ENGINEERING $759,330,000

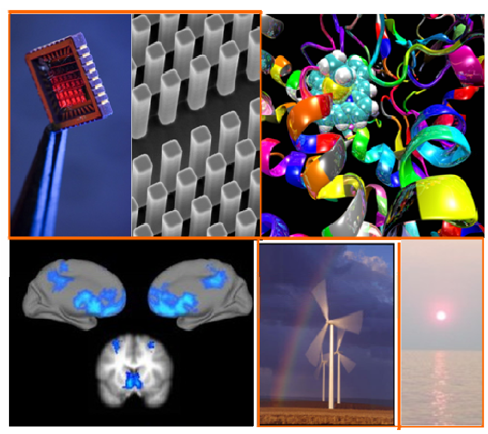
The FY 2009 Budget Request for the Directorate for Engineering (ENG) is $759.33 million, an increase of $122.46 million, or 19.2 percent, over the FY 2008 Estimate of $636.87 million.

Engineering Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Chemical, Bioengineering, Environmental and Transport Systems (CBET)	$128.27	$131.00	$173.34	$42.34	32.3%
Civil, Mechanical and Manufacturing Innovation (CMMI)	157.30	159.81	201.88	42.07	26.3%
Electrical, Communications and Cyber Systems (ECCS)	83.24	83.50	94.36	10.86	13.0%
Industrial Innovation and Partnerships (IIP)	120.78	121.67	140.90	19.23	15.8%
SBIR/STTR	*108.67*	*109.37*	*127.00*	*17.63*	*16.1%*
Engineering Education and Centers (EEC)	115.16	115.89	119.85	3.96	3.4%
Emerging Frontiers in Research and Innovation (EFRI)	25.25	25.00	29.00	4.00	16.0%
Total, ENG	$629.99	$636.87	$759.33	$122.46	19.2%

Totals may not add due to rounding.

From manufacturing nano-sized devices to bolstering the Nation's energy security, engineering research and education enable innovative solutions to society's most significant challenges. The systems approach inherent to engineering is becoming crucial for resolving increasingly complex problems and relentlessly advancing the frontiers of knowledge and innovation by integrating multiple disciplines.

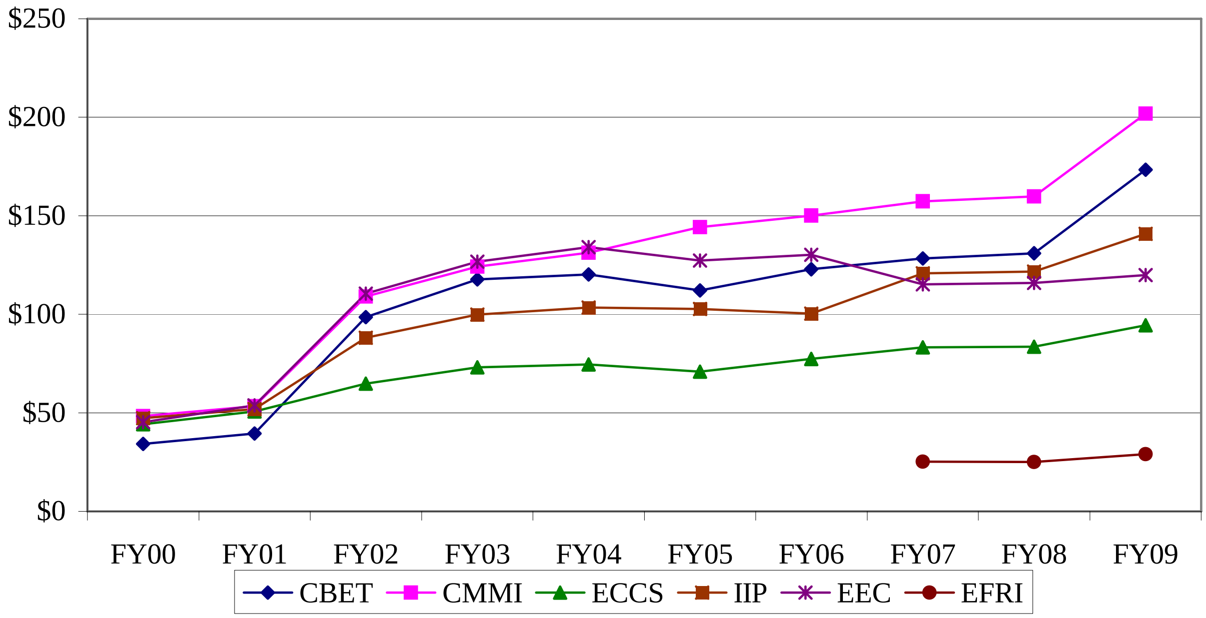


Engineering spans the frontiers: micro- and nano-scale materials, modeling of complex systems, technology and human abilities, and alternative energy.

Engineers are uniquely positioned to not only advance fundamental understanding, but also to transform discovery into the innovation essential to the nation's prosperity, national security, quality of life, and economic competitiveness.

The innovation fueled by engineering improves every component of society: advances in nanotechnology and intelligent manufacturing to create new materials and redefine how materials and structures are designed; algorithms to control and predict complexity in systems including atomistic structures, factories, the national power grid, and the global economy; better technologies for harnessing and storing renewable energy; complex models and sensors for assessing and monitoring water resources, climate change, and the environment; biocompatible materials for improving human health; and new approaches to medical treatment and monitoring.

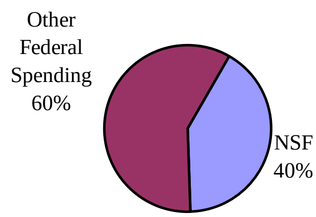
ENG Subactivity Funding
(Dollars in Millions)



RELEVANCE

The Directorate for Engineering provides 40 percent of the total federal support in university-based, fundamental engineering research. Having started the National Nanotechnology Initiative in 2000, the Directorate for Engineering continues to steer the basic and frontier engineering research that fuels U.S. technology.

Federal Support of Basic Research in Engineering at Academic Institutions



The following research themes for fiscal year 2009 define transformative research directions. These themes answer key challenges that are recognized by technology and government leaders and that are set forth in the American Competitiveness Initiative (ACI) and the America COMPETES Act.

Cognitive Engineering: Intersection of Engineering and Cognitive Sciences. Engineering and neuroscience knowledge are overlapping, particularly in cognitive engineering, which works in two directions: first, developing technologies to improve understanding of brain functions, particularly learning, as well as technologies that improve human productivity and potential; and second, using this understanding to engineer powerful systems and devices that simulate neural networks. Such systems and devices can bolster monitoring of large-scale, complex systems, and also enable dynamic optimization and advanced decision-making. Understanding the systems behind human intelligence can help in designing robotic intelligence. Smart machines that sense and adapt autonomously are the kinds of competitive innovations envisioned for both ACI and America COMPETES. This research also has the potential to provide new knowledge and technologies – as well as a systems-based understanding of the brain and nervous system – to bolster the NSF-wide investment in Adaptive Systems Technology.

Competitive Manufacturing and Service Enterprises. Increasingly a knowledge-based industry, manufacturing is experiencing a paradigm shift, redefining the properties of materials and the assembly and robustness of structures of all scales. Advances in nanomanufacturing can lead to lower-cost materials having designed-in properties. These advances are enabled by implementation of advanced sensors and control theory, and these processes can translate to effective delivery of services such as wireless access, transportation, and even medical information. Thus, advances in manufacturing processes also sharpen U.S. competitiveness in the service sector, a primary U.S. employer and a major industry in the global, knowledge-based economy. Supporting research that can increase U.S. manufacturing competitiveness directly meets one of the goals set for NSF in the America COMPTES Act. It also bolsters the ACI goals and initiatives of creating world-class capability and capacity in nanofabrication and nanomanufacturing; improving sensor and detection capabilities resulting in world-leading automation and control technologies; and transforming health care through information technology.

Complexity in Engineered and Natural Systems. The Nation's infrastructure, such as the national power grid; the environment and its changes due to a warming climate; security, such as predicting and responding to adversarial behavior; healthcare and its delivery; and the economy, which is affected by how people react to information – all these involve large numbers of interacting elements and people and suggest many of the issues of complex systems. To understand, predict, describe and design for complex behavior requires a fundamental understanding of complexity, a goal yet to be reached. Investment is crucial for research advancing knowledge of complexity, developing high-end computing capability for modeling complex systems, realizing transforming technologies based on understanding complexity, and strengthening the community's ability to work across disciplines. It also addresses the ACI goals of addressing gaps and needs in cyber-security and information assurance to protect our IT-dependent economy; and enabling scientific advancement through modeling and simulation at unprecedented scale and complexity. Furthermore, these advances will also support the specific needs – such as networking protocols and architectures that make systems more resilient – set by America COMPETES for NSF to enable research that advances communication and information technology for all citizens.

