The $59 million increase in HCI&IM is due to increases in DARPA's language translation programs. The $12 million increase in LSN is the result of scaling up cognitive networking activities for technical demonstrations and testbeds with the military services.

DOE/SC

Comparison of 2006 request ($227 million) and 2006 estimate ($256 million): The $27 million increase in HEC R&D is to support development of a HEC Leadership Computing Facility at Oak Ridge National Laboratory.

Comparison of 2006 estimate ($256 million) and 2007 request ($345 million): The $31 million increase in HEC I&A is to enhance SciDAC partnerships to deliver applications for petascale computing systems in areas critical to DOE missions and complementary investments to expand high-performance computing capacity at NERSC. The $51 million increase in HEC R&D is for enhancements to the Leadership Computing Facility including investments at ORNL and investments at ANL in low power density leadership-class computing, which were a part of the original competitively selected Leadership Computing Facility proposal.

NSA[9]

Comparison of 2006 request ($101 million) and 2006 estimate ($141 million): HEC R&D increased $52 million to accelerate Black Widow and Eldorado system investments; a $12 million reduction in HCSS investments helped offset this increase. The decrease in the HCSS budget is also due to a shift in reporting of $14 million of investments to the new CSIA PCA.

Comparison of 2006 estimate ($141 million) and 2007 request ($118 million): With accelerated investments in 2006, Black Widow R&D will be largely completed, reducing funding required in 2007.

NASA

Comparison of 2006 request ($74 million) and 2006 estimate ($78 million): HEC I&A increased $7 million due to Columbia high-end computing system costs being higher than initially estimated. A shift to agency-wide management of HEC investments adds an additional $19 million of investments at Goddard Space Flight Center to HEC I&A. Reductions in HCI&IM, LSN, and HCSS are due to NASA's continuing transformation to focus on R&D aimed at implementing its Vision for Space Exploration.

Comparison of 2006 estimate ($78 million) and 2007 request ($82 million): NASA's budget remains relatively stable from 2006 to 2007.

AHRQ

Comparison of 2006 request ($68 million) and 2006 estimate ($62 million): AHRQ's LSN budget decreases due to reductions in research on privacy and security law, and in health information exchanges at the state level in support of large-scale exchanges of health information at regional and national levels.

Comparison of 2006 estimate ($62 million) and 2007 request ($57 million): Beginning in 2007, the HHS will take the lead on data standards interagency agreements, resulting in some of the $10 million that AHRQ had budgeted for this work being reallocated to spending outside of the NITRD Program.

NIST

Comparison of 2006 request ($42 million) and 2006 estimate ($39 million): Reductions in HEC I&A and HCI&IM spending account for the decrease in NIST's budget. The addition of CSIA as a new PCA results in funding that had previously been reported under HCSS now being nearly equally divided between the CSIA and HCSS PCAs.

Comparison of 2006 estimate ($39 million) and 2007 request ($43 million): NIST's budget receives a $4 million increase from 2006 to 2007, divided equally between the CSIA and HCI&IM PCAs.

[9] NSA's budget reporting includes unclassified funding from DTO (formerly ARDA).

DOE/NNSA

Comparison of 2006 request ($114 million) and 2006 estimate ($35 million): A portion of the reduction in DOE/NNSA's budget is due to decreases in the ASC Program budget. The bulk of the reduction does not correspond to changes in programmatic activities, but is due to new classification and characterizations of DOE/NNSA investments resulting from new business processes in use at the agency. The percentage of major technical efforts categorized as R&D has been reduced in several instances, while investments in network infrastructure, legacy codes, infrastructure operations and maintenance, data management activities, storage procurements, and software tools development and licenses have been characterized as outside the scope of R&D activities. For comparison, had investments been categorized per these new business processes last year, the previously reported 2006 request would have been $39 million.

Comparison of 2006 estimate ($35 million) and 2007 request ($42 million): The main component of DOE/NNSA's budget increase is an increase of $8 million in HEC R&D, to support participation as a mission partner in Phase III of DARPA's HPCS program, and to pursue a next-generation successor to the BlueGene/L high-end computing system.

