ENGINEERING $580,680,000

The FY 2006 Budget Request for the Directorate for Engineering (ENG) is $580.68 million, an increase of $19.38 million, or 3.5 percent, over the FY 2005 Current Plan of $561.30 million.

Engineering Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Bioengineering and Environmental Systems (BES)	51.00	48.22	50.68	2.46	5.1%
Chemical and Transport Systems (CTS)	69.21	65.79	68.99	3.20	4.9%
Civil and Mechanical Systems (CMS)	67.22	81.98	84.21	2.23	2.7%
Design and Manufacturing Innovation (DMI)	65.92	63.85	67.41	3.56	5.6%
Electrical and Communications Systems (ECS)	74.61	71.64	74.35	2.71	3.8%
Engineering Education and Centers (EEC)	134.03	127.06	129.71	2.65	2.1%
Office of Industrial Innovation (OII)	103.58	102.76	105.33	2.57	2.5%
Total, ENG	$565.57	$561.30	$580.68	$19.38	3.5%

Totals may not add due to rounding.

The Directorate for Engineering supports the leading edge of fundamental engineering research. The fruits of this activity yield critical new technologies; innovative systems that enhance the way we live, work and play; and the foundation to build the world's most capable engineering workforce. Together, these engineering investments ensure that our nation will be more secure and more prosperous, and its citizens will be healthier and more productive.

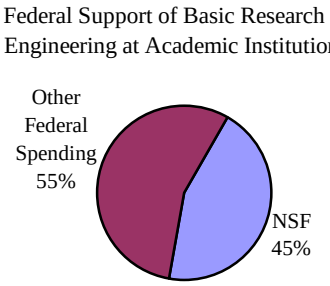
The engineering research and innovation supported by the Directorate for Engineering spans all areas of science (See "Comparable Division of Science and Engineering" table below). ENG also supports the entire spectrum of fundamental engineering research – from new discoveries to research advancing underpinning methodologies. It does not include incremental product change or late term product development.

Engineering Innovation involves using scientific knowledge and design methodologies to create new structures, new devices, and new systems and processes that lead to significant social and economic value. Some of the research that ENG currently supports will develop new nano materials and processes that will lead to whole new industries, develop new means of building and protecting our infrastructure to be more resistant to natural disasters and those of human origin, and create new smart drug delivery systems that are tailored to individuals.

COMPARABLE DIVISION OF SCIENCE AND ENGINEERING	
SCIENCE Research and Discovery	**ENGINEERING** Research and Engineering Innovation
Physics	Mechanical Engineering; Electrical Engineering; Nuclear Engineering
Chemistry	Chemical Engineering
Astronomy	Aerospace Engineering
Biosciences	Bioengineering; Biomedical Engineering
Geosciences	Civil Engineering
Social and Behavioral Sciences	Industrial and Systems Engineering; All Engineering Fields
Computer Sciences	All Engineering Fields
Mathematics	All Engineering Fields

RELEVANCE

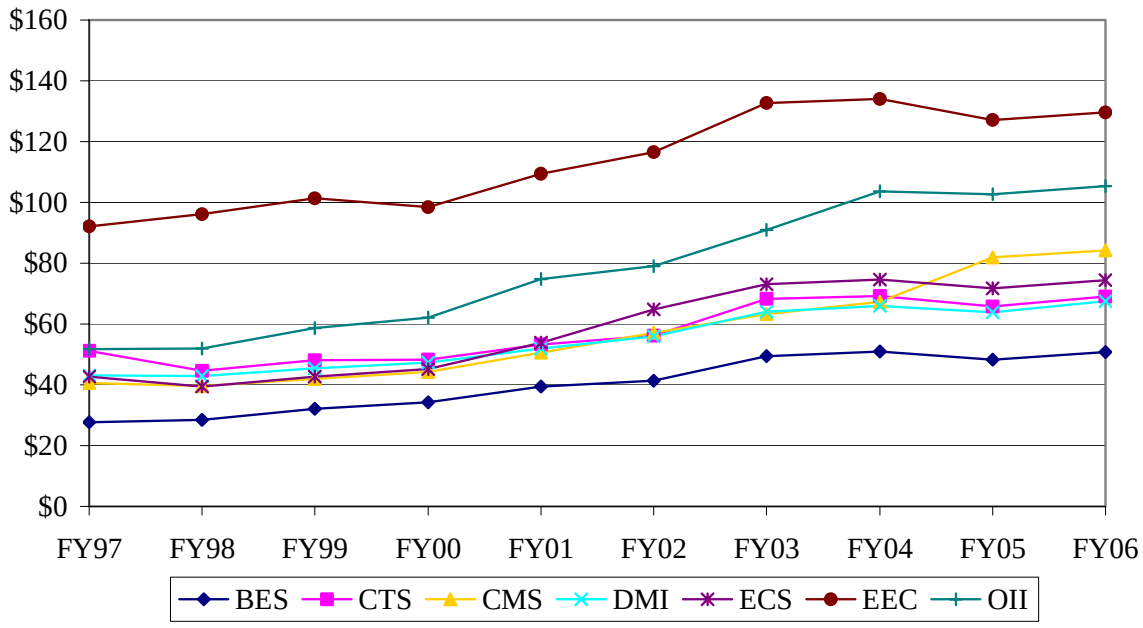
The Engineering Activity is a major source of federal funding for university-based, fundamental engineering research, providing 45 percent of the total federal support in this area.



ENG investments in engineering research and education build and strengthen a national capacity for innovation that leads to the creation of new, shared wealth and a better quality of life. ENG investments align closely with Administration Research and Development priorities, with a commitment to emerging technologies—nanotechnology, cyberinfrastructure, network systems, molecular electronics, photonics, metabolic engineering, bioengineering, and manufacturing innovation. Support for research in these areas contributes to major advances in health care, manufacturing, and homeland security. It also enables the technological advancement of our society. A recent Lemelson-MIT project highlighted what it considered to be the top 25 innovations of the past 25 years. Among these advances were fiber optics, cell phones, air bags, HDTV, and the number one innovation – the Internet. This list demonstrates the impact of engineering innovation on our daily lives.

ENG leads the Foundation's efforts in the area of nanotechnology, plays a significant leadership role in the National Nanotechnology Initiative (NNI), and works closely with the other NSF Activities and other federal agencies in advancing this exciting field. Nanotechnology has the potential to enable revolutionary technologies that can advance a broad spectrum of science and engineering disciplines. Nanotechnology is reaching into all areas of society and the economy. In 2003, over 5,300 U.S. patents in nanotechnology were issued, all "Fortune 500" manufacturing companies have entered the field, and over 1,000 new business startups have been documented. Current estimates point to revenues of $1 trillion and the creation of 2 million new jobs by 2015.

ENG Subactivity Funding
(Dollars in Millions)



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

ENG FY 2005 Current Plan...……..$561.30

Bioengineering and Environmental Systems (BES) +$2.46

The funding increase will be used to (1) support a solicitation on the vibrant new field of Quantitative Systems Biotechnology (QSB), and (2) fund Collaborative Large-scale Engineering Analysis Network for Environmental Research (CLEANER) planning activities. QSB is the transformative result of the impact of the genomic revolution from the biological sciences powerfully interfacing with engineering, computer science, and mathematics. Work on QSB so far has focused primarily on very simple organisms, such as bacteria and yeast. The new solicitation will advance toward more complex organisms, eventually to include humans. Profound impact on human health, wealth, and environment is anticipated. For CLEANER, the strategic intent is to fundamentally transform and radically advance the scientific and engineering knowledge base required to address the challenges of large-scale, human-dominated, complex environmental systems, in particular, the quality and quantity of the nation's water supply, an issue of increasing concern.