Energy, Water and the Environment. The development of new energy sources must harness and distribute energy from renewable sources and lessen the burden of power generation on the water supply, itself already affected by climate change. Frontier research in all fields of engineering can drive essential breakthroughs for developing systems that increase the efficient use of energy and thus lessen demand; for understanding, modeling and developing methods to minimize water use during energy production; for monitoring the supply and quality of water in order to better manage them; and for addressing the ACI goal of overcoming technological barriers to efficient and economic use of hydrogen and solar energy. Engineering research builds knowledge in biofuels, hydrogen production, solar cells, energy conversion and storage, power distribution, and carbon sequestration – all crucial to securing energy security and to reducing the accumulation of greenhouse gases in the atmosphere.

Systems Nanotechnology. The potential of successfully manipulating matter at the nanoscale is only beginning to be realized. The next frontier in nanotechnology is to create controllable systems built from nanoscale components. Such systems will support crucial applications, such as petascale computing; designing-in properties by manufacturing materials from the nanoscale; regenerating human tissue and organs from the nanoscale; designing systems of nano-sized sensors for use in medicine, agriculture, biological research, or national security; selectively filtering harmful particles from water; and manufacturing devices, such as solar cells, that efficiently convert and store renewable energy. Advances in nanotechnology permeate all facets of society, and thus meet many of both the ACI and America COMPETES goals, such as realizing commercial use of renewable energy; developing world-leading high-end computing capability (at the petascale) and capacity; creating world-class capability and capacity in nanofabrication and nanomanufacturing; and realizing materials breakthroughs critical to cutting-edge research (ACI); and nanoelectronics for advancing communications and information technology.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, ENG...……………………………………………………….....................…$636.87

Chemical, Bioengineering, Environmental and Transport Systems (CBET) +$42.34

CBET research brings engineering together with the physical sciences, with the information sciences and with the life sciences, uniquely positioning the CBET community to address complex problems. The Division will increase support in key applications of the physical sciences, such as catalysis, chemical process design, environmental engineering, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particulate processes. These investments contribute to advances that are important for energy, the environment, transportation, information technologies, health-related products, and other areas that both impact our daily lives and sustain and enhance U.S. competitiveness.

Current high-emphasis applications of the life sciences include postgenomic engineering, tissue engineering, biophotonics, nano-biosystems, and biotechnology. Increased support will lead to improved biosensors, biomaterials, controlled drug release, bioimaging, medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, bioremediation, water and waste treatment, and food engineering.

Civil, Mechanical and Manufacturing Innovation (CMMI) +$42.07

Provides increased support in the areas related to analyzing, modeling, designing, building, and securing the nation’s critical infrastructure, and for strengthening its manufacturing and service enterprises. CMMI will continue to increase investments in engineering education to foster a world-class engineering workforce. Support will also be increased for projects utilizing the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and for hazard-related research.

Electrical, Communications and Cyber Systems (ECCS) +$10.86

Provides increased support for innovative research in nano and micro systems, and communication systems and cyber systems that integrate physical devices and components with computational intelligence and networks. This research will aid in the design, development, and implementation of new complex and hybrid systems with engineering solutions for a variety of domain-specific applications to benefit society. Additional funds will also support core research in the emerging areas of diagnostic and implantable devices; flexible electronics; neuromorphic engineering; quantum electronics; energy scavenging and alternative energy technologies; and interdependencies of critical infrastructure in power and communications.

Industrial Innovation and Partnerships (IIP) +$19.23

IIP is home for the two legislatively mandated small business research programs, the Small Business Innovation Research (SBIR) program (+$15.77 million) and the Small Business

Technology Transfer (STTR) program (+$1.86 million). In addition, IIP leverages industrial support through two research programs, the Industry/University Cooperative Research Centers (I/UCRC) program (+$870,000) and the Grant Opportunities for Academic Liaison with Industry (GOALI) program (+$730,000).

Engineering Education and Centers (EEC) +$3.96

In FY 2009, EEC will provide support for Engineering Research Centers, Nanoscale Science and Engineering Centers, engineering education research, and engineering workforce development. Research will be supported to improve the development, management, and productivity of quality engineering education at both the undergraduate and graduate levels. Topics of particular interest include: the aims and objectives of engineering education, the content and organization of the curriculum, how students learn problem solving, how to encourage creativity and design, developing new methods for assessment and evaluation of how students learn engineering, understanding the business aspect of engineering education, and conducting research that helps us understand how to attract a more talented and diverse student body to all levels of engineering study.

Emerging Frontiers in Research and Innovation (EFRI) +$4.00

EFRI support increases by $4.0 million and will foster transformative opportunities that are interdisciplinary and high risk with high potential payoff leading to: new research areas for NSF, ENG, and other agencies; new industries or capabilities that result in a leadership position for the country; and/or significant progress on a recognized national need or grand challenge. EFRI was established in FY 2007 to bring together researchers from different disciplines who work at the frontiers where new knowledge is generated. Now that global competition is increasing, the technical underpinnings of the past may not be adequate to ensure our continued success. EFRI will provide critical, strategic support of fundamental discovery, particularly in areas leading to breakthrough technologies.

Subtotal, Changes +$122.46

FY 2009 Request, ENG ……………………………………………………………………........$759.33

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, ENG………………………………………………………………………....$636.87

<u>Discovery</u> +$116.37

ENG has a vital role to play in advancing focus areas and the Foundation-wide activities for FY 2009. Engineering-supported research will be especially relevant in the following areas:

Cyber-enabled Discovery and Innovation (+$8.81 million).

ENG increases will support simulation-based engineering and science, a crucial and far-reaching capability enabled by cyberinfrastructure. As cyber-enabled discovery advances, so too must the use of it, such as multiscale modeling, sensor systems, simulation, and integration of large data sets. These advances can allow predictive decision-making. The next generation of models will rapidly synthesize design alternatives for large and complex systems, and will simultaneously capture changes through space and time across many components of multiscale systems and processes.

Science and Engineering Beyond Moore's Law (+$4.0 million).

Engineering contributions are fundamental to advances in this area. For example, research in nanomanufacturing, photonics, micro- and nanoelectronics, and molecular electronics, will result in the new materials and devices – such as silicon microelectronics that exploit properties at the quantum level – required to realize computing capacity beyond the limits suggested by Moore's Law.

Adaptive Systems Technology (+$3.49 million).

ENG will support this NSF-wide investment, particularly in the area of neural engineering, an emerging field that bridges molecular, cellular, systems, cognitive, and behavioral neuroscience with engineering, physics, chemistry, mathematics, and computer science. This field promises to develop engineering techniques and systems that will enable new understanding of the brain, nervous and sensory systems, and other crucial processes in the body, and the use of this understanding in engineered systems.

Dynamics of Water Processes in the Environment (+$530,000).

The fulcrum point of this research is forecasting: supporting research for monitoring changes in the water supply and its quality, anticipating droughts or flooding, and understanding how human activity and environmental changes affect dynamics in water supplies. ENG will support research to develop monitoring methods, particularly advanced sensor systems and networks, as well as modeling for a variety of applications, including monitoring of natural and human-built water systems. ENG will support this activity to bolster research on society's critical need to strategically manage a finite resource for which demand is growing.

Disciplinary and Interdisciplinary Research (+$72.85 million).

An increase of $72.85 million will bring support for core research areas to a total of $370.88 million. ENG will continue to build on its strong system of merit review and investigator-initiated proposals, which advance the frontiers of knowledge and innovation by working across traditional boundaries and encouraging multidisciplinary, cutting-edge, and high-impact research including the Climate Change Technology Program. ENG's core represents a broad and synergistic convergence of fields, disciplines, and frontier opportunities. This core supports both newly emerging fields and long-standing challenges that are poised for major advancement. The Office of Emerging Frontiers in Research and Innovation will continue to identify, prioritize, and fund emerging areas in engineering research, innovation, and education.

Faculty Early Career Development Program (CAREER) (+$7.45 million).

Funding increases by $7.45 million, to a total of $45.85 million, to provide 18 additional awards.

Nanoscale Science and Engineering Centers (NSEC) (+$720,000).

Funding increases by $720,000, to a total of $24.75 million, to provide for planned expansion of one center.

