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 all of the agency's directorates also contribute. Additionally, NSF makes research, education, or research infrastructure investments in every NITRD Program Component Area (PCA). In FY 2010, NITRD represents approximately 16 percent of the agency's budget.

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

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request
Biological Sciences	$83.50	$86.15	-	$93.00
Computer and Information Science and Engineering	535.26	573.74	235.00	633.00
Engineering	19.20	20.70	-	23.70
Geosciences	15.56	18.98	-	22.98
Mathematical and Physical Sciences	76.03	78.93	21.90	86.82
Social, Behavioral and Economic Sciences	22.84	17.00	3.00	22.80
Office of Cyberinfrastructure	185.15	199.28	80.00	219.00
Subtotal, Research and Related Activities	$937.54	$994.78	$339.90	$1,101.30
Education and Human Resources	9.00	9.50	-	9.50
Total, NITRD Request	$946.54	$1,004.28	$339.90	$1,110.80

Totals may not add due to rounding.

NSF's FY 2010 Request continues strong support for NITRD. 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 seven of the eight PCA Coordinating Groups.

NITRD Funding in FY 2010

Large Scale Networking ($110.63 million): CISE will continue support for activities in the Network Science and Engineering (NetSE) program, which includes the Future Internet Design (FIND) program, and for the Network Technology and Systems (NeTS) program. NetSE focuses on understanding the complexity of networks due to scale and heterogeneity of components, from devices to people; and on revolutionary network architectures for the future. OCI will renew its International Research Network Connections (IRNC) activity which will include opportunities to fund experimental networks.

Cybersecurity and Information Assurance ($67.36 million): NSF will continue to fund research on cybersecurity foundations, network security, and systems software that supports the objectives of the *Federal Plan for Cyber Security and Information Assurance Research and Development.* CISE will devote $40.0 million to research in usability, theoretical foundations, and privacy to support the Comprehensive National Cybersecurity Initiative. Support will continue for several centers, including one devoted to the scientific exploration of new technology that will radically transform the ability of organizations to design, build, and operate trustworthy information systems for critical infrastructure, and one investigating software architectures, tamper-resistant hardware, cryptographic protocols and verification systems as applied to electronic voting systems.

High-End Computing Research and Development (R&D) ($106.56 million): OCI and CISE will support the development of simulation, optimization and analysis tools that exploit the potential of petascale computing to advance the frontiers of scientific and engineering research. NSF's investment in Science and Engineering Beyond Moore's Law will focus on revolutionary new computing hardware technologies, as well as related programming models, languages and tools, all of which promise to inform the computing systems of the future.

High-End Computing Infrastructure and Applications ($314.34 million): Continuation of the acquisition of a high performance computing system in OCI is included at an annual level of $50.0 million. OCI is following-up the existing TeraGrid activity with eXtreme Digital (XD). XD will provide computational, storage, networking and visualization resources to the open science and engineering communities.

CISE will invest in research infrastructure resources to support the acquisition, enhancement, and operation of state-of-the-art infrastructures and facilities that enable high-quality computing research and education in a diverse range of institutions and projects.

Several NSF directorates will increase their investments in this PCA to capitalize on the growing importance of cyberinfrastructure in furthering their research and education goals. For example, MPS and ENG will increase activity in modeling and simulation of complex systems, development of numerical algorithms and software implementations that push the boundaries of computing infrastructure, and use of the grid computing infrastructure.

MPS will strengthen support of research and education activities that contribute to and utilize the Virtual Astronomical Observatory, a federation of astronomical databases. Support of other databases and digital libraries also will increase. MPS will support enhanced participation of remote access to instrumentation and increased connection of institutions that are distant from each other, such as a minority institution and its partner.

GEO will continue to support state-of-the-art computing systems and data management services at the National Center for Atmospheric Research (NCAR). Part of this high performance computing environment, the Climate Simulation Laboratory (CSL), helps keep the U.S. at the forefront of 21st century climate science.