Chemical and Transport Systems (CTS) +$3.20

CTS research and education investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy. The division is experiencing increased proposal pressure in the core areas of chemical and transport systems. Growth in nanoscale engineering, the frontiers of manufacturing, and environmentally relevant energy technologies will occur. Particular emphasis will be placed on critical infrastructure systems related to safety and security. The increase in funding in FY 2006 will be focused on support of investigator-initiated ideas and pioneering research within this area of safety and security. Significant potential exists for fundamental lasting impact on both physical and cyberinfrastrucuture systems.

Civil and Mechanical Systems (CMS) +$2.23

The CMS division will utilize the increase to accommodate the important transition from the construction phase to the operations and research phase for the Network for Earthquake Engineering Simulation (NEES). NEES represents an $82 million MREFC investment made between FY 2000 and FY 2004, and is entering a ten-year operations and research phase. It will not only increase our understanding of how the constructed environment responds to earthquakes and tsunamis, but will also be a prototype for future cyberinfrastructure applications across all scientific and engineering disciplines. CMS will also respond to increasing proposal pressures in emerging areas in civil and mechanical systems, such as simulation-based engineering science, nanomechanics, complex systems, biomechanics, smart structures, and mechatronics.

Design and Manufacturing Innovation (DMI) +$3.56

Innovation remains an intellectual focus of DMI core programs. This increment in core programs will create tools for the 3D nano- and micro-factories of the future, and provide the knowledge to design globally competitive and sustainable

manufacturing enterprises. With a reallocation of base funds and the requested increase, FY 2006 will focus on rebuilding core programs as well as the Grant Opportunities for Academic Liaison with Industry (GOALI) program. This is a priority for DMI, because investigator-initiated research lays the groundwork for future investments in education, research, and innovation.

Electrical and Communications Systems (ECS) +$2.71

The increase supports "Integrative Systems" principles in the design, development and implementation of new nano/micro/macro/complex and hybrid systems with engineering solutions for a variety of application domains. Integrated systems are increasingly viewed as critical in meeting a broad range of societal challenges in the 21st Century, including those associated with sensing, imaging, telecommunications, wireless networks, power systems, environment, health care, transportation, biomedicine, manufacturing, natural disasters, homeland security, and other systems-related areas.

Engineering Education and Centers (EEC) +$2.65

EEC is reformulating its current support for engineering education into a new program aimed at defining and elevating fundamental research into how students learn engineering. To date, engineering education reform has been based more on qualitative ideas of how to engage students in their learning and not on fundamental research that integrates an understanding of how students learn, and how the curriculum can be improved to attract more talented and diverse students. The new initiative combines the Department Level Reform program and the unsolicited Engineering Education program into a new Transforming Engineering Education program.

Office of Industrial Innovation (OII) +$2.57

OII is in a unique position to pull together novel research ideas that intersect the frontiers of research in nano-bio-info technology. With the increase in funding, OII will target "Security Technology" in its Small Business Innovation Research (SBIR) solicitation, to help address the national priority of homeland security.

In FY 2005 the Foundation reorganized the ENG Division structure to further enhance Organizational Excellence. Under the proposed reorganization, ENG separated the SBIR/STTR component of the Design, Manufacture and Industrial Innovation (DMII) Division and created a new Subactivity called the Office of Industrial Innovation (OII). The new name for the DMII Division was changed to Design and Manufacturing Innovation (DMI). This easy-to-identify structure will further strengthen NSF and ENG's management of this legislatively authorized federal program.

Subtotal, Changes +$19.38

FY 2006 Request, ENG……..…..$580.68

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

ENG FY 2005 Current Plan……..……..$561.30

Core Research +$8.32

Disciplinary and interdisciplinary research in the ENG core will increase by $8.32 million for a total of $242.19 million.

Bioengineering and Environmental Systems	+2.14 million
Chemical and Transport Systems	+2.82 million
Civil and Mechanical Systems	+0.85 million
Design and Manufacturing Innovation	+3.21 million
Electrical and Communications Systems	+2.31 million
Engineering Education and Centers	-3.01 million

Core research increases specifically support the ENG Subactivities. These increases, and management decisions aimed at constraining the numbers of proposals received, will result in an important, but small (3 percent) increase in the ENG funding rate. Funding increases serve to boost pioneering research in fields such as biomedical engineering, reaction engineering, nano/bio mechanics, hazard mitigation and disaster response, security and critical infrastructure, nanoelectronics, and environmentally benign design and manufacturing.

Faculty Early Career Development Program (CAREER) +$1.00

Support for the CAREER program increases to a total of $32.0 million, enhancing opportunities for junior-level engineering researchers to receive support for developing activities.

Research Experience for Teachers (RET) +$1.50

The RET program totals $4.0 million to support the active involvement of K-12 teachers and community college faculty in engineering research in order to bring knowledge of engineering and technological innovation into their classrooms.

Research Experiences for Undergraduates (REU) +$1.50

Support for the REU program increases to a total of $12.80 million, allowing support for 100 additional students.

Industry/University Cooperative Research Centers (I/UCRC) +$1.25

Funding for the I/UCRC program will increase from $6.0 million to $7.25 million with the funds being used to provide research supplements to advance the underlying fundamental science and technology of the centers.

Small Business Innovation Research (SBIR) +$2.32

Small Business Technology Transfer (STTR) +$0.25

Network for Earthquake Engineering Simulation (NEES) +$0.98

Operations and Maintenance costs for the non-profit NEES Consortium, Inc. increase to a total of $20.52 million, to manage, operate and maintain the geographically distributed national NEES facility.

Net, all other program changes ……..…….…… $2.26
Subtotal, Changes +$19.38

FY 2006 Request, ENG……$580.68

PRIORITY AREAS

In FY 2006, ENG will support research and education efforts related to broad, Foundation-wide priority areas in Biocomplexity in the Environment, Nanoscale Science and Engineering, Mathematical Sciences, and Human and Social Dynamics. Additional support for these areas comes through awards to unsolicited proposals.

Engineering Investments in NSF Priority Areas
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Biocomplexity in the Environment	6.00	6.00	6.00	0.00	0.0%
Nanoscale Science and Engineering	108.88	127.77	127.77	0.00	0.0%
Mathematical Sciences	2.91	2.91	2.91	0.00	0.0%
Human and Social Dynamics	2.00	2.00	2.00	0.00	0.0%

Biocomplexity in the Environment: A total of $6.0 million will support activities in the Materials Use: Science, Engineering, and Society (MUSES) program.

Nanoscale Science and Engineering: A total of $127.77 million will foster an accelerated transition from scientific discoveries to engineering innovation, due to the increased rate of discoveries in the last several years. Funding priority will be given to: (1) research enabling the nanoscale as the most efficient manufacturing domain, including fabrication of nanostructured materials, nanosystems, and nanoscale catalysis; (2) nanobiotechnology and nanobiology for improving human performance; (3) innovative nanotechnology solutions to biological-chemical-radiological-explosive detection and protection; (4) discovery, understanding, and potential application of phenomena specific to the nanoscale; (5) nanoelectronics and nanophotonics; (6) development of new instrumentation and standards for imaging, characterization, and manipulation of materials and systems in three dimensions at the nanoscale; (7) education and training of a new generation for future industries, including high school, undergraduate, graduate, and informal education; and (8) understanding and addressing the societal implications of nanotechnology.

Mathematical Sciences: A total of $2.91 million will continue to support synergistic collaborations between mathematicians and engineers to strengthen engineering modeling and experimental work and enhance undergraduate and graduate engineering education.

Human and Social Dynamics: A total of $2.0 million will be invested in Decision Making and Risk activities to support studies on the security and reliability of critical infrastructure networks, and in Dynamics of Human Behavior to focus on the integration of nanotechnology, biotechnology, information technology, and cognitive science for improving human physical and mental abilities, as well as a new generation of tools and processes to achieve this goal.

QUALITY

ENG maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds that were allocated to projects that undergo external merit review was 96 percent in FY 2004, the last year for which complete data exist.

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 Directorate 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 a year and members represent a cross section of engineering with representatives from many different sub-disciplines within the field, a cross section of institutions including industry, broad geographic representation, and balanced representation of women and under-represented minorities.