Engineering Research Centers (ERC) (+$690,000).

Funding increases by $690,000, to a total of $53.55 million, to provide for the planned growth of the 2008 class of Generation-3 ERCs.

Industry/University Cooperative Research Centers (+$870,000).

Funding increases by $870,000 to a total of $7.57 million. Engineering support provided to each center will increase by approximately $10,000 per center. The NSF investment in this program leverages investment of approximately $65.0 million annually from industry, university, state, and other federal partners.

Science and Technology Center (-$670,000).

Funding for the Nanobiotechnology Science and Technology Center decreases by $670,000, to a total of $2.66 million, as the Class of 2000 centers receive final-year phase-down funding.

Small Business Innovation Research/Small Business Technology Transfer (+$17.63 million).

Funding increases by $17.63 million, to a total of $127.0 million to meet the mandated agency spending target of 2.80 percent of the agency's extramural research budget.

Learning +$2.54

Integrative Graduate Education & Research Traineeship program (IGERT) (+$290,000).

Funding for the IGERT program increases by $290,000, to a total of $7.59 million, and will support additional students through this program.

Research Experience for Undergraduates (REU) (+$1.65 million).

Including REU Sites and REU Supplements, this program increases by $1.65 million, to a total of $14.45 million, providing support to approximately 80 additional students.

Research Experiences for Teachers (RET) (+$600,000).

Including support for the RET Sites and Supplements, this program increases by $600,000, to a total of $5.20 million, providing research experiences for approximately 60 additional teachers.

Research Infrastructure +$0.85

Network for Earthquake Engineering Simulation (+$850,000).

Funding for operations and maintenance costs increases by $850,000 to a total of $23.02 million, to provide for inflationary increases at the 15 equipment sites that make up this national network.

Stewardship +$2.70

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$122.46

FY 2009 Request, ENG………...…………………………………………………...…..….$759.33

NSF-WIDE INVESTMENTS

In FY 2009, ENG will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

Engineering NSF-wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Adaptive Systems Technology	-	-	$3.49	$3.49	N/A
Climate Change Science Program	1.00	1.00	1.00	-	-
Cyber-Enabled Discovery and Innovation	-	8.00	16.81	8.81	110.1%
Cyberinfrastructure	54.00	56.00	60.00	4.00	7.1%
Dynamics of Water Processes in the Environment	-	-	0.53	0.53	N/A
Human and Social Dynamics	2.00	1.50	-	-1.50	-100.0%
National Nanotechnology Initiative	137.02	137.02	140.02	3.00	2.2%
Networking and Information Technology R&D	11.20	19.20	28.01	8.81	45.9%
Science & Engineering Beyond Moore's Law	-	-	4.00	4.00	N/A

Adaptive Systems Technology: ENG will support this NSF-wide investment, particularly in the area of neural engineering, an emerging field that bridges molecular, cellular, systems, cognitive, and behavioral neuroscience with engineering, physics, chemistry, mathematics, and computer science. This field promises to develop engineering techniques and systems that will enable new understandings about the brain, nervous and sensory systems, and other crucial processes in the body. ENG provides a foundation for this initiative through the research supported by its Cognitive Engineering theme.

Cyberinfrastructure (CI): ENG currently funds the operation and research program of NEES, the George E. Brown Jr. Network for Earthquake Engineering Simulation. NEES is NSF's first distributed-network cyberinfrastructure research facility. In FY 2009, support increases by $4.0 million to a total of $60.0 million and will fund ENG projects at the device, node, network, and system levels that will enable enhanced capabilities for the next generation of cyberinfrastructure. Funding will support projects that use cyberinfrastructure to enable frontier research in ENG domain areas.

Dynamics of Water Processes in the Environment: The fulcrum point of this research is forecasting: supporting research for monitoring changes in the water supply and its quality, anticipating droughts or flooding, and understanding how human activity and environmental changes affect dynamics in water supplies. ENG will support research to develop monitoring methods, particularly advanced sensor systems and networks, as well as modeling for a variety of applications, including monitoring of natural and human-built water systems. ENG will support this initiative to bolster research on society's critical need to strategically manage and secure a finite resource for which demand is growing.

National Nanotechnology Initiative (NNI): NSF leads the U.S. nanotechnology research effort, and ENG is the focal point within NSF for this critical national research endeavor. The goal is to support fundamental research and catalyze synergistic science and engineering research and education in emerging areas of nanoscale science and technology as well as research directed at the environmental, health, and safety (EHS) impacts of nanotechnology. ENG supported research can push nanotechnology to the next step, from the present development of passive nanostructures to the next-generation of active nanostructures that would function as devices and systems. Applications include creating new materials that are built, and could even self-assemble, from the nanoscale; realizing petascale computing; regenerating human tissue and organs from the nanoscale; designing systems of nano-sized sensors for monitoring a human's health, a water supply's volume and quality, or an infrastructure; and manufacturing devices, such as solar cells, that efficiently convert and store renewable energy.

Networking and Information Technology Research and Development (NITRD): ENG supports an array of fundamental computer and network research, including the Control, Networks and Computational Intelligence (CNCI) program, which covers creative research and education underlying the analysis and design of intelligent engineering networks for control, communications, computation, and energy.

Science and Engineering Beyond Moore's Law: With silicon-based technologies and materials, computer processing power does in fact have a limit. This initiative supports research aimed at using new materials, methods, algorithms and knowledge to meet increasingly higher needs for computer processing power, information storage, reduced energy usage, and other computing demands. It is time now to exploit quantum states and interactions, new connection architectures, and new algorithms.

QUALITY

ENG maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. In FY 2007, the last year for which complete data exist, 96 percent of research funds were allocated to projects that underwent external merit review.

To ensure the highest quality in processing and recommending proposals for awards, ENG convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review, and provide a retrospective assessment of the quality of results of NSF's investments. The Division of Electrical, Communications and Cyber Systems (ECCS) will be reviewed in FY 2008 and the Chemical, Bioengineering, Environmental and Transport Systems (CBET) and Civil, Mechanical and Manufacturing Innovation (CMMI) divisions will be reviewed in FY 2009.

ENG also receives advice from the Advisory Committee for Engineering (AC/ENG) on such issues as: the mission, programs, and goals that can best serve the engineering community; how ENG can promote quality graduate and undergraduate education in the engineering sciences; and priority investment areas in engineering research. The AC/ENG meets twice each year. Its members represent a cross section of engineering, with representatives from many different sub-disciplines within the field. Members also come from a variety of institutions, have broad geographic representation, and represent a balance of underrepresented groups.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Engineering Funding
By Strategic Outcome Goal
(Dollars in Millions)

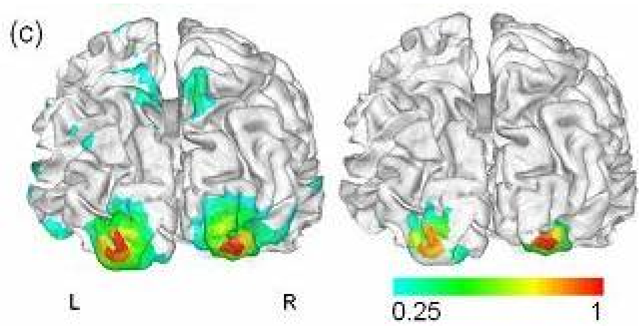
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$543.18	$544.72	$661.09	$116.37	21.4%
Learning	47.96	52.08	54.62	2.54	4.9%
Research Infrastructure	30.40	31.57	32.42	0.85	2.7%
Stewardship	8.46	8.50	11.20	2.70	31.8%
Total, ENG	$629.99	$636.87	$759.33	$122.46	19.2%

Totals may not add due to rounding.

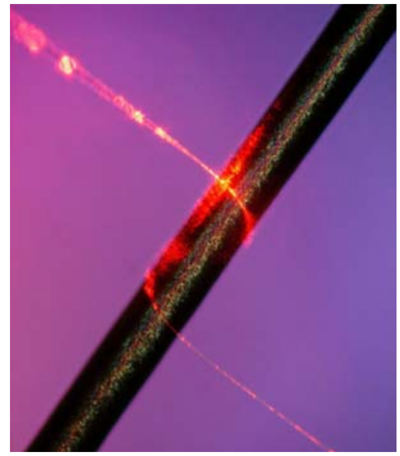
ENG will continue its commitment to education, training, and increasing diversity within all of its Divisions. The FY 2009 budget will maintain award size and continue to focus on multidisciplinary research activities, interagency partnerships, and international activities with special attention given to broadening participation at all levels.