NOAA

Comparison of 2006 request ($20 million) and 2006 estimate ($16 million): The decrease in NOAA's budget, mostly in HEC I&A, is due to Congressional action reducing NOAA's operations, research, and facilities budget.

Comparison of 2006 estimate ($16 million) and 2007 request ($23 million): The 2007 request restores funds cut in 2006 and includes additional increases, mainly to HEC I&A.

EPA

Comparison of 2006 request, 2006 estimate and 2007 request (all $6 million): The NITRD Program budget for EPA remains level at $6 million.

NITRD Program Budget Summary by PCA

A broad analysis of the NITRD Program budget by PCA, which summarizes the most substantial changes to PCA budgets in 2007 using 2006 estimated spending as a baseline, appears below. This section summarizes the more detailed information about significant changes within agency budgets provided above.

Because of the continuing priority placed on high-end computing by the Administration, the 2007 budget request for HEC I&A is $884 million, an increase of $59 million above 2006 estimated spending. The bulk of the new funding is requested by NSF and DOE/SC for procurements of and/or enhancements to leadership-class computing systems. Budget increases more than offset the reduction in OSD's HEC I&A budget, due to higher-level funding reallocations within DoD, primarily within HPCMPO.

Also because of the budget emphasis on high-end computing, the 2007 budget request for HEC R&D is $440 million, an increase of $56 million above 2006 estimated spending. Most of the change is accounted for by budget increases for DOE/SC to enhance its SciDAC partnerships and for DARPA for Phase III of the HPCS program, a planned decrease in NSA's request due to the 2006 acceleration of Black Widow R&D, and an increase in DOE/NNSA's request.

As a new NITRD PCA, CSIA reports R&D in the NITRD Program Budget Supplement for the first time this year. The 2007 budget request for CSIA is $176 million,[10] an increase of $14 million above 2006 estimated spending. This increase is mainly the result of a larger budget request at NSF due to an elevated emphasis on cyber security via the Cyber Trust program and related activities.

The 2007 budget request for HCI&IM is $825 million, an increase of $63 million above 2006 estimated spending. Budget request increases at NSF for R&D in scientific data management and at DARPA for its Learning, Reasoning and Integrated Cognitive Systems programs are the most substantial changes for this PCA.

The 2007 budget request for LSN is $405 million, an increase of $11 million above 2006 estimated spending. Increases in budget requests at DARPA for scaling up cognitive networking activities, and at DOE/SC for enhancements to ESnet to support management of petascale data from scientific facilities and high performance

[10] Please see footnote 1 on page 20.

computing facilities, account for most of the change in this PCA. Budget increases more than offset the reduction in DoD Service research organizations' LSN budget, due to higher-level funding reallocations within DoD, primarily within the Army.

The 2007 budget request for HCSS is $145 million, an increase of $12 million above 2006 estimated spending. An increase in NSF's budget request for HCSS accounts for most of this difference.

The 2007 budget request for SEW is $114 million, an increase of $2 million above 2006 estimated spending. Funding for this PCA remains relatively stable.

The 2007 budget request for SDP is $86 million, an increase of $2 million above 2006 estimated spending. Funding for this PCA remains relatively stable.

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Participation in the NITRD Program

The following goals and criteria developed by the NITRD Program are intended to enable agencies considering participation to assess whether their research and development activities fit the NITRD framework.

NITRD Goals

- Provide research and development foundations for assuring continued U.S. technological leadership in advanced networking, computing systems, software, and associated information technologies
- Provide research and development foundations for meeting the needs of the Federal government for advanced networking, computing systems, software, and associated information technologies
- Accelerate development and deployment of these technologies in order to maintain world leadership in science and engineering; enhance national defense and national and homeland security; improve U.S. productivity and competitiveness and promote long-term economic growth; improve the health of the U.S. citizenry; protect the environment; improve education, training, and lifelong learning; and improve the quality of life.