PERFORMANCE

NSF's FY 2006 budget is also aligned to reflect funding levels associated with the Foundation's four strategic outcome goals and the ten investment categories highlighted in the FY 2003-2008 Strategic Plan. These categories were designed as a mechanism to better enable assessment of program performance and to facilitate budget and performance integration.

Engineering
By Strategic Outcome Goal and Investment Category
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
People					
Individuals	68.27	62.22	66.22	4.00	6.4%
Institutions	19.39	17.87	18.73	0.86	4.8%
Collaborations	2.13	1.00	2.13	1.13	113.0%
	89.79	81.09	87.08	5.99	7.4%
Ideas					
Fundamental Science and Engineering	248.42	233.87	242.19	8.32	3.6%
Centers Programs	98.46	97.54	97.81	0.27	0.3%
Capability Enhancement	109.88	108.76	112.58	3.82	3.5%
	456.76	440.17	452.58	12.41	2.8%
Tools					
Facilities	11.75	32.29	33.27	0.98	3.0%
Infrastructure and Instrumentation					
Polar Tools, Facilities and Logistics					
Federally-Funded R&D Centers					
	11.75	32.29	33.27	0.98	3.0%
Organizational Excellence	7.27	7.75	7.75		
Total, ENG	$565.57	$561.30	$580.68	$19.38	3.5%

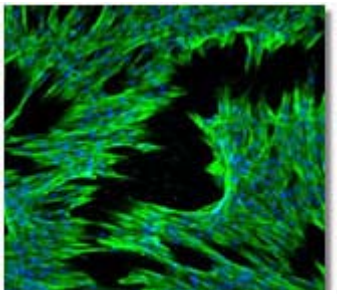
Totals may not add due to rounding.

ENG will continue its commitment to education, training, and increasing diversity within all of its Subactivities. The FY 2006 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

Research On Bio-Material Scaffolding Could Lead to Replaceable Body Parts

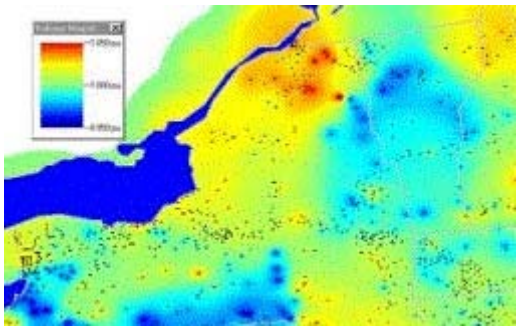
Kristi Anseth is a chemical engineer at the University of Colorado at Boulder. She is leading a team of researchers in building the scaffolds of new materials that promise to elevate many aspects of medical care for injuries and disease. Already a nationwide leader in the study of biomaterials, Anseth's creative work at the intersection of chemistry, biology, and engineering may one day lead to wide use of easily replaceable body parts for people suffering from injuries or chronic conditions. NSF has named Anseth to receive the Alan T. Waterman Award, the Foundation's most prestigious honor for young researchers.



Picture depicts how cells within the heart valve can be regulated through a delivery of biologically active molecules.

Real-Time Monitoring of National Electric Power Grid

Basic research conducted by the NSF-supported Industry/University Cooperative Research Center on Power Systems Engineering (PSerc) has been used to create innovative new software tools for real-time monitoring of the health of the nation's electric power grid. These tools directly address the root causes of cascading power failures, such as the one that affected the eastern United States in August 2003. Now being tested in California, the new monitoring tools are designed to alert power system operators to potentially dangerous grid conditions in a more timely and effective way, thus increasing their ability to take corrective action to prevent widespread power failures. The tools were developed by the Consortium for Electric Reliability Technology Solutions (CERTS), of which PSerc is a founding member.



New visualization technologies made possible by PSerc basic research are designed to enhance the capacity of electric power system operators to monitor grid conditions, maintain system reliability, and prevent cascading blackouts.

Biodegradable Machining Compound Used for Hard Drive Manufacturing is More Effective Than Toxic Ones

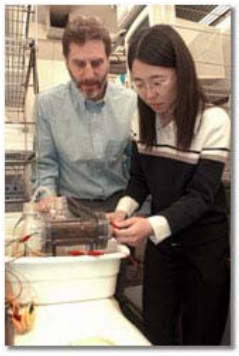
Machine used by Ventana Research for evaluating fluids during the Phase I SBIR program.

Derived in part from green tea, a new biodegradable machining compound for computer hard drive manufacturing is three to four times more effective than its toxic counterparts. In an industry where more than 161 million hard drives leave assembly lines each year, the new compound could significantly improve manufacturing efficiency and minimize environmental risks. Engineered by John Lombardi of Ventana Research Corporation in Tucson, Arizona, as part of a Small Business Innovation Research (SBIR) grant, the chemical is part of a slurry that polishes the ceramics—made from aluminum oxide and titanium carbide—used in computer hard drive read-write heads.

Wearable Device Gives New Freedom to the Visually-Impaired

Using a common laptop computer and a sophisticated head-mounted projection device, students at the University of Washington have created a system to help people with poor vision navigate around stationary objects. The Wearable Low Vision Aid is the first portable device to draw attention to obstacles using an illuminated, vibrating crystal that projects a warning icon—a raster image much like a television's—onto the user's retina. The system was built entirely by graduate and undergraduate students over the past four years under the direction of Eric Seibel, research assistant professor for mechanical engineering at the Human Interface Technology Laboratory at the University of Washington.

The head-mounted components of the Wearable Low Vision Aid. Shown are the camera with a ring of infra-red LEDs (left) and the head mounted display (right).



Biological Fuel Cell

Biological Fuel Cell Makes Electricity While Cleaning Water

Something big may be brewing on the sewage-treatment circuit thanks to a new design that puts bacteria on double duty—treating wastewater and generating electricity at the same time. The key to making it work is an innovative, single-chambered microbial fuel cell. A fuel cell resembles a battery, generating electricity from a chemical reaction. But instead of running down unless it's recharged, the cell receives a constant supply of fuel and then releases electricity. Typical fuel cells run on hydrogen. In a microbial fuel cell, bacteria metabolize their food—in this case, organic matter in wastewater—to release electrons that yield a steady electrical current. The single-chambered prototype, developed by researchers at Pennsylvania State University, allows the process to work efficiently in wastewater.

Robot First: Giant "Printer" Builds Wall

A robot developed with NSF support has built the first wall ever constructed entirely by machine, with no use of human hands. Measuring about 5 feet long, 3 feet high, and 6 inches thick, the wall was constructed in January 2004 in the University of Southern California lab of Behrokh Khoshnevis, who calls his creation "the most historic wall since the Great Wall of China." Khoshnevis believes that by the end of 2005, his robots will be able to construct a one-story, 2,000-square foot home on site in a single day. His pioneering efforts to automate the building process are based on a technology known as Contour Crafting, a layered fabrication process controlled by computer. After 7 years of research and development, Khoshnevis has created a robot that can build large structures by extruding semi-liquid material from a pump in inch-thick layers to form the outside edges of an object, such as the wall of a building. The robot moves back and forth along a gantry installed at the construction site to deposit each layer of the wall. After the exterior layers have been laid down, the robot returns to pour concrete or other filler material into the hollow wall. In effect, this technology will enable homes

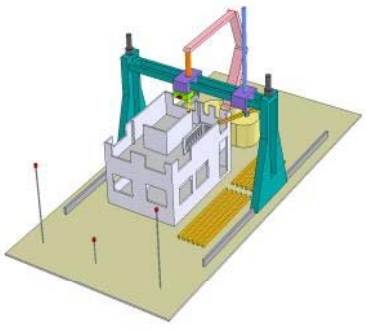


Diagram of the construction of a conventional building using Contour Crafting.

and other structures to be "printed out" from computer design software, much as ink jet printers produce documents from word processing software.