Recent Research Highlights

► **Mapping the Brain in Time and Space:** Electroencephalography, or EEG, is a method for mapping brain activity in close to real-time. However, it cannot pinpoint the location of that activity accurately. Functional magnetic resonance, or fMRI, can help to pinpoint the spatial origins of activity, but not quickly enough. Treating neurological diseases requires mapping brain activity at a high resolution in both time and space. Researchers from the University of Minnesota-Twin Cities have conducted integrated, high-resolution functional mapping by taking simultaneous measurements with both EEG and fMRI and integrating the data. They also developed an algorithm to reconcile inconsistencies between the two methods. This combined approach offers a new window into brain functions and has major biomedical applications. (CBET)



Comparison between cortical imaging from EEG alone (left) and the multimodal imaging integrating EEG and fMRI (right). *Credit: Bin He, University of Minnesota-Twin Cities.*



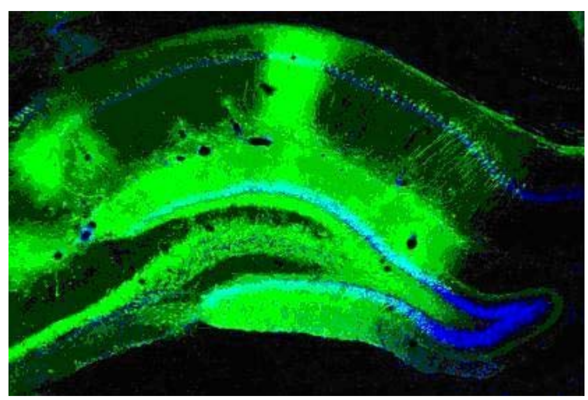
► **Light at the Nanoscale: Vast Potential:** Researchers at Harvard have developed a technique for fabricating nanowires that could propel the miniaturization of microphotonic devices and transform telecommunications. They developed a novel method for successfully thinning a silica fiber to a diameter as small as 100 nanometers. At this size, light moves along the nanowire like a train along rails, rather than moving contained within the wire as it does in fiber optic cables. This difference opens a vast array of flexibility and possibility in manipulating light at the nanoscale – including the development of high-resolution sensors or of optical transistors, a gateway to optical computer chips. The team is also developing fundamental knowledge of the nonlinear behavior of light at the nanoscale. (ECCS)

Light moves along a nanowire, pictured here wrapped around a human hair. *Credit: Eric Mazur, Harvard University.*

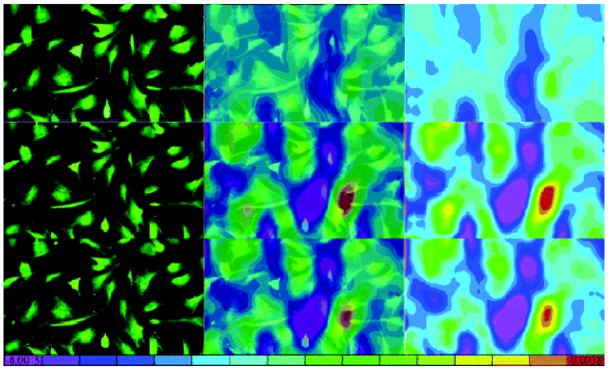
► **High-Efficiency Plastic Solar Cell:** The widespread use of solar cells is hampered not only by how efficiently the cells convert sunlight into electricity, but also by the need to lower production costs for commercial use. With Phase II funding from the Small Business Innovation Research program, Konarka Technologies Inc. has developed a lightweight, flexible, low-cost, and more efficient solar cell. The cells are actually plastic reels coated with layers of dye-sensitized titania nanoparticles in a high-volume, continuous process. The dyes enable the cells to capture relatively larger portions of the visible spectrum and to absorb more of its energy. (IIP)

Konarka's roll-to-roll, high volume manufacturing process produces thin, flexible solar cells. *Credit: Konarka Technologies Inc.*

► **Engineering Viruses to Transform Gene Therapy:** Gene therapy is a process of inserting specified genes into tissue. This enhancement of genetic information could offer a means for permanently curing many crippling diseases caused by genetic defects. One challenge of gene therapy is the safe and effective delivery of the genes. Researchers at the University of California-Berkeley are developing a process to engineer viruses, which deliver genes as part of their life cycle. The engineered viruses could deliver specific genes into designated portions of the genome of targeted cells, and do so with less risk to the immune system. The process uses directed evolution, an algorithm that mimics evolution by generating a large library of viruses and selecting out the appropriate mutation. Currently, the team has engineered a virus that targets one cell type common in the brain. (CBET)



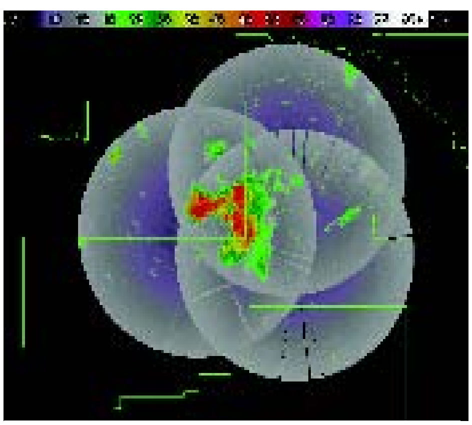
Pictured is the hippocampus of an adult rat brain (the hippocampus may be the site of Alzheimer's formation in humans). The blue cells are the original tissue. The green areas are where the engineered virus, which carried a gene encoding the green fluorescent protein (GFP), have successfully entered the hippocampus and delivered the GFP gene. *Credit: David Schaffer, University of California at Berkeley.*



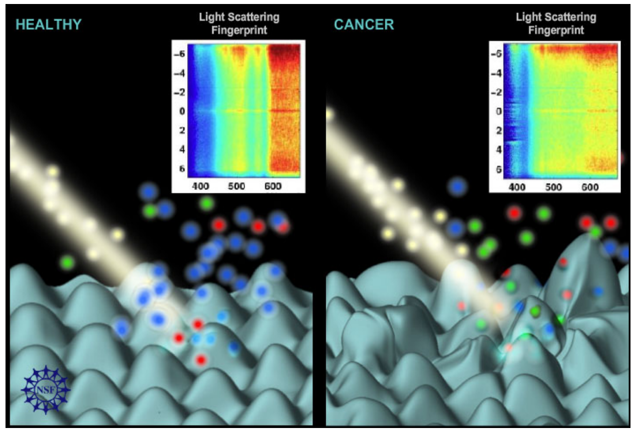
The way gold nanorods respond to light makes it possible to track how a group of cells (pictured at left) placed in a collagen film (middle and right) push (violet areas) and stretch (red areas) their surroundings as they adjust to a new environment. *Credit: Sarah Baxter, University of South Carolina.*

► **Nanorods Outline Cell-Induced Changes in Collagen:** Research is showing that the way cells respond to mechanical changes in their environments is critical to how those cells, and the tissues they comprise, function. A team of University of South Carolina (USC), Columbia, researchers is studying this interaction at the cellular level and in three dimensions, a critical ability. Metallic nanoparticles are useful tools for studying biological systems because of their size and because, with darkfield microscopy, they produce a pattern of bright scattered light in the visible spectrum. The USC team inserted gold nanorods into a cell-populated collagen film. Digital image analysis allowed tracking of the movement and deformation of the light pattern, and thus of deformation between cells, as the cells tested their environment. Watching the dynamics of the mechanical environment at the micro-scale can be used to predict a tissue's bulk properties that evolve from changes in its microstructure. This understanding can aid in many applications, including tissue regeneration. (CMMI)

► **Network Collects Data for Predicting a Tornado**: Atop a communications tower in tornado alley in Oklahoma is a large white dome ready to collect information from the lower atmosphere, specifically about rainfall and wind. Microwave pulses bounce back with more energy from clouds filled with more water. The sensor is part of a new network that will collect data, transmit it via wireless communication, and help to determine rainfall and track the hot spots in a storm. The Center for Collaborative Adaptive Sensing of the Atmosphere, an Engineering Research Center, aims to detect, predict and warn of tornados and other weather hazards. Now online, its first testbed of a network of distributed radar sensors covers 7,000 square kilometers of tornado alley. The network collects real-time data near the ground, where existing long-term Doppler techniques don't measure. As part of its work with the Experimental Warning Project run by the National Oceanic and Atmospheric Administration, the network last spring detected the presence of a tornado not seen by existing techniques. The network is designed to adapt itself to collect data in a form needed by specific end-users, such as the local meteorologist or emergency responders. (EEC)



