NETWORKING AND INFORMATION TECHNOLOGY R&D

The National Science Foundation is a primary federal agency supporting the Networking and Information Technology Research and Development (NITRD) program. NSF's NITRD portfolio includes all funding in the Directorate for Computer and Information Science and Engineering (CISE) and the Office of Cyberinfrastructure (OCI), and contributions from all of the agency's other directorates. NSF makes research, education, or research infrastructure investments in every NITRD Program Component Area (PCA). NSF's Assistant Director for CISE is co-chair of the NITRD Subcommittee of the National Science and Technology Council's Committee on Technology, and OCI provides NSF representation to the subcommittee. In addition, NSF works in close collaboration with other NITRD agencies and participates at the co-chair level in five of the seven PCA Coordinating Groups and all of the Senior Steering Groups.

NSF's FY 2013 Request continues strong support for NITRD at a level of $1.207 billion, a 6.1 percent increase over the FY 2012 Estimate. NITRD activities represent approximately 16 percent of NSF's FY 2013 budget. CISE and OCI's combined support comprises 77 percent of NSF's NITRD activities.

Several NSF-wide investments, both new and continuing, are reflected in various NITRD PCAs:
- Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21), designed to develop and deploy comprehensive, integrated, sustainable, and secure cyberinfrastructure to accelerate research and new functional capabilities in computational and data-intensive science and engineering, primarily supports investments in six program component areas: Large Scale Networking; High End Computing Research and Development (R&D); High End Computing Infrastructure and Applications; Human-Computer Interaction and Information Management; Software Design and Productivity; and Social/Economic/Workforce Implications of IT and IT Workforce Development.
- The Science, Engineering, and Education for Sustainability (SEES) cross-Foundation investment supports activities in Large Scale Networking as well as in Software Design and Productivity, High End Computing R&D, and Social/Economic/Workforce Implications of IT and IT Workforce Development.
- The National Robotics Initiative (NRI), a cross-agency initiative engaging four U.S. agencies (NSF, NASA, NIH and USDA) in a concerted program to provide U.S. leadership in science and engineering research and education aimed at the development of next generation robotics, supports activities in Human-Computer Interaction and Information Management, High Confidence Software and Systems, and Social/Economic/Workforce Implications of IT and IT Workforce Development.
- Advanced Manufacturing investments encompass research in nanotechnology, cyber-physical systems, and robotics, as well as expanded industry/university cooperation. Activities are supported in High End Computing R&D, High End Computing Infrastructure and Applications, and High Confidence Software and Systems.
- Enhancing Access to the Radio Spectrum (EARS), which supports research in wireless communication, spectrum sharing, and mobile computing, as well as the development of wireless testbeds, supports activities in Large Scale Networking, High End Computing R&D, and High End Computing Infrastructure and Applications.
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS), expands the Cyber-Physical Systems (CPS) program to accelerate advances in 21st century smart engineered systems. CEMMSS will begin to establish a scientific basis for engineered systems interdependent with the physical world and social systems; synthesize multi-disciplinary knowledge to model and simulate systems in their full complexity and dynamics; and develop a smart systems technology framework. CEMMSS includes investments in the National Robotics Initiative (NRI), an important multi-agency activity. CEMMSS supports activities in High End Computing R&D, High Confidence Software and

Systems, Human-Computer Interaction and Information Management, Software Design and Productivity, and Social/Economic/Workforce Implications of IT and IT Workforce Development.

- The Comprehensive National Cybersecurity Initiative (CNCI) supports activities in Cybersecurity and Information Assurance.
- Secure and Trustworthy Cyberspace (SaTC) aligns NSF cybersecurity investments (including investments from CISE, OCI, SBE, MPS, and ENG) with the President's national cybersecurity strategy, Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program. SaTC supports scientific foundations, induces change, maximizes research impact, and accelerates transitions to practice. SaTC supports activities in Cybersecurity and Information Assurance.
- Expeditions in Education (E^2) aims to generate a stronger and more deliberate infusion of cutting-edge science, engineering, and innovation into programs that focus on preparing a world-class scientific workforce for the twenty-first century, and to ensure that all of NSF's education and workforce investments are drawing on the latest educational theory, research, and evidence. E^2 supports activities in Social/Economic/Workforce Implications of IT and IT Workforce Development.