Awards to ENG researchers

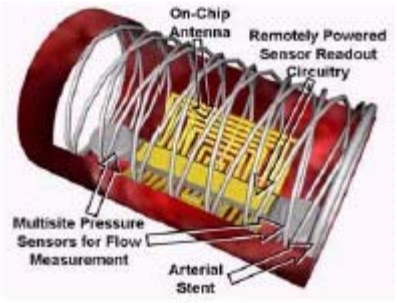
Innovative Solar Cell Boosts Energy Output

High performance luminescent solar concentrator (LSC)

A grantee at Penn State Erie, The Behrend College, has developed a multiple-dye high performance luminescent solar concentrator (LSC) that converts solar energy into electricity at 36 percent greater efficiency than that of the best single-dye LSC. An LSC is a thin, flat plate of highly fluorescent material that uses total internal reflection to concentrate light at its edges, where it is absorbed and converted to electricity by semiconductor solar cells.

Wireless Micro-Sensor Monitors Blood Flow from the Inside

Researchers at the Wireless Integrated MicroSystems (WIMS) ERC at the University of Michigan have developed an "active stent." This device has a wireless differential-pressure measurement system embedded in a micro-fabricated stent that can be used to diagnose reductions in intra-arterial blood flow caused by the onset of restenosis. The device is only 200µm thick, with a volume of $2mm^3$. It can detect a 13 percent reduction of blood flow in the carotid artery.



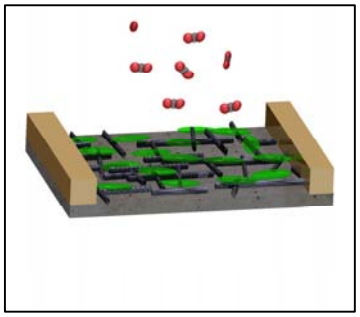
Wireless micro-fabricated "Active Stent"

Simple Chemistry Predicts Pinhole Leaks in Copper Pipes

NSF-supported investigator Marc Edwards, Professor of Civil and Environmental Engineering at the Virginia Polytechnic Institute and State University, has completed the first laboratory experiments demonstrating that changes in water chemistry alone are sufficient to cause pinhole leaks in copper tubing in drinking water distribution systems. An outbreak of such leaks began in home plumbing systems in the suburbs of Washington, D.C., and elsewhere in the late 1990s, costing consumers billions of dollars per year for repair and replacement. While investigating the causes of these leaks, Edwards discovered very high levels of lead contamination in D.C.-area drinking water and designed new sampling procedures for testing drinking water to measure more accurately the degree of lead contamination. Environmental exposure to high levels of lead can seriously impair virtually all aspects of mental and physical functioning, especially the rapidly developing neurological systems of young children. The goal of Edwards' ongoing research is to enable scientists and engineers to rationally predict and prevent problems with pinhole corrosion. With current support from NSF's program on Materials Use: Science, Engineering and Society (MUSES), Edwards works with a multidisciplinary team investigating the broader economic, social, and health aspects of materials failure in drinking water infrastructure. Edwards testified in March 2004 before the U.S. House of Representatives Committee on Government Reform on lead in Washington, D.C. drinking water. In April 2004, *Time* magazine named Edwards an Innovator and one of the most influential people in the nation on the future of water resources issues. He was a 1995 recipient of an NSF Presidential Faculty Fellowship.

Nanotech Sensor Monitors Breathing: New Tool For Emergency Response

Researchers have created a tiny device that can monitor a victim's breathing in emergency situations by effectively shrinking an operating room machine into a small, disposable tool that can be carried to a disaster site. NSF-supported researchers at Nanomix, Inc., in Emeryville, Calif., have created a transistor that fuses carbon nanotubes, polymers and silicon into a capnography sensor – a human breathing monitor. Alexander Star and his colleagues at Nanomix and the University of California, Los Angeles, describe the new sensor in the cover article of the November 15 issue of the journal *Advanced Materials*. Their study shows that carbon nanotube transistors fused with carbon dioxide-detecting polymers can determine carbon dioxide (CO_2) concentrations in both ambient and exhaled air.



Conceptual illustration of the carbon nanotube network device coated with poly (ethylene imine) and starch polymer layer for detection of CO_2 gas
Credit: Alexander Star, Nanomix

Robot Helps Children Develop Language Skills

Children interact with child-friendly therapeutic robot

Researchers at AnthroTronix Inc., a rehabilitation engineering company, have developed an interactive robotic system to facilitate receptive and expressive language development in children with disabilities. This child-friendly robot is controlled by gestures and voice activation; it is adaptable to individual needs regardless of physical limitations, and also allows the child to interact with its environment. This device provides therapists with an effective tool to support the integration of speech/language development with children's educational and social development.

Other Performance Indicators

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

Number of People Involved in ENG Activities

	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate
Senior Researchers	5,246	5,194	5,350
Other Professionals	1,478	1,463	1,507
Postdoctorates	392	388	400
Graduate Students	4,858	4,809	4,963
Undergraduate Students	2,285	2,262	2,420
Total Number of People	14,259	14,116	14,640

ENG Funding Profile

	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate
Statistics for Competitive Awards:			
Number	1,753	1,740	1,775
Funding Rate	20%	19%	22%
Statistics for Research Grants:			
Number of Research Grants	955	948	1,032
Funding Rate	15%	15%	18%
Median Annualized Award Size	$96,677	$96,677	$96,677
Average Annualized Award Size	$119,817	$119,900	$119,900
Average Award Duration, in years	2.9	2.9	2.9

BIOENGINEERING AND ENVIRONMENTAL SYSTEMS $50,680,000

The FY 2006 Budget Request for the Bioengineering & Environmental Systems Division is $50.68 million, an increase of $2.46 million, or 5.1 percent, above the FY 2005 Current Plan of $48.22 million.

Bioengineering and Environmental Systems Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Bioengineering and Environmental Systems	**$51.00**	**$48.22**	**$50.68**	**$2.46**	**5.10%**
Major Components:					
Research and Education Grants	47.35	43.57	46.03	2.46	5.6%
National Nanoscale Infrastructure Network	1.65	1.65	1.65	0.00	0.0%
Nanoscale Science & Engineering Centers	2.00	3.00	3.00	0.00	0.0%

About BES:

The Bioengineering and Environmental Systems (BES) Division supports research, innovation, and education in the rapidly evolving fields of bioengineering and environmental engineering. BES has two principal objectives. The first objective is to enable and facilitate the deployment of new technologies in these fields in service to society for use in the medical, biotechnology, and environmental arenas. The second objective is to advance bioengineering and environmental engineering education, particularly through the development of innovative programs by new faculty.

In general, 53 percent of the BES portfolio is available for new awards. The remaining 47 percent funds awards made in previous years.

BES achieves these objectives across its three program clusters:

- Biochemical Engineering/Biotechnology (BEB);
- Biomedical Engineering and Research to Aid Persons with Disabilities (BME/RAPD); and
- Environmental Engineering and Technology (EET).

BES Priorities for FY 2006:

Current BES high-emphasis research and education areas include post-genomic engineering, tissue engineering, biophotonics, nano-biosystems, and engineering environmental analysis and problem-solving options development. These high-emphasis research areas are built on a continuing base that includes biosensors, biomaterials, biomechanics, controlled release, bioimaging, medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, industrial bioproducts bioprocessing, bioremediation, ecological engineering, water and waste treatment, biomining, and food engineering.

Within the U.S. and international research communities, BES support has played a key role in catalyzing and developing highly promising new cutting edge bioengineering and environmental engineering research fields, such as tissue engineering and metabolic engineering. BES has also led the formation of interagency coordination and collaboration in these fields, including the Multi-Agency Tissue

Engineering Science (MATES) working group and the Metabolic Engineering Working Group. The NSF/DARPA/NIH Biophotonics Partnership is another joint effort initiated by BES.

Post-Genomic Engineering: As a consequence of the genomics revolution that is underway in the biological sciences, engineers now have an entirely new, and explosively growing database on which to build new engineering developments and innovations that will provide important advances in the medical, biotechnology, and environmental arenas.