ENG will increase support of virtual organizations to leverage distributed physical experimentation, data collection, modeling and analysis capabilities using high-end computing and large scale networking infrastructures.

BIO will invest in activities to broaden access to and usability of high performance computing resources in the biological sciences. Current biology applications claim substantial HPC computing resources that are narrowly focused in specific areas of biology. With increasing availability of large amounts of diverse data from plant, animal and microbial genomics to ecosystems modeling, additional areas of biology will likely require expanded access to and development of HPC resources.

High Confidence Software and Systems ($74.80 million): As part of the Cyber-enabled Discovery and Innovation (CDI) investment, CISE will support research on software for tomorrow's complex cyber-physical systems, such as smart automobiles, sensor nets for environmental monitoring, and embedded medical devices, and similarly in mobile, portable, and pervasive computing devices, such as cell phones,

digital cameras, flexible displays, radio-frequency identification (RFIDs), multi-media multi-modal handhelds, and household robots.

ENG will increase support of novel cyber-physical systems that combine the physical sensing and actuation functions with the computing and control functions into tightly-coupled high confidence systems.

Human Computer Interaction and Information Management ($283.39 million): The multidisciplinary CDI emphasis will focus on creation of new knowledge from digital data, including novel algorithms, data mining, and dimension reduction methodologies, new visualization methods to enhance human cognition, and innovative technologies to address data confidentiality, privacy, security, provenance, and regulatory issues.

BIO's investments in this area 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 that provide an intuitive display of the complex networks of interactions among organisms and their environments, and make it practical for scientists to search vast collections of biological images simply and quickly.

NSF will focus increased attention on the issues of federation, preservation, curation, and access to large, heterogeneous collections of scientific data and information. High capacity data management and high capacity computing are increasing challenges for a growing number of research communities. OCI will develop activities for a robust and resilient national and global digital data framework for preservation and access to the resources and products of the digital age. OCI will invest in data, modeling paradigm and software interoperability in the area of virtual organizations.

SBE and CISE are co-funding a new solicitation, with the first awards expected in FY 2010 on Socio-Computational Systems, encouraging research on the interaction between people and machines.

ENG's investment in this area will focus on creating new pathways to connect researchers with each other and with state-of-the-art experimental facilities. ENG will also invest in curation of data generated by the large number of geographically dispersed sensors that will be used for real-time control of complex systems.

Software Design and Productivity ($58.48 million): CISE will support research on the scientific and engineering principles for developing software for tomorrow's complex cyber-based systems. Advances in software foundations, including new computational models, techniques, languages, tools, metrics, and processes for developing and analyzing software for these complex systems, will be pursued.

BIO, through its Biological Databases and Informatics program, will promote new ways of enabling science through the use of cyberinfrastructure, including new visual programming environments and integrated information systems that allow an entire community of experts to contribute simultaneously to understanding genome dynamics.

ENG will invest in developing new algorithms and software that can efficiently scale to the petascale levels. ENG will also invest in virtual organizations to enhance the productivity of researchers by providing them access to computational tools, specialized facilities and observational data from anywhere in the world.

Social, Economic and Workforce ($95.24 million): Through CDI, NSF will support investments that infuse computational thinking into computing education at all levels and in all fields of science and engineering.

CISE will continue to support the Broadening Participation in Computing program, aimed at significantly increasing the number of students who are U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines. CISE also will continue support to revitalize undergraduate education in computing through the CISE Pathways to Revitalized Undergraduate Computing Education (CPATH) program, begun in FY 2006. The CPATH vision is of a U.S. workforce with the computing competencies and computational thinking skills imperative to the Nation's health, security and prosperity in the 21st century.

OCI will support activities in cyber-learning that will pursue new opportunities for using cyberinfrastructure as a platform for providing effective online laboratory experiences to students and teachers. In collaboration with partners across NSF, OCI will support creative explorations and demonstrations of the use of cyberinfrastructure to integrate research with education, the development of innovative technologies that will facilitate the integration of research and education, and research on how educators and students interact with cyberinfrastructure along with exploring novel uses of cyberinfrastructure.