Networking and Information Technology Research and Development Funding
(Dollars in Millions)

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Request
Biological Sciences	$93.00	$99.00	$99.00
Computer and Information Science and Engineering	636.06	653.59	709.72
Engineering	21.00	18.30	19.80
Geosciences	22.98	22.98	26.98
Mathematical and Physical Sciences	83.88	93.75	94.75
Social, Behavioral, and Economic Sciences	22.21	29.51	29.20
Office of Cyberinfrastructure [1]	300.75	211.64	218.27
Subtotal, Research and Related Activities	$1,179.88	$1,128.77	$1,197.72
Education and Human Resources	9.50	9.50	9.50
Total, NITRD	**$1,189.38**	**$1,138.27**	**$1,207.22**

Totals may not add due to rounding.
[1] FY 2011 Actual includes $90.50 million in funds that were obligated in FY 2010, de-obligated in FY 2011, and then obligated to other projects in the OCI portfolio.

FY 2013 NSF Investments by Program Component Area
The following information focuses on FY 2013 NSF investments, both new and continuing, by PCA.

Large Scale Networking (LSN) ($131.39 million) CISE and ENG will support research in new wireless communications and spectrum sharing architectures and services as part of Enhancing Access to the Radio Spectrum (EARS). A portion of NSF's investment in CIF21 will address broadband applications and research on end-to-end performance from the desktop to major scientific and computational facilities.

Cybersecurity and Information Assurance (CSIA) ($114.12 million) CSIA includes support for the Comprehensive National Cybersecurity Initiative (CNCI) at $57.0 million and for NSF's Secure and Trustworthy Cyberspace (SaTC) program. CISE investments in SaTC, in partnership with EHR, ENG, MPS, OCI, and SBE, include developing scientific foundations; inducing change through designed-in security, moving target defense, tailored trustworthy space, and cyber economic and behavioral incentives; and accelerating transition to practice.

<u>High-End Computing R&D (HEC R&D) ($109.85 million)</u>   Support is provided for CISE's nanotechnology research, including participation in the National Nanotechnology Initiative Signature Initiative. HEC R&D also includes support for NSF's investment in SEES, focusing on research that will develop the theory and design principles to effectively tackle energy versus computation and communication tradeoffs and the development of new theory, algorithms, and design principles to optimize energy-computational performance in computing and communications systems. HEC R&D also includes support for CIF21to develop new functional capabilities in support of highly parallel computing and for research on technical and economic models for flexible spectrum access, real-time auctions, and on-demand spectrum services as part of EARS. MPS, through the Division of Materials Research, will support research on quantum effects and their use for information science, potentially leading to new paradigms for high-end computing.

<u>High-End Computing Infrastructure and Applications (HEC I&A) ($255.62 million)</u> HEC I&A includes increased efforts by OCI to develop software and algorithms for high-end computing systems. It also includes MPS and ENG investment in new computational methods, algorithms, robust software and other computational tools to support researchers in the mathematical and physical sciences and engineering. The CISE investment in computational infrastructure as part of CIF21 is reflected here, as well as the development of wireless testbeds that support experimentation with new wireless technology services as part of EARS.   HEC I&A also includes investments in innovative partnerships and collaborations between universities and industries, including the Industry/University Cooperative Research Centers program (I/UCRC); GEO support for operations and maintenance for the new NCAR Wyoming Supercomputer facility; and BIO's support for development of pioneering informatics tools and resources that have the potential to transform research in biology.

<u>High Confidence Software and Systems (HCSS) ($97.64 million)</u>   CISE and ENG will increase investments in the National Robotics Initiative and in Cyber-Physical Systems as part of CEMMSS as well as continue investments in smart health and wellbeing. As development of the next generation of robotics proceeds, complete confidence in the systems supporting robots that work beside, or cooperatively with, people in areas such as manufacturing, space, and undersea exploration must be assured. High confidence surgical robots and medical devices are central to high quality healthcare and building trust in robotic aids. CISE and ENG will support advanced manufacturing technologies research in cyber-physical systems such as smart infrastructure that will blend traditional concrete-and-steel physical infrastructure systems with cyber-infrastructure systems such as computers, networks, and sensors. BIO support for HCSS will expand and enhance access to the national resource of digital biological and paleontological data, and the Bio/computation Evolution in Action CONsortium (BEACON) Center established to study the power of evolutionary processes and to transfer those discoveries from biology into computer science and engineering design.