Tissue Engineering (TE): TE for ENG includes gene and drug delivery. A common thread throughout TE areas is the unique biocompatible (and often biologically based) polymers that act as the matrix for cells to develop into three-dimensional tissues, and shield drugs and genes until they are delivered to the proper organs or specific target cells without causing side effects on healthy cells. The search for these key materials, and understanding how and why they function as they do, are key BES goals. A renewed research thrust in tissue culture engineering will be an important contributing factor in the rapid development of practical ex vivo cell culture techniques and stem cell culture technology for medical applications.

Biophotonics: Biophotonics seeks to exploit the power of photonics to advance bioengineering. Low cost diagnostics will require novel integration of photonics, molecular biology, and material science. Complex biophotonic sensors capable of detecting and discriminating among large classes of biomolecules are important not only to biology and medicine but also to environmental sensing.

Nano-Biosystems: Many nanoscale systems and phenomena are based on biological systems. BES plays a key role in funding exploratory research on biosystems at nanoscale. Chips and sensors, combined with microfluidics, are intimately integrated with the nanobiotechnology area, since many of these systems are used on chips for medical, environmental, and other sensing applications.

Engineering Environmental Analysis and Problem-Solving Options Development: Rapidly expanding cyberinfrastructure capabilities are enabling the potential for developing radically new approaches to engineering analysis of environmental problems. Building on such new analysis approaches, it will be possible to generate problem-solving options for implementation alternatives that are based on strong participation not only by engineers, but the full complement of stakeholders, including biological and physical scientists, social scientists, community members, and government officials at the local, state, federal, and in some cases, international levels. On the technical side, development of new sensors, databanks, communication networks, analytical models, and even conceptual frameworks is required.

BES will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network (NNIN) and Nanoscale Science and Engineering Centers (NSECs).

Changes from FY 2005:

- The Sensor and Sensors Network solicitation run in FY 2005 will not be repeated in FY 2006. Funds in the amount of $3.0 million will be reallocated coupled with the BES overall increase of $2.46 million to:

    - The solicitation on Quantitative Systems Biotechnology (QSB), which was not run in FY 2005,
    - Collaborative Large-scale Engineering Analysis Network for Environmental Research (CLEANER) planning activities, and
    - BME/RAPD unsolicited awards.

CHEMICAL AND TRANSPORT SYSTEMS $68,990,000

The FY 2006 Budget Request for the Chemical and Transport Systems Division is $68.99 million, an increase of $3.20 million, or 4.9 percent, above the FY 2005 Current Plan of 65.79 million.

Chemical and Transport Systems Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Chemical and Transport Systems	**$69.21**	**$65.79**	**$68.99**	**$3.20**	**4.9%**
Major Components:					
Research and Education Grants	61.48	57.11	60.29	3.18	5.6%
Nanoscale Science & Engineering Centers	2.20	3.15	3.15	0.00	0.0%
National Nanoscale Infrastructure Network	1.55	1.55	1.55	0.00	0.0%
Science & Technology Center	3.98	3.98	4.00	0.02	0.5%

About CTS:

The Chemical and Transport Systems (CTS) Division supports research and education in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CTS research and education investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy. These include the process industries (chemicals, pharmaceuticals, forest products, materials, petroleum, food, and textiles), utilities, microelectronic component manufacturers, and producers of consumer products of all kinds.

CTS supports research in the core disciplines of chemical reaction engineering, interfacial phenomena and separations, fluid dynamics and particle processes, and combustion and thermal transport. These areas are essential to ensure continued growth of the fundamental engineering knowledge base, which is the foundation for advances in a wide range of technologies.

In general, 70 percent of the CTS portfolio is available for new awards. The remaining 30 percent funds awards made in previous years.

CTS Priorities for FY 2006:

CTS will continue to support research in the core disciplines such as catalysis, chemical process design, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particle processes for many applications including sensors and membranes. These investments contribute to advances that are important for the environment, energy, transportation, information technologies, health-related products, and other areas that impact our daily lives.

While sustaining the vitality of these core research areas, CTS actively supports the following key areas of particular NSF emphasis:

Nanoscale Science and Engineering: This is an important area for CTS, especially for its role in enabling novel systems innovation including product development, manufacturing techniques, nano-bio-

technology, and environmental sustainability. CTS support in this area is maintained at the FY 2005 level of $27.30 million. This funding allows continued development of research in the synthesis and processing of matter at the nanometer-length scale, producing materials with novel physical, optical, chemical, and biological properties. Much of the materials processing at the nano-scale occurs at the surface or interface between various phases. Understanding structural morphologies and properties at the molecular and nano-scale and developing methods to integrate these new functional materials to bulk scale via new experimental tools and simulation capabilities will permit major advances and applications in many areas central to CTS and other engineering fields.

The specific fields of catalysis, micro-fluidics, interfacial, plasma, and bulk materials processing, and adsorption media for selective chemical and biochemical separations find applications through use of selective membranes, fuel cells, sensors, and environmental technologies. The syntheses of particles, films, and 3D structures with functional nanoscale features by methods involving nucleation, molecular and particle self-assembly, controlled thermal and molecular transport, as well as chemical reactions, is a priority for CTS nano-scale research. In order to accelerate the benefits from increased investments in fundamental research on these topics, CTS will allocate funds to address issues that deal with scale-up of the synthesis processes, development of new instrumentation, chemical and bio-sensors, and electronic materials, as well as refined methods for materials characterization at the nanoscale. The results of this pioneering research will also find uses in other fields of science and engineering.

Smart Manufacturing and Processing: Manufacturing of specialty products, such as pharmaceuticals, health-related diagnostics, and high-value additives, involve the integration of materials design, synthesis, characterization and processing steps. Both theoretical and experimental strategies, such as combinatorial methods and lab-on-the-chip techniques, contribute to this integration. Molecular design and synthesis, self-assembly and directed assembly of gaseous, liquid, and solid materials at the nano-scale, micro-fluidics, and nano-fluidics constitute some of the frontier research activities that CTS will pursue. Molecular design and process control based on the range of scale from molecular to enterprise-wide considerations is an important activity.

Other CTS processing areas that are of growing importance are powder processing based on a fundamental understanding of particles interactions, laser surface interactions, crystal growth processing, combustion synthesis of materials, manufacturing with jets of materials, and the development of nano materials for tailoring the thermal, mechanical, and electrical properties of composite systems. A promising new approach explored in CTS is high throughput manufacturing of nano-porous films via flow-induced micelle alignment and other liquid-liquid micro-fluidics systems.

Environmentally and Energy Focused Processes and Products: CTS will continue support of environmentally relevant technologies and fundamental aspects of energy production. Research leading to products and processes that avoid negative environmental impact will be a CTS priority. Examples of CTS interest areas are environmentally benign production processes that minimize undesirable side products, new biocatalysis methods that permit the use of renewable feedstocks, and separation and purification processes that use less energy, as well as environmentally sound solvents, cleaner combustion processes, and reliable process-design methods that reduce or eliminate environmental impact.

Energy-focused research is an active CTS area, and it includes catalysts for fuel cells, new structures and compositions for hydrogen storage, and materials used in energy production from alternative resources. The hydrogen economy will need an array of new materials for the range of energy production, fuel storage, and conversion that is envisioned. CTS is interested in fundamental aspects of development of fuel cells including the further development of micro fuel cells as well as large ones for transportation.

Other related environmental and energy-focused CTS interests include fluid-sediment interactions over complex coastal topography and river flow and the analysis and design methodology that may revolutionize the shape and energy efficiency of aircraft of the future**.**

Safety and Security: Research in this area is directed at assisting development of improved, long-range homeland security technologies. One CTS effort includes sensors-related research that provides for fast and selective responses and development of robust sensors that are very compact. Safety involves a system approach integrating detection, analysis, validation, and decision making into a proactive prevention process. CTS research focuses on fast, accurate, non-intrusive detection and sensing methods for chemical, thermal, and biological events and process control and prevention strategies**.** Flow and mixing of cohesive powders is a CTS research topic of great interest to the pharmaceutical, chemical, and petrochemical industry, but also has application in natural phenomena such as landslides and avalanches. A fundamental understanding of the underlying mechanisms will enable process design and optimization of industrial processes and prediction and mitigation of related natural hazards.