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, and the effects of technology on learning, and efforts that advance teaching and learning opportunities in nanotechnology and/or cyberinfrastructure. Additionally, in FY 2010, EHR will fund research that highlights the educational use of information tools that operate seamlessly across formal and informal learning environments and across traditional computers, mobile devices and newly emerging information and communications.

SBE will continue to study the impact of IT 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, and the effects of technology on learning, and efforts that advance teaching and learning opportunities in nanotechnology and/or cyberinfrastructure through the Science of Learning Centers (SLC) Program.

BIO will strengthen IT capabilities in all biological sub-disciplines through support for postdoctoral fellowships in bioinformatics; integrative graduate programs that combine training in biology and computer sciences (via the NSF-wide Integrative Graduate Education and Research Traineeship (IGERT) program); undergraduate summer institutes in bioinformatics through the interagency Bioengineering and Bioinformatics Summer Institutes program; and other mechanisms.

NITRD by Program Component Area

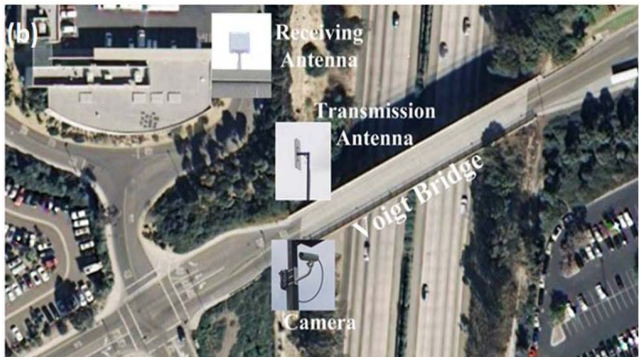
(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request
Large Scale Networking	$88.61	$99.00	$60.37	$110.63
Cybersecurity and Information Assurance	57.36	63.26	26.38	67.36
High End Computing R&D	82.92	77.55	36.48	106.56
High End Computing Infrastructure and Applications	285.13	323.42	62.33	314.34
High Confidence Software and Systems	57.33	62.09	37.01	74.80
Human-Computer Interaction and Info Management	248.28	250.32	67.68	283.39
Software Design and Productivity	51.29	54.81	10.89	58.48
Social/Economic/Workforce	75.63	73.83	38.76	95.24
Total, NITRD Request	$946.54	$1,004.28	$339.90	$1,110.80

Totals may not add due to rounding.

Recent Research Highlights

► **Making Bridges Safer:** Using the Sensor Network Highway Bridge Testbed, University of California at San Diego researchers are developing essential strategies for monitoring the condition of highway bridges and constructed facilities. The testbed draws upon research innovations in sensor networks, data archiving and management database procedures, system identification techniques, machine learning tools, and visualization capabilities to assess long-term and sudden changes in the bridge's structural condition. Decision-support tools developed detect and assess, in real-time, damage caused by natural or man-made events and/or progressive environmental deterioration. These tools will save lives by identifying problems before imminent failures, and they facilitate post-event response after a failure. Further, they accrue cost savings in maintenance and can extend a bridge's useful lifetime.