Evaluation Criteria for Participation

Relevance of Contribution
The research must significantly contribute to the overall goals of the NITRD Program and to the goals of one or more of the Program's eight Program Component Areas (PCAs) – High End Computing Infrastructure and Applications (HEC I&A), High End Computing Research and Development (HEC R&D), Cyber Security and Information Assurance (CSIA), Human-Computer Interaction and Information Management (HCI&IM), Large Scale Networking (LSN), High Confidence Software and Systems (HCSS), Social, Economic, and Workforce Implications of Information Technology (IT) and IT Workforce Development (SEW), and Software Design and Productivity (SDP) – in order to enable the solution of applications and problems that address agency mission needs and that place significant demands on the technologies being developed by the Program.

Technical/Scientific Merit
The proposed agency program must be technically and/or scientifically sound, of high quality, and the product of a documented technical and/or scientific planning and review process.

Readiness
A clear agency planning process must be evident, and the organization must have demonstrated capability to carry out the program.

Timeliness
The proposed work must be technically and/or scientifically timely for one or more of the PCAs.

Linkages
The responsible organization must have established policies, programs, and activities promoting effective technical and scientific connections among government, industry, and academic sectors.

Costs
The identified resources must be adequate to conduct the proposed work, promote prospects for coordinated or joint funding, and address long-term resource implications.

Agency Approval
The proposed program or activity must have policy-level approval by the submitting agency.