CTS will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network (NNIN) and Nanoscale Science and Engineering Centers (NSECs), and a Science and Technology Center (STC) on New Materials for Water Purification.

Changes from FY 2005:

- The requested increase of $3.20 million in funding in FY 2006 will be distributed among the four core areas to support high-potential ideas and pioneering research as well as two additional awards in the Faculty Early Career Development (CAREER) Program. This distribution will ultimately be based on actual proposals received in FY 2006.

CIVIL AND MECHANICAL SYSTEMS $84,210,000

The FY 2006 Budget Request for the Civil and Mechanical Systems Division is $84.21 million, an increase of $2.23 million, or 2.7 percent, above the FY 2005 Current Plan of $81.98 million.

Civil and Mechanical Systems Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Civil and Mechanical Systems	**$67.22**	**$81.98**	**$84.21**	**$2.23**	**2.7%**
Major Components:					
Research and Education Grants	65.42	60.04	61.29	1.25	2.1%
Nanoscale Science & Engineering Centers	1.60	2.20	2.20	0.00	0.0%
National Nanoscale Infrastructure Network	0.20	0.20	0.20	0.00	0.0%
Network for Earthquake Engineering Simulation	-	19.54	20.52	0.98	5.0%

About CMS:

The Civil and Mechanical Systems (CMS) Division has two major goals: to invest in research and workforce development that will provide the fundamental and quantitative foundation for the engineering profession in application to civil and mechanical systems and the built environment, and to support the rapid development and deployment of new knowledge and technology in service to the public to decrease vulnerability to natural and technological hazards.

In general, 61 percent of the CMS portfolio is available for new awards. The remaining 39 percent funds awards made in previous years.

CMS Priorities for FY 2006:

CMS research contributes to the knowledge base and intellectual growth in the areas of mechanics and materials, infrastructure construction and management, dynamics and control, sensing for civil and mechanical systems, geotechnology, structures, as well as the reduction of risks and casualties induced by earthquakes and other natural and technological hazards. The division encourages cross-disciplinary partnerships for frontier research at the intersections with traditional civil and mechanical engineering disciplines, to promote discoveries using technologies such as sensors, adaptive systems, nanotechnology, and simulation to enable revolutionary advances in our nation's civil and mechanical systems.

The $2.23 million increase coupled with a reallocation of funds in the CMS budget will be utilized in strengthening research in the core programs. These investments are clustered into the following three higher–level themes:

1. *Engineered Materials and Mechanics*
2. *Intelligent Civil and Mechanical Systems*
3. *Infrastructure Systems and Hazard Mitigation*

In addition, recent events have brought focus on the nation's increasingly interdependent, complex and vulnerable human, social, natural and physical systems. CMS pursues cross-directorate and interagency partnerships such as the Partnership for Advancing Technology in Housing (PATH) program with the Department of Housing and Urban Development (HUD) that provides such knowledge enhancement and advanced tools for the evaluation of vulnerability. In support of this and of NSF's mission in the National Earthquake Hazards Reduction Program (NEHRP), CMS invests in research on the impact of natural and technological hazards on constructed, natural, and human environments. CMS funds rapid-response reconnaissance investigations following extreme events in the United States or abroad. CMS continues to invest in a variety of crosscutting activities, such as Nanoscale Science and Engineering, Biocomplexity in the Environment, Human and Social Dynamics, Mathematical Sciences priority areas, and others.

NEES Operations and Grand Challenge Research: The main priority of the CMS division continues to be the operations and research for the Network for Earthquake Engineering Simulation (NEES). The construction of NEES, funded during FY 2000-2004 within the Major Research Equipment and Facilities Construction (MREFC) account, was successfully completed October 2004. NEES is a project to construct, upgrade, and network an innovative system of geographically distributed test facilities in earthquake engineering. The integration of the system is accomplished via NEESgrid, which utilizes innovative grid computing technologies. This project will also promote international collaborations for earthquake and tsunami engineering research, as well as education and outreach opportunities. For additional information on this project, see the Facilities Chapter. The non-profit NEES Consortium, Inc. has been established, with funding of approximately $20 million per year from CMS, to manage, operate, and maintain the geographically distributed national NEES facility. With over 500 members, both institutional and individual, and an elected board of representatives, it includes all elements of the research community in earthquake engineering. All research, as well as educational and outreach activities, utilizing NEES will be scheduled through the NEES consortium. This consortium will be responsible for maintaining the NEES infrastructure, both at the equipment sites, as well as its integration via NEESgrid. The NEES Consortium will also link the U.S. earthquake engineering research community to earthquake engineering research activities/facilities in Japan, Europe, and other nations. In FY 2006 at least $9 million will be used to support basic research in multi-hazard engineering involving experimental and theoretical simulations at the NEES facilities. NEES research will address important challenges in earthquake and tsunami engineering research. These are described in the recent National Research Council study entitled *Preventing Earthquake Disasters; The Grand Challenge in Earthquake Engineering*, National Academies Press, 2003.

CMS will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network (NNIN) and Nanoscale Science and Engineering Centers (NSECs).

Changes from FY 2005:

- The CMS division will utilize the increase of $1.25 million in Research and Education Grants to respond to increasing proposal pressures in emerging areas in civil and mechanical systems, such as simulation based engineering science, complex systems, nanomechanics, biomechanics, smart structures, and mechatronics.

- An increase of $980,000 to a total of $20.52 million will continue to accommodate the important transition from the construction phase to the operations and research phase for the Network for Earthquake Engineering Simulation (NEES).

DESIGN AND MANUFACTURING INNOVATION $ 67,410,000

The FY 2006 Budget Request for the Design and Manufacturing Innovation Division is $67.41 million, an increase of $3.56 million, or 5.6 percent above the FY 2005 Current Plan of $63.85 million.

Design and Manufacturing Innovation Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Design and Manufacturing Innovation	**$65.92**	**$63.85**	**$67.41**	**$3.56**	**5.6%**
Major Components:					
Research and Education Grants	62.17	59.00	62.56	3.56	6.0%
Nanoscale Science & Engineering Centers	2.30	3.40	3.40	0.00	0.0%
National Nanoscale Infrastructure Network	1.45	1.45	1.45	0.00	0.0%

About DMI:

The Design and Manufacturing Innovation (DMI) Division supports academic research and education for discovery and innovation in new enterprises, and the enhancement of productivity and global competitiveness in existing U.S. industries. This Division also supports the development of a diverse human resource base comprised of an educated, adaptable and knowledge-enabled workforce, which is vital to U.S. global competitiveness. The core DMI programs – Engineering Design, Operations Research, Manufacturing Enterprise Systems, Service Enterprise Engineering, Nanomanufacturing, Materials Processing and Manufacture, and Manufacturing Machines and Equipment – support discoveries and innovations that will help to create the nation's 21st Century manufacturing enterprises.

The Grant Opportunities for Academic Liaison with Industry (GOALI) program, managed by DMI for the Engineering Directorate, enables partnerships between industry and academe with a common intellectual and educational agenda.

A major change in the Design and Manufacturing Innovation (DMI) Division during FY 2005 was the establishment of a separate Office of Industrial Innovation in the Engineering Directorate, which moved the Small Business Innovation Research and Small Business Technology Transfer programs out of DMI.

In general, 87 percent of the DMI portfolio is available for new awards. The remaining 13 percent funds awards made in previous years.

DMI Priorities for FY 2006:

DMI's core programs support investigator-initiated, fundamental research on topics related to design, manufacture, and service systems that provide products and systems of value to society. In FY 2006, DMI plans to continue to invest in research leading to environmentally benign design and manufacture systems, engineered service systems for health care delivery, and additive hybrid net shape processes to produce the meso- and micro-scale machines that will be needed for micro and nanoscale products.