This radar image was generated from reflectivity data collected by the CASA testbed radar network in southwestern Oklahoma. The data revealed morphological details of this Aug. 15, 2006, storm not visible with current methods. *Credit: David McLaughlin, CASA Engineering Research Center.*



At the nanoscale, light scatters differently from cancerous tissue than it does from normal tissue. *Credit: Nicolle Rager Fuller, National Science Foundation.*

► **Early, Non-invasive Detection of Pancreatic Cancer:** Using novel light-scattering techniques, researchers have found the first evidence that early stage pancreatic cancer causes subtle changes in part of the small intestine. The easily monitored marker may ultimately enable a non-invasive procedure that can detect the cancer early, much earlier than current detection procedures allow. Pancreatic cancer has no obvious symptoms, a primary reason it killed more than 33,000 people in the United States last year. Also, the pancreas can become dangerously inflamed if examined directly, so routine inspections for at-risk patients are usually not an option. The new detection techniques, produce an optical fingerprint gathered from altered tissue in the small intestine, then enhance the data for a clearer diagnosis. Researchers scanned tissue samples from 19 people already diagnosed with pancreatic cancer and 32 without the disease. They properly distinguished patients with cancer at an accuracy approaching 100 percent. The clearest results came from patients in the earliest stages of the disease. Moreover, the new technique works at the nanoscale, allowing it to differentiate cancerous or pre-cancerous tissue from normal tissue, even if the specimens look identical under a normal biopsy. (CBET)

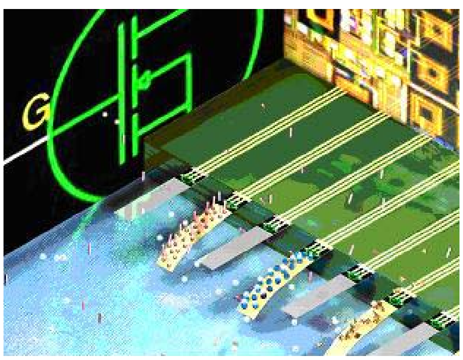


Illustration of the technique's potential: a chip hosting multiple sensing pairs that can, in real-time, detect the presence of several different molecules in parallel. *Credit: Vinayak P. Dravid and Soo-Hyun Tark, Northwestern University.*

► **Using Transistors to Sense Biomolecules:** A unique sensor system could potentially detect the presence of heart disease from a person's drop of blood or detect the presence of chemicals used for explosives. The technique uses microcantilevers, long exploited for sensing. Biomolecules (such as specific types of DNA or specific proteins) placed on the microcantilever uniquely bind with target molecules in a specific environment, such as a liquid or gas. Their binding causes surface stress that bends the microcantilever. Traditionally, optics has been used to measure microcantilever bending. Instead, researchers have embedded transistors (specifically, metal-oxide-semiconductor-field-effect-transistors), into the microcantilever. They found that deflections as small as 5 nanometers create measurable changes in drain current of the transistor. This alternative measuring technique affords more flexibility, such as the ability to perform high-resolution sensing in liquids or environments in which light scatters. They could also equip a chip with several cantilever-transistor pairs designed to sense different molecules, allowing sensing of the relative amounts of given molecules in an environment. They have a patent for the technique and are investigating applying it to the sensing of explosives. (ECCS)

Other Performance Indicators

The tables below show the change in the number of people benefiting from ENG funding, and trends in the award size, award duration, number of awards, and funding rates.

Number of People Involved in ENG Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	6,766	6,868	7,760
Other Professionals	1,385	1,406	1,589
Postdoctorates	386	392	443
Graduate Students	6,110	6,202	7,008
Undergraduate Students	3,010	3,055	3,452
Total Number of People	17,657	17,923	20,252

ENG Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,958	1,978	2,235
Funding Rate	20%	20%	25%
Statistics for Research Grants:			
Number of Research Grants	1,114	1,136	1,590
Funding Rate	16%	16%	20%
Median Annualized Award Size	$99,768	$99,800	$101,500
Average Annualized Award Size	$115,860	$116,000	$118,000
Average Award Duration, in years	3.0	3.0	3.0

CHEMICAL, BIOENGINEERING, ENVIRONMENTAL AND TRANSPORT SYSTEMS $173,340,000

The FY 2009 Budget Request for the Chemical, Bioengineering, Environmental and Transport Systems Division (CBET) is $173.34 million, an increase of $42.34 million, or 32.3 percent, above the FY 2008 Estimate of $131.0 million.

Chemical, Bioengineering, Environmental and Transport Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Chemical, Bioengineering, Environmental, and Transport Systems	**$128.27**	**$131.00**	**$173.34**	**42.34**	**32.3%**
Major Components:					
Research and Education Grants	115.67	118.17	160.23	42.06	35.6%
Science and Technology Center (STC)	4.05	4.00	4.00	-	-
National Nanoscale Infrastructure Network (NNIN)	3.20	3.20	3.20	-	-
Nanoscale Science and Engineering Centers (NSEC)	5.35	5.63	5.91	0.28	5.0%

About CBET:

The Chemical, Bioengineering, Environmental and Transport Division supports research to enhance and protect U.S. national health, energy, environment, security, and wealth. Through CBET, the physical, life and social sciences are merged in engineering research and education, resulting in advances in the rapidly evolving fields of bioengineering and environmental engineering, and in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy, including chemicals, pharmaceuticals, medical devices, forest products, metals, petroleum, food, textiles, utilities, and microelectronics. CBET supports research in biotechnology and the chemical, environmental, biomedical, mechanical, civil, and aerospace engineering disciplines.

To achieve synergy across disciplinary boundaries, CBET is organized in four program clusters: Chemical, Biochemical, and Biotechnology Systems; Transport and Thermal Fluids Phenomena; Biomedical Engineering and Engineering Healthcare; and Environmental Engineering and Sustainability.

In general, 63 percent of the CBET portfolio is available for new research grants. The remaining 37 percent funds continuing grants made in previous years.

CBET Priorities for FY 2009:

The Division will continue to support research in key applications of the physical sciences, such as catalysis, chemical process design, environmental engineering, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particulate processes. These investments contribute to advances that are important for energy, the environment, transportation, information technologies, health-related products, and other areas that both impact our daily lives and sustain and enhance U.S. competitiveness.

Current high-emphasis areas include multi-disciplinary research funded across programs within and external to the division. This cross-disciplinary research leads to improved biosensors, biomaterials, controlled drug release, improved medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, bioremediation, water and waste treatment, and food engineering. While sustaining the vitality of these core research areas, CBET actively supports the following theme areas:

Energy, Environment, and Sustainability: CBET will continue to support research on environmentally benign processes. Energy conversion areas include green gasoline production from biomass, cleaner combustion processes, fabrication of new materials for solar cells, novel electrode materials for fuel cells, microbial fuel cells, liquid biofuels, and biohydrogen. The management of greenhouse gases with their links to climate change will be supported. CBET leads the Water and Environmental Research Systems (WATERS) Network project (NSF support of $6.20 million for FY 2009), which has, as its objective, the transformation, at a national scale, of research on water resource engineering. WATERS is aimed at observing, monitoring, and predicting the nation's water supply by integrating complex natural environments with engineered systems. Resilient, sustainable infrastructure is a new area of support for several programs within the division.

Nanoscale Science and Engineering: CBET will continue its leadership role in supporting research for designing, synthesizing, and analyzing nanoscale systems. Current emphasis is on active nanoscale systems leading to improved devices and sustainable manufacturing techniques. CBET also plays a key role in funding exploratory research on biosystems at the nanoscale. For example, chips and sensors, combined with microfluidics, are integrated intimately with nanobiotechnology. Many of these systems are for medical, environmental, and other sensing applications.

Cyber-enabled Discovery and Innovation (CDI): CDI efforts are pervasive throughout CBET's programs. Projects involving CDI are funded throughout CBET, and draw increasingly on High Performance Computing (HPC) capabilities that will be enhanced by NSF-level CDI investments. Multi-scale modeling is growing rapidly in the academic communities funded by CBET. CBET hosts the interagency solicitation on multi-scale modeling in Biomedical, Biological, and Behavioral systems. CBET is also part of an interagency working group on multi-scale chemical sciences and process informatics kinetics, and encourages strong interaction between modeling and experimental efforts.

Complex Engineered and Natural Systems: CBET invests heavily in complex natural systems through the environmental programs, including the plan for the WATERS Network, and through projects awarded in the Biomedical Engineering and Engineering Healthcare cluster. Examples of these types of awards include the development of artificial retinal implants for sight restoration and neurotechnology-based computer interfaces to allow people with brain injuries to have use of their limbs.