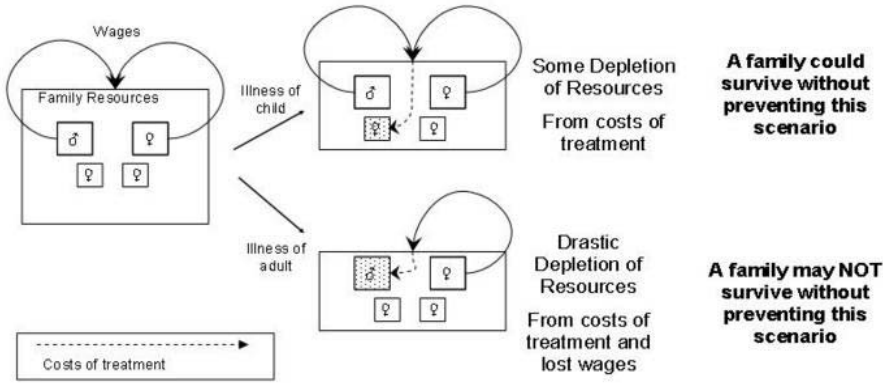


UC San Diego Voigt Drive/I-5 bridge testbed, (a) Side view, and (b) Locations of camera and deployed antennae for sensor network data transmission. *Credit: (Top) A. Elgamal and M. Fraser at University of California, San Diego; (Bottom) ©2009 Google-Imagery ©2009 DigitalGlobe, GeoEye, U.S. Geological Survey*

► **Protecting the Nation's Power Grid:** Researchers from the University of Illinois at Urbana-Champaign, Dartmouth College, Cornell University, and Washington State University are addressing the challenge of how to protect the nation's power grid. Our electric power infrastructure depends on the health of underlying computing and communication networks, which are at serious risk from both malicious cyber attacks and accidental failures. The research plan focuses on securing the devices, communications, and data systems that make up the power grid to ensure trustworthy operations during normal conditions, cyber-attacks, and power emergencies. Two years into the project, progress has been made at all levels: hardware development and support; establishment of protocols; basic research to provide direction for the next-generation IT infrastructure for the power grid; and development of a testbed environment for experimenting with next-generation infrastructure.

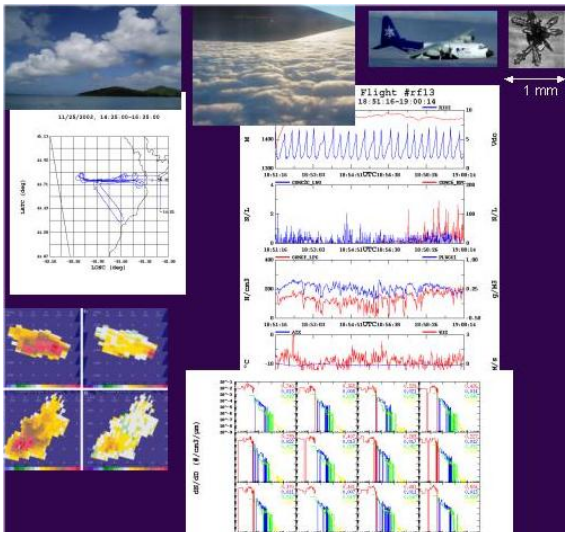
TCIP researchers work to provide end-to-end secure and real-time power grid monitoring and control. *Credit: http://commons.wikimedia.org/wiki/File:Ligne_haute-tension.jpg.*

► **Interactions between Disease and Economics in the Developing World**: The effects of disease in developing regions around the world drastically burden individuals, families, and communities. There are direct economic costs associated with treatment, and indirect costs associated with lost wages and productivity. Existing economic models in infectious disease epidemiology have focused on cost-benefit analyses of public health intervention strategies, where costs are frequently estimated in terms of cumulative disease incidence and money, and benefits are estimated by "numbers of new cases (or deaths) prevented". NSF funded researchers have gone one step deeper, using computational and mathematical models to analyze the relationship between disease and economic pressures on individuals, communities, and families. Preliminary results demonstrate that the holistic cost of disease in a population can be reduced by preferentially allocating health resources to wage-earners. The models show that this optimizes the long-term health of whole families and the communities.