<u>Human Computer Interaction and Information Management (HCI&IM) ($297.24)</u>   HCI&IM includes CISE support for the National Robotics Initiative, part of CEMMSS, as well as support for smart health and wellbeing. As part of the next generation of robotics, co-robot systems will be characterized by their flexibility and resourcefulness. They will use a variety of modeling or reasoning approaches, and use real-world data in real-time, demonstrating a level of intelligence and adaptability seen in humans and animals. Research in smart health and wellbeing will focus on human-centered intelligent information systems and tools that collect, mine, synthesize, protect and share appropriate data and knowledge with healthcare organizations, practitioners, caregivers, and individuals to enable effective, safe, and well-informed decision-making by all stakeholders. HCI&IM also includes NSF investments in CIF21 related to big data, data analytics, and visualization tools and a focus on expanding the national data infrastructure through the DataNet and Virtual Organizations programs in OCI. BIO investments in HCI&IM will facilitate discovery through tools that integrate the published literature with the expanding universe of digital data collections, expand capacity for understanding through virtual environments, and

make it practical for scientists to search vast collections of biological images simply and quickly. MPS investments will focus on the provision of new automated data-analysis pipelines that will provide initial reference images for the data-rich radio interferometers that are just coming on line, with analysis tools and guidance for those scientists who need to interact with the data in order to achieve image fidelities beyond those that can be delivered using automated processing techniques. SBE will continue investments to increase the benefit of computer technologies to scientists as well as non-science users.

Software Design and Productivity (SDP) ($83.69 million) SDP support reflects increased investment in CIF21 with a focus on software sustainability, and new research on smart systems as part of CEMMSS. OCI support for SDP includes increasing investment in the Software Institutes for Sustainable Innovation (SI2) program to support efforts to create and maintain usable software. The program supports both individual software development efforts and centers of excellence that will become long-term resources to ensure sustainable software infrastructure within scientific communities. BIO support for SDP includes support for the interagency and international Collaborative Research in Computational Neuroscience program (CR-CNS). BIO funds research involving the development of software and other computational tools to advance biological knowledge as well as computational innovations. SDP also includes support for SBE's National Center for Science and Engineering Statistics to continue exploration of new methods to enhance data collections, analysis, and sharing capabilities, which will help NCSES better serve its role of providing information on the science and engineering enterprise. In addition, SBE will partner with CISE in exploring the emerging interface between computer science and economics.

Social, Economic and Workforce (SEW) Implications of IT and IT Workforce Development ($117.67 million) As part of the National Robotics Initiative, SEW research in CISE will focus on human-robot interaction, a critical component in achieving effective human robot partnerships in manufacturing, education, space exploration, etc. In addition, CISE's continued emphasis on smart health and wellbeing focuses on, for example, assistive technologies and quality of life aids. This also reflects CISE support for big data and e-science collaboration tools as part of CIF21 and support for E^2 through the Cyberlearning Transforming Education program. EHR will continue to study the impact of information and communication technology on educational practice, new approaches to using technology in education, application and adaptation of technologies to promote learning in a variety of fields and settings, the effects of technology of learning, and efforts that advance teaching and learning opportunities utilizing cyberinfrastructure. These efforts also will support science, technology, engineering and mathematics education for the cyber-workforce through workforce programs and research and development in learning sciences. OCI increases support for the study of virtual organizations to better understand how research communities use cyberinfrastructure to improve collaboration. BIO support for SEW focuses on advancing the nation's ability to incorporate and apply biological knowledge to economic development and other issues of societal importance. SBE will continue to support the social, economic and workforce aspects of information technology, focusing on the nature and dynamics of IT impacts on technical and social systems.

NITRD by Program Component Area

(Dollars in Millions)

	FY 2011 Actual	FY 2012 Estimate	FY 2013 Request
Large Scale Networking	$128.14	$121.76	$131.39
Cybersecurity and Information Assurance	76.51	98.49	114.12
High End Computing R&D	103.36	102.98	109.85
High End Computing Infrastructure and Applications	357.00	249.96	255.62
High Confidence Software and Systems	78.01	84.67	97.64
Human-Computer Interaction and Info Management	283.25	291.98	297.24
Software Design and Productivity	54.72	78.26	83.69
Social/Economic/Workforce	108.399	110.17	117.67
Total, NITRD	**$1,189.38**	**$1,138.27**	**$1,207.22**

Totals may not add due to rounding.

[1] FY 2011 Actual includes $90.5 million in funds that were obligated in FY 2010, de-obligated in FY 2011, and then obligated to other projects in the OCI portfolio.