Glossary

AFRL - DoD's Air Force Research Laboratory
AHRQ - HHS's Agency for Healthcare Research and Quality
ANL - DOE's Argonne National Laboratory
ARC - NASA's Ames Research Center
ARDA - Advanced Research and Development Activity (superseded by the Disruptive Technology Office)
ARL - DoD's Army Research Laboratory
ARO - DoD's Army Research Office
ARSC - Arctic Region Supercomputing Center
ASC - DOE/NNSA's Advanced Simulation and Computing program (formerly ASCI, for Accelerated Strategic Computing Initiative)
BIRN - NIH's Biomedical Informatics Research Network
Black Widow - NSA-supported next-generation (2007) system in the X1/X1e massively parallel, vector-processing system line
BlueGene - A vendor supercomputing project dedicated to building a new family of supercomputers
BlueGene/L - Scalable experimental new supercomputing system being developed in partnership with DOE/SC and DOE/NNSA; expected to achieve 300-teraflops+ processing speeds
BlueGene/P - The next generation in the BlueGene line after BlueGene/L
CaBIG - NIH's cancer Biomedical Informatics Grid
CAIDA - Cooperative Association for Internet Data Analysis
CAREER - NSF's Faculty Early Career Development Program
CENIC - Corporation for Network Initiatives in California
CENTCOM - DoD's United States Central Command
CG - Coordinating Group
CHEETAH - NSF's Circuit-switched High-speed End-to-End ArcHitecture network
CIIP - Critical Information Infrastructure Protection
CIO - Chief information officer
CMS - HHS's Centers for Medicare and Medicaid Services
COPs - Communities of practice
CSIA - Cyber Security and Information Assurance, one of NITRD's eight Program Component Areas
CSTB - Computer Science and Telecommunications Board of the National Academies
DARPA - DoD's Defense Advanced Research Projects Agency
DDDAS - Dynamic Data Driven Applications Systems
DETER - NSF- and DHS-initiated cyber DEfense Technology Experimental Research network
DHS - Department of Homeland Security
DLI - DoD's Defense Language Institute
DNS - Domain Name System
DOC - Department of Commerce
DoD - Department of Defense
DOE - Department of Energy
DOE/NNSA - DOE/National Nuclear Security Administration
DOE (OE) - DOE's Office of Electricity Delivery and Energy Reliability
DOE/SC - DOE's Office of Science
DOJ - Department of Justice
DOT - Department of Transportation
DRAGON - NSF's Dynamic Resource Allocation (via GMPLS) Optical Network
DTO - Disruptive Technology Office (formerly ARDA); budget reported through NSA this year
Eldorado - NSA-supported multithreaded system
EMIST - NSF/DHS Evaluation Methods for Internet Security Technology project
EPA - Environmental Protection Agency
ESCHER - Embedded Systems Consortium for Hybrid and Embedded Research, a joint effort of DARPA and NSF
ESMF - Earth System Modeling Framework
ESnet - DOE/SC's Energy Sciences network
ESSC - DOE/SC's Energy Sciences network (ESnet) Steering Committee
ETF - Extensible Terascale Facility
FAA - DOT's Federal Aviation Administration
FBI - Federal Bureau of Investigation
FDA - HHS's Food and Drug Administration
FISMA - Federal Information Security Management Act
FIU - Florida International University
FY - Fiscal Year
GALE - DARPA's Global Autonomous Language Exploitation program
GENI - NSF's Global Environment for Network Investigations
GEOSS - Global Earth Observation System of Systems, a cooperative effort of 34 nations, including the U.S., and 25 international organizations to develop a comprehensive, coordinated, and sustained Earth observation system
GMPLS - Generalized Multi-Protocol Label Switching
GSA - General Services Administration
GSFC - NASA's Goddard Space Flight Center
HCI&IM - Human-Computer Interaction and Information Management, one of NITRD's eight Program Component Areas
HCSS - High Confidence Software and Systems, one of NITRD's eight Program Component Areas
HEC - High-end computing
HEC I&A - HEC Infrastructure and Applications, one of NITRD's eight Program Component Areas
HEC R&D - HEC Research and Development, one of NITRD's eight Program Component Areas
HECRTF - High-End Computing Revitalization Task Force
HEC-URA - HEC University Research Activity, jointly funded by multiple NITRD agencies
HHS - Department of Health and Human Services
HPC - High-performance computing
HPCMPO - OSD's High Performance Computing Modernization Program Office
HPCS - DARPA's High Productivity Computing Systems program
HRI - Human-robot interaction
INCITE - DOE/SC's Innovative and Novel Computational Impact on Theory and Experiment program
Infiniband - A high-speed serial computer bus, intended for both internal and external connections
I/O - Input/output
IP - Internet Protocol
IPsec - IP security protocol
IPv6 - Internet protocol, version 6
IRS - Internal Revenue Service
ISI - Information Sciences Institute
IT - Information technology
ITR - NSF's Information Technology Research program
IT R&D - Information technology research and development
IU - Indiana University
IWG - Interagency Working Group
JET - LSN's Joint Engineering Team
JETnets - Federal research networks supporting networking researchers and advanced applications development
JPEG - An image file format developed by the Joint Photographic Experts Group