A schematic of economic and health processes feeding off each other. *Credit: Fred Roberts, DIMACS.*

► **Why is this Cloud Raining on Me?:** To better understand atmospheric processes that affect both global climate phenomena and daily weather events, we rely upon complex observations and sophisticated models that consider the effects of atmospheric clouds and their dynamics. Cumulus clouds, for example, present over much of the globe, affect heat patterns and amounts of moisture, and modulate the level of radiation entering and leaving the Earth's atmosphere. These and other types of clouds influence long-standing, fundamental questions about precipitation. Observational data collected through multiple modalities such as ground based radars and aircraft flying through the clouds are combined with highly complex cloud models and other atmospheric, aquatic, and land-based measurements and models, to analyze and predict possible weather scenarios, including precipitation. A collaborative team of computer and atmospheric scientists at Purdue University and the University of Utah have produced advances in comparative and correlative multivariate visualizations that have improved interpretation of modeling studies and results.

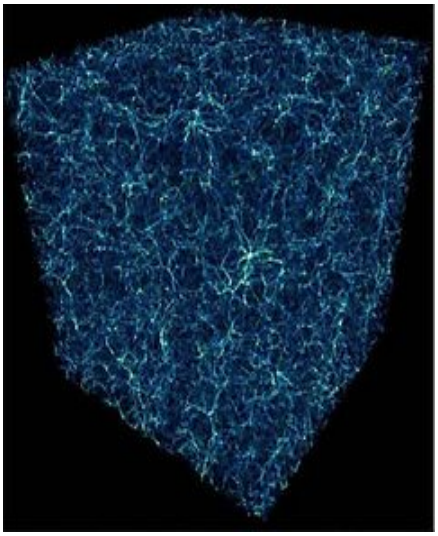


Many different types of data at a variety of scales and timelines are necessary to bring together for analysis of cloud patterns and prediction of precipitation patterns. The new interactive visual system for atmospheric phenomena enables analysis, correlation and hypothesis testing to gain new insight into the factors that control precipitation. *Credit: Purdue University. D. Ebert and Sonia Lasher-Trapp.*

► **Liquidity Costs in Agricultural Futures Markets Easier to Estimate with Teragrid:** Researchers at the University of Illinois at Urbana-Champaign used sales data for lean hogs and live cattle from the Chicago Mercantile Exchange to test their new method of measuring costs in agricultural futures markets. Initially, each day's worth of data required an entire day to process on a desktop computer, so they turned to TeraGrid resources for the critical computation and human resources needed to evaluate their simulations. The program still takes an entire day to run, but the team has the calculations for all of the days of the month, not just one. Studies done by the researchers and the models used will enable better predictions of how the agricultural economy moves and how those moves will in turn affect the customer.

These charts show the Bid-Ask spread estimates for live cattle and lean hogs in research conducted by Julieta Frank and Philip Garcia. RM (Roll) is a serial covariance estimator, TW (Thompson and Waller) is a mean absolute price change estimator, HAS (Hasbrouck) is a Gibbs sampler estimator using a truncated distribution of "C", and ABS is a Gibbs sampler estimator using absolute values of "C"; "C" refers to cost of liquidity. *Credit: Julieta Frank and Philip Garcia, Office for Futures and Options Research, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.*

► **What Are Baryons and Why Do They Matter?:** Much of the gaseous mass of the universe is bound up in a tangled web of cosmic filaments that stretch for hundreds of millions of light-years, according to a new supercomputer study by University of Colorado researchers. A significant portion of the gas is in the filaments that connect galaxy clusters and is hidden from direct observation. According to the standard cosmological model, the universe consists of about 25 percent dark matter, 70 percent dark energy, and only 5 percent normal matter. The latter consists primarily of baryons-hydrogen, helium and heavier elements. Observations cannot account for about 40 percent of the baryons. Many astrophysicists believe the missing baryons are in the intergalactic medium. As astronomers begin to see these filaments and understand their nature, they will learn more about the missing baryons in the Universe.



A portion of a supercomputer simulation of the universe. The bright object in the center is a galaxy cluster about 1 million-billion times the mass of the Sun. In between the filaments, which store most of the universe's mass, are giant, spherical voids nearly empty of matter. *Credit: Matthew Hall (NCSA), Brian O'Shea (LANL) and Eric Hallman (University of Colorado, Boulder).*