CBET continues to participate in major NSF-wide investments and supports large scale facilities through Science and Technology Centers, Nanoscale Science and Engineering Centers and the National Nanotechnology Infrastructure Network.

Changes from FY 2008:

- Support increases by $2.98 million for the CDI NSF-wide investment.
- Support of $1.40 million for the SEBML NSF-wide investment.
- $1.0 million in support of the AST NSF-wide investment.
- Support of $290,000 for the WATER NSF-wide investment.
- Support increases by $280,000 for Nanoscale Science & Engineering Centers.
- An increase of $36.39 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.

CIVIL, MECHANICAL AND MANUFACTURING INNOVATION $201,880,000

The FY 2009 Budget Request for the Civil, Mechanical and Manufacturing Innovation Division (CMMI) is $201.88 million, an increase of $42.07 million, or 26.3 percent, above the FY 2008 Estimate of $159.81 million.

Civil, Mechanical and Manufacturing Innovation Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Civil, Mechanical and Manufacturing Innovation	**$157.30**	**$159.81**	**$201.88**	**$42.07**	**26.3%**
Major Components:					
Research and Education Grants	129.95	130.85	171.80	40.95	31.3%
Network for Earthquake Enginnering and Simulation (NEES)	20.74	22.17	23.02	0.85	3.8%
National Nanoscale Infrastructure Network (NNIN)	1.65	1.65	1.65	-	-
Nanoscale Science and Engineering Centers (NSEC)	4.96	5.14	5.41	0.27	5.3%

About CMMI:

The Civil, Mechanical and Manufacturing Innovation (CMMI) Division supports fundamental research to advance the frontiers of knowledge in order to enable a globally competitive and sustainable future for the nation. CMMI supports research to advance the domain knowledge in areas related to analyzing, modeling, designing, building, and securing the nation's critical infrastructure, and to strengthening its manufacturing and service enterprises.

CMMI programs are organized into four areas: resilient and sustainable infrastructure, manufacturing and service enterprises, mechanics and engineered materials, and engineering decision sciences. These areas will provide funds for the creation of necessary knowledge to design and secure the nation's infrastructure, and to grow our nation's wealth-producing enterprises.

A major portion of CMMI's portfolio supports the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) and hazard-related research. NEES is a system of 15 experimental facilities located at universities across the United States that work together via cyberinfrastructure. This research facility addresses important challenges in earthquake and tsunami engineering research that previously could not be addressed, such as testing structures at near to full scale. Investments in fundamental earthquake engineering and other hazard-related research enables NSF's Engineering Directorate to quickly send research teams to gather ephemeral data immediately following natural as well as man-made disasters. The fundamental knowledge gained from these investments is being used to design predictive systems for the nation's infrastructure to mitigate damage, down time, and loss of life from a wide range of hazards.

CMMI's design, manufacture, and service portfolio is the largest among the federal agencies that support fundamental research and discovery driven by innovative research ideas from the community rather than by pre-defined specifications. This has led to early investments in solid-modeling systems, optimization and network methods, and processes that provide solid representations directly from digital data and enable engineered processes for growing tissue.

In general, 67 percent of the CMMI portfolio is available for new research grants. The remaining 33 percent funds continuing projects made in previous years and operation of facilities and centers.

CMMI priorities for FY 2009:

CMMI's priorities for FY 2009 align with ENG's priorities in:

- *Cognitive Engineering* by supporting research in the areas of nano- and bio-mechanics as well as biosensors and bioactuators.
- *Competitive Manufacturing and Service Enterprises* by supporting research in the enabling processes, systems and enterprises to advance nanomanufacturing and the technology for healthcare delivery.
- *Complexity in Engineered and Natural Systems* by supporting research that leads to fundamental knowledge of complex systems and their modeling and research that leads to technologies for the protection, maintenance, or modification of the nation's critical civil and cyber infrastructure.
- *Energy, Water and the Environment* through support for research in understanding the effects of material processing on the environment and the usage of water and energy.
- *Systems Nanotechonology* by supporting research in areas that support design, analysis, and manufacture of systems based on advances in nanotechnology.

A major priority for CMMI is support for NEES research and operations, as well as the grand challenges NEES research addresses. Research will continue to involve experimental and theoretical simulations at the NEES facilities as well as expand educational outreach. CMMI is engaged with its research community to focus its investment priorities. This includes several workshops, cosponsored with DOD agencies, on fundamental research needs in the area of jointed structures; and workshops for the Mechanical, Civil, and Environmental Engineering communities to define their future research directions.

CMMI supports nanoscale science and engineering, with programs in the Mechanics and Engineered Materials cluster, including Nanomanufacturing and Nano/Bio-Mechanics. These programs have a critical role in converting discoveries into innovations, and are a key component of the Directorate's *Nanotechnology* theme and the grand challenges for the National Nanotechnology Initiative. A range of manufacturing discoveries and innovations are needed to design the systems and processes to deliver products, devices and components that take advantage of the unique properties of the nanoscale. Simultaneously, an entirely new manufacturing workforce needs to be educated and trained in nanotechnology to bring to fruition the many exciting opportunities that nanotechnology has opened up. CMMI's Nanomanufacturing program will continue to support research on improving human physical and mental abilities through the integration of nanotechnology, biotechnology, information technology, and cognitive science, as well as a new generation of tools and processes to achieve this goal.

Changes from FY 2008:

- Support increases by $3.84 million for the CDI NSF-wide investment.
- Support of $1.0 million for the SEBML NSF-wide investment.
- $1.49 million in support of the AST NSF-wide investment.
- Support of $120,000 for the WATER NSF-wide investment.
- An increase of $34.50 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.
- An increase of $850,000 to a total of $23.02 million will continue to accommodate the operations phase for the Network for Earthquake Engineering Simulation.
- Support increases by $270,000 for Nanoscale Science & Engineering Centers.

ELECTRICAL, COMMUNICATIONS AND CYBER SYSTEMS $94,360,000

The FY 2009 Budget Request for the Electrical, Communications and Cyber Systems (ECCS) Division is $94.36 million, an increase of $10.86 million, or 13.0 percent, over the FY 2008 Estimate of $83.50 million.

Electrical, Communications and Cyber Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Electrical, Communications and Cyber Systems	**$83.24**	**$83.50**	**$94.36**	**$10.86**	**13.0%**
Major Components:					
Research and Education Grants	71.23	72.37	83.71	11.34	15.7%
Nanoscale Science and Engineering Centers (NSEC)	3.13	3.25	3.44	0.19	5.8%
National Nanoscale Infrastructure Network (NNIN)	4.81	4.55	4.55	-	-
Science and Technology Center (STC)	4.07	3.33	2.66	-0.67	-20.1%

About ECCS:

ECCS will address fundamental research issues underlying device and component technologies, power and energy, controls, computation, networking, communications and cyber technologies. ECCS will support the integration and networking of intelligent systems at the nano, micro and macro scales for a variety of application domains in healthcare, environment, energy, communications, disaster mitigation, homeland security, transportation, manufacturing, and other systems-related areas. ECCS envisions a research community that will address major technological challenges for the next generation of devices and systems due to convergence of technologies and increased emphasis on interdisciplinary research to achieve the goals of the American Competitiveness Initiative and the America COMPETES Act. ECCS will integrate education into its research programs to ensure the preparation of a diverse workforce for the 21st century that can enable innovative advances in emerging technologies as drivers of the global economy.

ECCS is organized around three programs: Electronics, Photonics and Device Technologies; Power, Controls and Adaptive Networks; and Integrative, Hybrid and Complex Systems, which will focus on research and educational issues of device and component technologies, network and computational technologies, and systems engineering.

In general, 70 percent of the ECCS funds are available for new research grants; the remaining 30 percent funds continuing grants made in prior years.

ECCS Priorities for FY 2009:

The Electronics, Photonics and Device Technologies (EPDT) program will seek to improve the fundamental understanding of devices and components based on the principles of electronics, photonics, magnetics, organics, electro-optics, electromechanics, and related physical phenomena at the nanoscale. The program will enable discovery and innovation in advancing the frontiers of spin electronics, molecular electronics, bioelectronics, nonsilicon electronics, flexible electronics, optoelectronics, microwave photonics, power electronics, and mixed signal devices. EPDT will further support related topics in quantum engineering, novel electromagnetic materials-based devices, radio-frequency integrated circuits, and reconfigurable antennas for communications, telemedicine and other wireless applications.