Retrospective assessments conclude that DMI grants have resulted in fundamental contributions leading to the creation of new research fields and knowledge in design, manufacturing, and service. A recent example of the critical role of basic manufacturing research, which is featured on the cover of the NNI strategic plan, shows that the road to commercialization began at NSF with research funded by DMI, subsequent support by other federal agencies, and commercialization enabled by NSF SBIR/STTR investments. Looking toward the future, DMI is engaged with its research community through benchmarking studies in the fields of hybrid additive/subtractive manufacturing processes and micro machines, that will transform material on the nano to meso scales – with precision and performance only dreamed of today.

DMI also supports the development of people, through foundation-wide programs and supplements such as CAREER, ADVANCE, REU, and RET, as well as foundation-wide interdisciplinary research priorities critical to the nation's future.

Nanomanufacturing, converting the discoveries of nanoscience into new products for the benefit of society, is a key component of the Nanoscale Science and Engineering (NSE) priority area, and is a grand challenge 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 nano scale. 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. While the nanomanufacturing program is the focal point of NSE in DMI, the need for new knowledge from different fields makes NSE an important component of all the academic research programs in DMI.

The Materials Use: Science, Engineering, and Society (MUSES) Program is an emphasis of the Biocomplexity in the Environment (BE) priority area, supporting the design and synthesis of new materials with environmentally benign impact on biocomplex systems.

The Mathematical Sciences priority area offers multidisciplinary opportunities for advances in distributed sensors systems, scalable manufacturing enterprise systems, modeling uncertainty and managing risk, and new modeling techniques that predict processing behavior and product performance on scales ranging from the molecular to the macro.

DMI will continue to provide support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network (NNIN) and Nanoscale Science and Engineering Centers (NSECs).

Changes from FY 2005:

- In FY 2005, DMI began phasing down its support of the Innovation and Organizational Change Program. In FY 2006, DMI will discontinue supporting this program, reallocating the remaining $500,000 to other core programs.

- With this reallocation of base funds and a requested increase of $3.56 million, FY 2006 will focus on rebuilding core programs as well as the GOALI program. This is a priority for DMI, because investigator-initiated research lays the groundwork for future investments in education, research, and innovation. DMI's investments in Nanomanufacturing will strengthen improvement of human physical and mental abilities through the integration of nanotechnology, biotechnology, information technology, and cognitive science, as well as building a new generation of tools and processes to achieve this goal.

ELECTRICAL AND COMMUNICATIONS SYSTEMS $74,350,000

The FY 2006 Budget Request for the Electrical and Communications Systems Division is $74.35 million, an increase of $2.71 million, or 3.8 percent, over the FY 2005 Current Plan of $71.64 million.

Electrical and Communications Systems Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Electrical and Communications Systems	**$74.61**	**$71.64**	**$74.35**	**$2.71**	**3.8%**
Major Components:					
Research and Education Grants	63.68	59.66	62.35	2.69	4.5%
Nanoscale Science & Engineering Centers	2.40	3.45	3.45	0.00	0.0%
National Nanoscale Infrastructure Network	4.55	4.55	4.55	0.00	0.0%
Science and Technology Center	3.98	3.98	4.00	0.02	0.5%

About ECS:

The Division of Electrical and Communications Systems (ECS) addresses fundamental research issues underlying component and device technologies, computation, networking, control, and systems principles at the nano, micro and macro scales, and supports the integration and networking of intelligent systems for a variety of application domains in sensing, imaging, telecommunications, wireless networks, natural disasters, homeland security, power systems, environment, transportation, biomedicine, nanomanufacturing, and other device and systems-related areas. ECS envisions a research community that will address major technological challenges in devices and systems due to the convergence of micro/nano/info/bio-electronics, controls, communications, networks, and computation.

ECS has a continuing goal to integrate education into its programs to ensure the education of a diverse workforce in the 21st Century who will continue innovative advances for the rapid development of emerging technologies as drivers of the global economy. This vision is encouraged and strengthened by the "Engineer of 2020" report of the National Academy of Engineering (NAE) that foresees a "bewildering array of new technologies" confronting an engineering profession that must be educated in research, development and design, as well as possessing the attributes of strong analytical skills, creativity, ingenuity, professionalism, and leadership.

The strategic development of ECS programs in research and education supports NSF themes in nanotechnology, biocomplexity in the environment, cyberinfrastructure, human and social dynamics, sensors and sensor networks, information technology, mathematical sciences, and the workforce for the 21st Century. ECS strengthens its programs through linkages to other areas of engineering, science, industry, and government.

In general, 76 percent of the ECS portfolio is available for new awards. The remaining 24 percent funds awards made in previous years.

The ECS Division is organized around three programs that focus on research and educational issues of device and component technologies, computational technologies, and integrative systems: (1) Electronics, Photonics, and Device Technologies (EPDT), (2) Control, Networks, and Computational Intelligence (CNCI) and (3) Integrative Systems (IS).

ECS Priorities for FY 2006:

The EPDT program seeks to improve the fundamental understanding of devices and components based on the principles of electronics, photonics, magnetics, electro-optics, electromagnetics, electromechanics, and related physical phenomena. The program will continue to invest in advancing the frontiers of spin electronics, molecular electronics, bioelectronics, nonsilicon electronics, organic electronics, photonics, optoelectronics, MEMS/NEMS, power electronics, and microwave and mixed signals. EPDT further support related topics in quantum engineering, communications, and computing. EPDT will continue to support revolutionary electromagnetic materials and device solutions, RF integrated circuits, and reconfigurable antennas needed for telecommunications, telemedicine, and other wireless applications. ECS will enable discovery and innovation through new approaches to electronics, beyond the scaling limits of complementary metal oxide semiconductor (CMOS) technology. Led by ECS, NSF has embarked on cooperative efforts with the semiconductor industry and Semiconductor Research Corporation on the theme of Silicon Nanoelectronics and Beyond (SNB). Research in SNB will explore the ultimate limits to scaling of features and alternative physical principles for devices at the nanoscale.

The CNCI program will continue to invest in the analysis and design of intelligent engineering networks and complex dynamical systems, for control, communications, computation, and energy applications in telecommunications, Internet, energy, transportation, and manufacturing. CNCI will further invest in adaptive dynamic programming, reinforced learning, pattern recognition, and intelligent agents to develop brain-like networked architectures performing real-time learning, computational video and imaging, and embedded control of robotics. ECS is committed to support the development of innovative hardware/software architectures for emerging areas of cyberinfrastructure and cybersecurity. ECS also continues a strong emphasis on critical infrastructure aspects of electric power systems and grids, including integration of renewable and distributed energy systems into large power networks, and understanding of associated regulatory and economic structures.

The IS program supports innovative research in areas that integrate device concepts and systems principles in the design, development, and implementation of new nano/micro/macro/complex and hybrid systems with engineering solutions for diverse applications. The program is intended to spur visionary systems-oriented activities in collaborative research and education environments. Emphasis in the IS program is on system-on-a-chip, system-in-a-package, cyberengineering systems, wireless and optical communications systems, quantum information systems, robotics and machine intelligent systems, power and energy systems, and organic/silicon-based hybrid systems, among others. Integrative systems continually offer new challenges in basic research and promise for future applications.

ECS will continue to provide management support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network (NNIN), Science and Technology Center on Nanobiotechnology at Cornell University, and Nanoscale Science and Engineering Centers at Cornell University and the University of California at Berkeley. ECS actively participates in the development and management of cross-disciplinary programs and has coordinated the multi-directorate research focus on Sensors and Sensor Networks. ECS has also funded a special research focus on Technological Challenges in Organic Electronics, Photonics, and Magnetics, with co-support from DARPA and the Office of Naval Research.

ECS is initiating a pilot program on Graduate Research Supplements (GRS) to current research grants funded by ECS for women and minority Ph.D. students majoring in electrical engineering disciplines, in order to increase the number of women and minority students in advanced academic and professional careers.

