

## NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD)

### Total Funding for NITRD (Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request
Biological Sciences	\$99.00	\$99.00	\$99.00
Computer and Information Science and Engineering <sup>1</sup>	937.11	865.23	950.25
Education and Human Resources	9.50	9.50	9.50
Engineering	18.30	18.30	19.80
Geosciences	20.00	22.98	24.00
Mathematical and Physical Sciences	101.25	93.75	94.15
Social, Behavioral, and Economic Sciences	31.09	29.51	30.70
<b>Total</b>	<b>\$1,216.25</b>	<b>\$1,138.27</b>	<b>\$1,227.40</b>

Totals may not add due to rounding.

<sup>1</sup> FY 2012 Actual includes obligations \$71.59 million over the enacted level for CISE due to recoveries of prior year unpaid obligations that were reobligated in FY 2012.

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 research, infrastructure, and education investments in the Directorate for Computer and Information Science and Engineering (CISE), as well as contributions from all directorates across the agency, enabling 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. 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 2014 Request continues strong support for NITRD at a level of \$1.23 billion, a 7.8 percent increase over the FY 2012 Enacted level. NITRD activities represent approximately 16 percent of NSF's FY 2014 budget. CISE's support comprises 77.4 percent of NSF's NITRD activities.

Several NSF-wide investments, both new and continuing, are reflected in various NITRD PCAs:

- 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 Research and Development (R&D), High End Computing Infrastructure and Applications (I&A), and High Confidence Software and Systems.
- The Comprehensive National Cybersecurity Initiative (CNCI) supports activities in Cybersecurity and Information Assurance.
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) expands advanced manufacturing technologies research in the Cyber-Physical Systems (CPS) program, and the National Robotics Initiative (NRI) 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 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, and Workforce Implications of IT and IT Workforce Development.

- Cyberinfrastructure Framework for 21<sup>st</sup> Century Science, Engineering, and Education (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: High End Computing R&D; High End Computing I&A; Large Scale Networking; Human-Computer Interaction and Information Management; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.
- Enhancing Access to the Radio Spectrum (EARS), which invests in wireless communication, spectrum sharing, and mobile computing, as well as the development of wireless testbeds, is supported in Large Scale Networking, High End Computing R&D, and High End Computing I&A.
- The National Robotics Initiative (NRI), a cross-agency initiative engaging four U.S. agencies (NSF, National Aeronautics and Space Administration, National Institutes of Health and the U.S. Department of Agriculture) provides U.S. leadership in robotics science and engineering research and education aimed at the development of co-robots, which work cooperatively with humans in application domains, such as advanced manufacturing, emergency response, and assistive healthcare. Activities are supported in Human-Computer Interaction and Information Management; High Confidence Software and Systems; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.
- Secure and Trustworthy Cyberspace (SaTC) aligns NSF cybersecurity investments 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.
- The Science, Engineering, and Education for Sustainability (SEES) investment supports activities in High End Computing R&D; Large Scale Networking; Software Design and Productivity; and Social, Economic, and Workforce Implications of IT and IT Workforce Development.

#### **FY 2014 NSF Investments by Program Component Area (PCA)**

The following information focuses on FY 2014 NSF investments, both new and continuing, by PCA.

Large Scale Networking (LSN) (\$136.34 million) CISE and ENG will support research in new wireless communications, spectrum sharing architectures and services, and mobile computing, as well as development of wireless testbeds as part of 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) (\$114.28 million) CSIA includes support for the CNCI and for NSF's SaTC program. CISE investments in SaTC, in partnership with EHR, ENG, MPS, and SBE, aim to support scientific foundations, induce change, maximize research impact, and accelerate transition to practice.

High-End Computing R&D (HEC R&D) (\$113.57 million) Support is provided for CISE's nanotechnology research, including participation in the National Nanotechnology 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 CIF21 to develop new functional capabilities in support of highly parallel computing and BIGDATA analytics, as well as 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.

High-End Computing Infrastructure and Applications (HEC I&A) (\$248.44 million) HEC I&A includes increased efforts by CISE's Division of Advanced Cyberinfrastructure (ACI) to develop software and algorithms for high-end computing systems. It also includes MPS and ENG investments 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. GEO supports EarthCube, a CIF21 investment that sustains cyberinfrastructure for the geosciences. 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's support for operations and maintenance for the 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.

High Confidence Software and Systems (HCSS) (\$103.27 million) CISE and ENG will increase investments in NRI and in CPS as part of CEMMSS as well as continue investments in Smart and Connected Health. As development of the next generation of robotics proceeds, complete confidence in the systems supporting those that work beside, or cooperatively with, people in application domains, such as advanced manufacturing, emergency response, and healthcare, become increasingly important. 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's 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.

Human Computer Interaction and Information Management (HCI&IM) (\$299.90 million) HCI&IM includes CISE support for the National Robotics Initiative, part of CEMMSS, as well as support for Smart and Connected Health. 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 and Connected Health 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 BIGDATA analytics and visualization tools, and the development of mid-scale pilots and prototypes toward a comprehensive, scalable data infrastructure. 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, facilitate opportunities for SBE researchers to understand human behavior and cognition and the effectiveness of virtual organizations in

the context of 21<sup>st</sup> century networked society (via CIF21) and focus on research that advances the core scientific and technological means of managing, analyzing, visualizing, and extracting information from large data sets.

Software Design and Productivity (SDP) (\$89.61 million) SDP support reflects increased investment in CIF21 with a focus on software sustainability, and new research on smart systems as part of CEMMSS. ENG's support for this PCA is primarily associated with the CPS and NRI components of the CEMMSS investment. CISE will make investments in the Software Institutes for Sustained Innovation (SI<sup>2</sup>) program to catalyze new thinking, paradigms, and practices in developing and using software that is robust, reliable, usable, and sustainable under the CIF21 umbrella. BIO support for SDP includes support for the interagency and international Collaborative Research in Computational Neuroscience program. 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 (NCSES) 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 continue to partner with CISE in exploring the emerging interface between computer science and social and behavioral science.

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

(\$121.99 million) As part of NRI, SEW research in CISE will focus on human-centered research in developing service robots, requiring significant advances in human-robot interaction. In addition, CISE's continued emphasis on Smart and Connected Health focuses on, for example, improvements in safe, effective, efficient, and patient-centered proactive and predictive health and wellness technologies. This also reflects CISE support for BIGDATA and e-science collaboration tools as part of CIF21, and support for cyberlearning and on-line education programs. Research in cyberlearning will integrate advances in technology with learning, design new technologies for integration in learning environments, and evaluate their use. 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. 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 Funding by Program Component Area**

(Dollars in Millions)

	FY 2012 Actual	FY 2012 Enacted/ Annualized FY 2013 CR	FY 2014 Request
Large Scale Networking	\$127.55	\$121.76	\$136.34
Cybersecurity and Information Assurance	99.20	98.49	114.28
High End Computing R&D	109.59	102.98	113.57
High End Computing Infrastructure and Applications <sup>1</sup>	329.27	249.96	248.44
High Confidence Software and Systems	88.36	84.67	103.27
Human-Computer Interaction and Info Management	270.62	291.98	299.90
Software Design and Productivity	85.20	78.26	89.61
Social, Economic, and Workforce	106.46	110.17	121.99
<b>Total</b>	<b>\$1,216.25</b>	<b>\$1,138.27</b>	<b>\$1,227.40</b>

Totals may not add due to rounding.

<sup>1</sup> FY 2012 Actual includes obligations \$71.59 million over the enacted level for CISE due to recoveries of prior year unpaid obligations that were reobligated in FY 2012.