The program will continue cooperative efforts with the semiconductor industry on new nanoelectronics concepts beyond the scaling limits of silicon technology. EPDT will provide additional emphasis on emerging areas of diagnostic and implantable devices, and will continue its support for manipulation and measurement with nanoscale precision through new approaches to instrumentation.

The Power, Controls and Adaptive Networks (PCAN) program will invest in the design and analysis of intelligent and adaptive engineering networks, including sensing, imaging, controls, and computational technologies for a variety of application domains. PCAN will further invest in adaptive dynamic programming, brain-like networked architectures performing real-time learning, cognitive and neuromorphic engineering, telerobotics and systems theory. PCAN will place strong emphasis on energy scavenging and alternative energy technologies, critical infrastructure aspects of electric power networks and grids including generation and integration of renewable, sustainable and distributed energy systems and associated high-power electronics, and interdependencies of critical infrastructure in power and communications. PCAN will also provide additional emphasis on quantum and molecular modeling and simulation of devices and systems.

The Integrative, Hybrid and Complex Systems (IHCS) program is intended to spur visionary systems-oriented activities in collaborative research and education environments for multidisciplinary integrative activities. IHCS will offer new challenges at nano/micro/macro levels of systems integration with engineering solutions for a variety of domain-specific applications. The program will support innovative research in nano/microsystems, communications systems, and cyber systems that integrate physical devices and components with controls, computational intelligence and networks. IHCS will also support integration technologies at intra- and inter-chip levels that target new communication system architectures, radio-frequency and optical wireless and hybrid communications systems, and mixed-signal systems. ECCS is committed to supporting the development of innovative hardware, signal processing, and software architectures for emerging areas of cyber systems for design, integration, and implementation of multi-scale and multi-level complex systems that will enable visualizing, analyzing, and reconfiguring of emergent-behavior for various applications. To leverage cyber-enabled discovery and innovation, IHCS will continue its support in the areas of high-performance computing to analyze and simulate the behavior of complex systems at the macroscale, and engineering virtual organizations to improve collaboration, archiving and sharing of data, and disseminating open-source software tools.

ECCS will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, as well as crosscutting activities. ECCS will support the development of people through Foundation-wide programs, such as CAREER and ADVANCE, and through REU and RET supplements, and will actively participate in the development and management of cross-disciplinary programs including small teams.

Changes from FY 2008:

- Support increases by $1.99 million for the CDI NSF-wide investment.
- Support of $1.60 million for the SEBML NSF-wide investment.
- $1.0 million in support of the AST NSF-wide investment.
- Support of $120,000 for the WATER NSF-wide investment.
- Support increases by $190,000 for Nanoscale Science & Engineering Centers
- An increase of $6.63 million to support leading edge, frontier research in core programs and in support of the Engineering research themes.
- Decreases support by $670,000 for the Science and Technology Center.

INDUSTRIAL INNOVATION AND PARTNERSHIPS $140,900,000

The FY 2009 Budget Request for the Industrial Innovation and Partnerships (IIP) Division is $140.90 million, an increase of $19.23 million, or 15.8 percent, over the FY 2008 Estimate of $121.67 million.

Industrial Innovation and Partnerships Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Industrial Innovation and Partnerships	**$120.78**	**$121.67**	**$140.90**	**$19.23**	**15.8%**
Major Components:					
Small Business Innovation Research (SBIR)	97.20	97.85	113.62	15.77	16.1%
Small Business Technology Transfer (STTR)	11.47	11.52	13.38	1.86	16.1%
Grant Opportunities for Academic Liaison with Industry (GOALI)	5.51	5.60	6.33	0.73	13.0%
Industry/University Cooperative Research Centers (I/UCRC)	6.60	6.70	7.57	0.87	13.0%

About IIP:

The Division of Industrial Innovation and Partnerships serves the entire Foundation by fostering partnerships aimed at advancing technological innovation. The division is organized to respond to the American Competitiveness Initiative (ACI) and the America COMPETES Act by catalyzing the transformation of discovery into societal benefits through stimulating partnerships for innovators. IIP is home to two legislatively mandated small business research programs, the Small Business Innovation Research program (SBIR) and the Small Business Technology Transfer program (STTR). Additionally, IIP leverages industrial support through two research programs, Industry/University Cooperative Research Centers (I/UCRCs) and Grant Opportunities for Academic Liaison with Industry (GOALI) programs.

Twice each year, SBIR and STTR release proposal solicitations containing topics targeted to innovative small businesses in the United States. These solicitations cover technologies that emphasize innovation with commercialization potential. From the business community perspective, SBIR/STTR investments are considered “pre-seed.” That is, they support research that is considered too high-risk for even early stage corporate investment. The research topics in the SBIR/STTR solicitations are designed to meet the needs of capital/investment markets, strategic partners, and national and societal priorities. They also have the potential to encourage new venture and business investments outside of the SBIR/STTR program.

The Industry/University Cooperative Research Centers (I/UCRC) program develops long-term partnerships among industry, academe, and government. The centers are catalyzed by a small investment from NSF, and are primarily supported by industry center members, with NSF taking a supporting, guiding role in their development and evolution. Each center is established to conduct research that is of interest to both the industry and the center. An I/UCRC contributes to the nation's innovation infrastructure base and enhances the intellectual capacity of the engineering and science workforce through the integration of research and education.

The Grant Opportunities for Academic Liaison with Industry (GOALI) program enables partnerships between industry and academe where there is a common intellectual, educational, and innovation agenda.

The program supports (a) faculty, postdoctoral fellows, and students to conduct research and gain experience in an industrial setting; (b) industry scientists and engineers to bring industrial perspective and integrative skills to academe; and (c) interdisciplinary university/industry teams to conduct long-term projects. The program targets high-risk and high-gain research, focusing on high-risk topics that would not otherwise be undertaken by industry. It enables development of innovative, collaborative university/industry educational programs, and the direct exchange of new knowledge between academe and industry.

IIP Priorities for FY 2009:

Within the SBIR/STTR research topics, Biotechnology, Information Technology, and Electronics Technology are positioned to potentially attract venture capital and "angel network" communities. Advanced Materials and Manufacturing and Chemical Technology research topics are of interest to the large corporations that see the potential for strategic partnerships with the small business community. Selected topics are launched in response to national priorities such as Manufacturing Innovation and Security Technology. To accelerate near term technological innovation, a special topic, Emerging Opportunities, and a supplement to qualifying Phase I grantees, were launched in 2006. Starting in FY 2006, SBIR and STTR programs reversed the downward trend in funding rate from a low of 14 percent by controlling release of solicitation topics. With increased funding in 2008, the target is to achieve a 20 percent funding rate.

The 47 I/UCRCs work closely with industry to develop enabling technologies needed to manage the electrical power system, improve manufacturing and biological processes, develop new materials, improve information and telecommunications technologies, and innovate new products and services. The I/UCRC program provides modest seed funds and management expertise to these highly leveraged centers, with states joining in many partnerships to expand the centers' activities to impact local economic development. The I/UCRC program also supports a supplemental research initiative to advance the underlying innovation potential of the centers. Currently, the I/UCRC and SBIR/STTR programs are exploring synergistic academic-small business partnership opportunities as a model to accelerate the innovation process.

The strategic plan for the Directorate for Engineering calls for increasing partnerships between academic and industrial communities. GOALI is well positioned to directly impact this objective. GOALI leverages its budget with support from other academic research programs by a factor of four-to-one. In FY 2009, the GOALI program will seek opportunities to accelerate innovation, strengthening the discovery knowledge base for a quicker transformation of discovery to societal benefit.

Changes from FY 2008:

- Increase of $15.77 million, to a total of $113.62 million for the Small Business Innovation Research program.
- Increase of $1.86 million, to a total of $13.38 million for the Small Business Technology Transfer program.
- Funding increases $870,000, to a total of $7.57 million for the I/UCRC program.
- Increase of $730,000, to a total of $6.33 million for GOALI program.

ENGINEERING EDUCATION AND CENTERS $119,850,000

The FY 2009 Budget Request for the Engineering Education and Centers (EEC) Division is $119.85 million, an increase of $3.96 million, or 3.4 percent, over the FY 2008 Estimate of $115.89 million.