LANL - DOE's Los Alamos National Laboratory
LBL - DOE's Lawrence-Berkeley National Laboratory
LCF - DOE's Leadership Computing Facility
LSN - Large Scale Networking, one of NITRD's eight Program Component Areas
MAGIC - LSN's Middleware and Grid Infrastructure Coordination team
MAN - Metropolitan area network
MAX - Mid-Atlantic eXchange
MCNC - Microelectronics Center of North Carolina
MIDAS - NIH's Modeling of Infectious Disease Agents Study
MPEG-7 - Moving Picture Experts Group's multimedia content description interface, release 7
MPI - Message-passing interface
MTU - Maximum transmission unit
MURI - Multidisciplinary University Research Initiative
MW - Middleware
NARA - National Archives and Records Administration
NASA - National Aeronautics and Space Administration
NationalLambda Rail - Consortium of organizations working to provide an optical network for research
NCAR - NSF-supported National Center for Atmospheric Research
NCBC - NIH's National Centers for Biomedical Computing
NCS-A - DOE/SC NERSC's new computer system-A
NCS-B - DOE/SC NERSC's 7-TF new computer system-B
NCSA - NSF-supported National Center for Supercomputing Applications
NERSC - DOE/SC's National Energy Research Scientific Computing Center
NERSC-4 - DOE/SC NERSC's 9-TF SP3 computing platform
NERSC-5 - DOE/SC NERSC's planned next-generation (100-150 TF) platform
NIH - HHS's National Institutes of Health
NIST - National Institute of Standards and Technology
NITRD - Networking and Information Technology Research and Development
NLANR - NSF-supported National Laboratory for Applied Network Research
NLM - NIH's National Library of Medicine
NOAA - National Oceanic and Atmospheric Administration
NRT - LSN's Networking Research Team
NSA - National Security Agency
NSF - National Science Foundation
NSTC - National Science and Technology Council
NVLAP - National Voluntary Lab Accreditation Program, supported by NIST and NSA
ODDR&E - OSD's Office of the Director, Defense Research and Engineering
OMB - White House Office of Management and Budget
OMNInet - Large-scale metro optical network testbed supported by national labs, universities, Canadian organizations, and vendor partners
ONR - DoD's Office of Naval Research
ONT - Optical networking testbed
OptiPuter - NSF-funded five-year project to interconnect distributed storage, computing, and visualization resources using photonic networks
ORNL - DOE's Oak Ridge National Laboratory
OS - Operating system
OSD - Office of the Secretary of Defense
OSTP - White House Office of Science and Technology Policy
PCA - Program Component Area
PDA - Personal digital assistant
PET - OSD (HPCMPO)'s Programming Environment and Training program
PI - Principal investigator
PITAC - President's Information Technology Advisory Committee
PNL - DOE's Pacific Northwest Laboratory
PSC - NSF-supported Pittsburgh Supercomputing Center
Purple - DOE/NNSA ASC's 100-TF SMP supercomputing platform under development, in tandem with Blue Gene/L, at LLNL
QoS - Quality of service
R&D - Research and development
ROM - Read-only memory
RTOS - Real-time operating system
SAPIENT - DARPA's Situation-Aware Protocols in Edge Network Technologies program
SC - DOE's Office of Science
SCADA - Supervisory control and data acquisition
SciDAC - DOE/SC's Scientific Discovery through Advanced Computing program
SDP - Software Design and Productivity, one of NITRD's eight Program Component Areas
SDSC - NSF-supported San Diego Supercomputer Center
SEW - Social, Economic, and Workforce Implications of IT and IT Workforce Development, one of NITRD's eight Program Component Areas
SoD - NSF's Science of Design program
SP3 - 7-TF scalable parallel platform at NERSC
StarLight - NSF-supported international optical network peering point in Chicago
State - Department of State
TF - Teraflop(s), a trillion floating point operations (per second)
TIDES - DARPA-funded Translingual Information Detection, Extraction and Summarization program
Treasury - Department of the Treasury
TREC - Text REtrieval Conference
TRUST - NSF's Team for Research in Ubiquitous Secure Technology
TSWG - Technical Support Working Group
UCAR - University Corporation for Atmospheric Research
UIC - University of Illinois at Chicago
UIUC - University of Illinois at Urbana-Champaign
UltraScience Net - DOE/SC's experimental research network
UMd - University of Maryland
UNC - University of North Carolina
USGS - United States Geological Survey
USASMDC/ARSTRAT - U.S. Army Space and Missile Defense Command/Army Forces Strategic Command
UW - University of Washington
UWisc - University of Wisconsin
VA - Department of Veterans Affairs
V&V - Verification and validation
VM - Virtual machine
VPN - Virtual private network
WAN - Wide area network
Wi-Max - Worldwide interoperability for microwave access, a set of wireless standards
WLAN - Wireless local area network
WRF - Weather Research and Forecasting model, a next-generation mesocale numerical weather prediction system developed collaboratively by Federal agencies
X1 - Scalable, hybrid scalar-vector high-end computing system developed with support from NSA and ODDR&E
X1e - follow-onFollow-on to the X1 (see Black Widow)
XT3 - Third generation of massively parallel processor (MPP) systems, following predecessors T3D and T3E

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