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Engineering Education and Centers	**$115.16**	**$115.89**	**$119.85**	**3.96**	**3.4%**
Major Components:					
Research and Education Grants	55.28	49.68	52.95	3.27	6.6%
Engineering Research Centers (ERC)	47.05	52.86	53.55	0.69	1.3%
Nanoscale Science and Engineering Centers (NSEC)	9.48	10.00	10.00	-	-
Network for Computational Nanotechnology	3.35	3.35	3.35	-	-

About EEC:

The Engineering Education and Centers (EEC) Division promotes and facilitates university research and curricula by supporting innovative programs that integrate research and education, improve the quality of the engineering workforce, cut across disciplines, and enable a breadth of investigation that spans from idea inception to proof-of-concept. The division's programs are divided into three major categories: development of interdisciplinary research centers that foster partnerships between academe, government and industry; advancing graduate and undergraduate engineering education; and development of a diverse and capable technical workforce. EEC programs address issues that are critical to all fields of engineering and benefit from a centralized management focus, as well as complement the research and education portfolios of the other divisions of the Directorate for Engineering. Included programs benefit from a scope encompassing all of engineering and a scale that both facilitates the incorporation of new scientific knowledge into engineering and requires rigorous monitoring and evaluation systems.

In general, 79 percent of the EEC portfolio is used to fund centers, graduate fellowships, and undergraduate programs. Approximately 21 percent of the EEC portfolio is available for new research grants.

EEC Priorities for FY 2009:

In FY 2009, EEC will provide support for Engineering Research Centers, Nanoscale Science and Engineering Centers, engineering education research, and engineering workforce development.

In FY 2009, 15 Engineering Research Centers will receive funding. Examples of center research include: research and development of sensory prostheses that interface to the human nervous system, systems for detection of and warning for severe storms, computer-integrated surgical systems, biomaterials for implants, reconfigurable manufacturing systems, and power electronics. In FY 2008, EEC is planning to add five new ERCs to the portfolio through the graduation to self-sufficiency of existing ERCs, and through the phasing down of support to others during FY 2006 and 2007 to prepare them for self-sufficiency.

The eight ongoing Nanoscale Science and Engineering Centers, fully or partially supported by EEC, perform research to advance the development of the ultra-small technology that will transform electronics, materials, medicine, and many other fields. They involve key partnerships with industry, national laboratories, and other sectors; and support education programs from the graduate to the pre-college levels designed to develop a highly skilled workforce. Funds are also provided to smaller interdisciplinary teams and to the Network for Computational Nanotechnology (www.nanHub.org), a web-accessible repository of simulations of nanoscale phenomena for research and education.

EEC programs in engineering education are aimed at transforming engineering education to produce an engineering workforce that is diverse and creative, understands the impacts of its solutions on both technical and social systems, and possesses the ability to adapt to the rapidly evolving technical environment in industry, academe, and society. In FY 2009, research will be supported to improve the development, management, and productivity of quality engineering education at both the undergraduate and graduate levels. Significant breakthroughs in understanding are sought so that our undergraduate and graduate engineering education can be transformed to meet the needs of the changing economy and society. Topics of particular interest include: the aims and objectives of engineering education, the content and organization of the curriculum, how students learn problem solving, how to encourage creativity and design, developing new methods for assessment and evaluation of how students learn engineering, understanding the business aspect of engineering education, and conducting research that helps us understand how to attract and retain a more talented and diverse student body to all levels of engineering study.

Existing programs in Research Experiences for Undergraduates (REU) Sites and Research Experiences for Teachers (RET) Sites, which have been shown to be successful programs for broadening participation in engineering programs at both the undergraduate and graduate levels, will increase in FY 2009.

Changes from FY 2008:

- Support for the Research and Education Grants increases by $3.27 million, to a total of $52.95 million.
- Funding for ERCs increases by $690,000, to a total of $53.55 million.

EMERGING FRONTIERS IN RESEARCH AND INNOVATION $29,000,000

The FY 2009 Budget Request for the Office of Emerging Frontiers in Research and Innovation (EFRI) is $29.0 million, an increase of $4.0 million, or 16.0 percent, over the FY 2008 Estimate of $25.0 million.

Emerging Frontiers in Research and Innovation Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Emerging Frontiers in Research and Innovation	**25.25**	**$25.00**	**$29.00**	**$4.00**	**16.0%**

About EFRI:

The Office of Emerging Frontiers in Research and Innovation (EFRI) resides within the Office of the Assistant Director for Engineering and was established in FY 2007 to fulfill the critical role of helping ENG focus on important emerging areas in a timely manner. Each year EFRI recommends, prioritizes, and funds interdisciplinary topics at the emerging frontier of engineering research and education. These emerging frontiers are frequently found in transformative interdisciplinary areas. The divisions within the NSF's Engineering Directorate are not strategically aligned to support this type of research, which often falls outside the usual classifications and research areas. EFRI enables ENG to pursue these interdisciplinary areas by allowing the engineering community to come forward with new and paradigm-shifting proposals at the interface of disciplines and fields.

Technological innovations, particularly over the past decade, have given rise to new industries, expanded our access to quality healthcare, and fueled our nation's prosperity even in the face of growing global competition. Now that global competition is increasing, the technical underpinnings of the past may not be adequate to ensure our continued success. EFRI will provide critical, strategic support of fundamental discovery, particularly in areas leading to breakthrough technologies.

EFRI investments represent transformative opportunities, potentially leading to: new research areas for NSF and other agencies; new industries or capabilities that result in a leadership position for the country; and/or significant progress on a recognized national need or grand challenge. These challenges may include areas such as safe, clean water; sustainable energy resources; technologies to overcome physical limitations from disease or injury; and integrated systems designed to thwart attacks on U.S. infrastructures and interests throughout the world. EFRI will have the necessary flexibility to target our long-term challenges, while retaining the ability and agility to adapt as new challenges demand.

In general, 100 percent of the EFRI portfolio is available for new research grants.

EFRI Priorities for FY 2009:

The role of the EFRI Office is to fund research opportunities that would be difficult to fund with current mechanisms, such as Small Grants for Exploratory Research, typical core awards, or large research center solicitations. The successful topics would likely require small- to medium-sized interdisciplinary teams of researchers with significant funding, for a period of time needed to make substantial progress that would provide evidence for additional follow-on funding through other established funding mechanisms.

Mechanisms: Potential EFRI topics can arise from input from a number of sources: the community, advisory committees, workshops, professional societies, academies, proposals and awards, and NSF committees of visitors. Yet, in the case of directed specified topics, the ENG program directors will play the central role within NSF.

Potential EFRI topics will be evaluated against criteria such as: Does the topic represent an opportunity for a significant leap or paradigm shift in a research area, or have the potential to create a new research area? Is there potential for making significant progress on a current national need or grand challenge? Is the financial and research scope beyond the capabilities of one division? Is the community able to organize and effectively respond?

Example topic areas that EFRI has pursued based on the above criteria are Autonomously Reconfigurable Engineered Systems (ARES), Cellular and Biomolecular Engineering (CBE), Cognitive Optimization (COPN), and Resilient and Sustainable Infrastructures (RESIN). In ARES, researchers are paving new research frontiers for engineering systems that can modify themselves when subject to *unplanned* events. In CBE, methods and technologies are being developed to regenerate some of the body's most complex tissues. COPN will fund projects that will build new dynamic optimization algorithms by studying the way systems of neurons do such complex tasks. RESIN will fund projects to develop the theoretical foundation, methods, and technologies for making interdependent critical infrastructures both resilient and sustainable.

EFRI research in FY 2009 will better enable the Engineering Directorate to meet its strategic goal of fostering frontier and transformative research. Topics for EFRI support will typically relate to the five key ENG Themes. These are:

- *Cognitive Engineering,* which focuses on the intersection of engineering and cognitive science;
- *Competitive Manufacturing and Service Enterprises*, which includes research that catalyzes multiscale manufacturing, from fundamental metrology to new knowledge for realizing atomic-scale control of raw materials and systems;
- *Complexity in Engineered and Natural Systems,* which addresses unifying principles that enable modeling, prediction, and control of emergent behavior in complex systems;
- *Energy, Water and the Environment*, which focuses on an integrative approach to understanding interconnections among energy, water, and the environment; and includes frontier research to improve the cost, sustainability, and security of our nation's energy system; and
- *Systems Nanotechnology,* which is the next frontier in nanotechnology. This research will help to create controllable systems built from nanoscale components and help in understanding interactions among nanostructures and their collective behavior in systems. Goals are discoveries and innovation for new industrial and medical applications.

These frontier research areas will guide the decision-making process throughout the Engineering Directorate, but specifically within the Office of Emerging Frontiers in Research and Innovation.

Changes from FY 2008:

The additional $4.0 million will allow for the support of 14 awards, rather than 12, to strengthen the impact of this important office.