ECS will hold grantees workshops to assess the results of research and education grants and to encourage interaction among principal investigators, as well as focused workshops to assess research and technology areas of current and future importance. ECS has organized a workshop jointly with the semiconductor industry on Silicon Nanoelectronics and Beyond; a U.S.-Japan Workshop on Nanophotonics; and a U.S.-India Workshop on Nanotechnology: Issues in Interdisciplinary Research and Education. ECS also convened a workshop at NSF on 21st Century Women in Science and Engineering involving 100 women undergraduate and graduate students, and a workshop on Bringing Control Engineering to Middle and High School Students and Teachers involving 250 students and their teachers from the Maui School District in Hawaii.

Changes from FY 2005:

The increase in the FY 2006 request will accommodate reallocations of funds in emerging areas within the core programs:

- An increase of $2.51 million will support "Integrative Systems" principles in the design, development and implementation of new nano/micro/macro/complex and hybrid systems with engineering solutions for a variety of application domains. Integrated systems, are increasingly viewed as critical in meeting a broad range of societal challenges in the 21st Century, including those associated with sensing, imaging, telecommunications, wireless networks, power systems, environment, health care, transportation, biomedicine, manufacturing, natural disasters, homeland security, and other systems-related areas.

- Reallocation of additional core funds in the amount of $3.0 million will support unsolicited proposals in the following emerging areas: quantum engineering, diagnostic and implantable devices, flexible electronics, ultra-fast communications, neuro-dynamic control and learning for complexity, and adaptive dynamic programming.

- An increase of $200,000 will also support two additional CAREER awards.

ENGINEERING EDUCATION AND CENTERS $129,710,000

The FY 2006 Budget Request for the Engineering Education and Centers Division is $129.71 million, an increase of $2.65 million, or 2.1 percent, from the FY 2005 Current Plan of $127.06 million.

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Engineering Education and Centers	**$134.03**	**$127.06**	**$129.71**	**$2.65**	**2.1%**
Major Components:					
Research and Education Grants	45.68	40.43	41.60	1.17	2.9%
Engineering Research Centers	65.60	61.57	61.80	0.23	0.4%
Earthquake Engineering Research Centers	5.99	6.00	6.00	0.00	0.0%
Nanoscale Science & Engineering Centers	8.41	9.71	9.71	0.00	0.0%
Industry/University Cooperative Research Centers	6.00	6.00	7.25	1.25	20.8%
Network for Computational Nanotechnology	2.35	3.35	3.35	0.00	0.0%

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 whose breadth of investigation spans from idea inception to proof-of-concept. The EEC'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's programs provide opportunities for teams of faculty and students to explore and test emerging technologies and curricular reforms with the potential to transform the engineering education enterprise, start-up new industries, or radically impact current industrial processes and products. Through involvement with EEC's awards, engineering students have the unique opportunity to integrate knowledge across disciplines to advance technology in partnership with industry, to understand how to link discoveries with design and manufacturing issues, and to benefit from new modes of engineering education informed by new learning theories, teaching methods, and new engineering and scientific discoveries. EEC programs address issues that are critical to all fields of engineering, and benefit from a centralized management focus, and complement the research and education portfolios of the other divisions of ENG. Its 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, 61 percent of the EEC portfolio is available for new awards. The remaining 39 percent funds awards made in previous years.

EEC Priorities for FY 2006:

In FY 2006, EEC will provide support for Engineering Research Centers (ERC), Nanoscale Science and Engineering Centers (NSEC), Earthquake Engineering Research Centers (EERC), and Industry/University Cooperative Research Centers (I/UCRC). Industry and universities develop long-term, interdisciplinary partnerships in NSF-supported centers, which spin off a broad range of fundamental knowledge and new inventions. The stream of advanced technologies emanating from the centers is carried into industry by partnerships with practicing engineers and scientists and by new generations of graduating engineers who have learned the skills needed to be effective leaders in technology innovation.

In FY 2005, 18 Engineering Research Centers (ERC) focused on the definition, fundamental understanding, development and validation of technologies needed to realize a well-defined class of engineered systems with the potential to spawn whole new industries or radically transform the product lines, processing, technologies, or service delivery methodologies of ongoing firms. ERC faculty, students, and their industrial partners integrate discovery and learning in an interdisciplinary environment that reflects the complexities and realities of real-world technology. ERC innovations impact the curriculum at all levels from precollege education to life-long learning. ERCs focus on diversity of the engineering workforce at all levels through recruitment and retention of women and underrepresented minorities in their core teams and through outreach partnerships with NSF diversity awardees such as the Louis Stokes Alliances for Minority Participation. ERCs conduct research and developed educational materials on key technologies related to the engineering of living tissues, sensory prostheses that interface to the human nervous system, extreme ultraviolet/soft X-ray light sources for advance microscopy at the nanoscale, systems for detection of and warning of severe storms, computer-integrated surgical systems, biomaterials for implants, environmentally benign manufacturing technologies for chemical and semiconductor manufacturing, advanced fibers and films processing, ultra fine particles, reconfigurable manufacturing systems, advanced semiconductor packaging, wireless integrated microsystems, subsurface sensing and imaging, integrated media systems, and power electronics. In FY 2006, four new ERCs will be added to the portfolio, enabled by funds released into the ERC Program through the graduation to self-sufficiency of five ERCs in FY 2005, and phasing down support to seven ERCs during FY 2005 and 2006 to prepare them for self-sufficiency. All ERCs operate with funds from NSF, academe, industry, and other federal agencies.

The eight 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. EEC's support is provided to give them the opportunity to explore engineered systems technologies. The centers address challenges and opportunities that are too complex and multi-faceted for individual researchers or small teams to tackle. They involve key partnerships with industry, national laboratories and other sectors and support education programs from the graduate to the pre-college level designed to develop a highly skilled workforce and advance pre-college training and the public understanding of science and engineering. Funds are also provided to smaller interdisciplinary teams and to the Network for Computational Nanotechnology, a web-accessible repository of simulations of nanoscale phenomena for research and education.

In FY 2005, the 50 I/UCRCs worked closely with industry to develop enabling technologies needed to manage the electrical power system, improve manufacturing and biological processes, develop new materials, information and telecommunications technologies, and innovate new products and services. EEC provides modest seed funds and management expertise to these highly leveraged centers, with states joining in many partnerships to expand the centers' activities to have an impact on local economic development. In FY 2006, funds will be added to the I/UCRC program to allow the current centers to compete for supplements for fundamental research that will advance their center's capability.

The three Earthquake Engineering Research Centers bring together multi-institutional teams of investigators to provide the knowledge and technology base for industry and public agencies to build and retrofit structures and other infrastructure to prevent damage from earthquakes. These centers take a systems approach, integrating engineering, seismological, and societal response knowledge to develop technologies and decision support systems. The centers integrate research and education and develop partnerships with industry and the public agencies responsible for earthquake hazard mitigation at the regional, state, and local levels. These centers are producing structural design models and earthquake hazard mitigation technology for buildings and transportation and lifeline systems and engaging designers and policymakers in the development of hazard mitigation strategies for communities with earthquake risks.

EEC programs in engineering education and human resource development 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 2006, EEC will expand the focus of our engineering education and human resource programs to 1) support research on how people learn engineering, especially design, creativity and innovation, and 2) to catalyze the restructuring of engineering education culture and pedagogy so it better fosters multidisciplinary systems level thinking among faculty and students, makes social impact more central to the study of engineering, and attracts more diverse students. These two foci flow from the recent National Academy of Engineering reports "Assessing the Capacity of the U. S. Engineering Research Enterprise: Preliminary Report for Public Review" and "The Engineer of 2020: Visions of Engineering in the New Century." Existing successful programs in Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) which have been shown to be successful programs for development of an engineering workforce will see increases in FY 2006.

Changes from FY 2005:

The FY 2006 Budget Request for EEC is $129.71 million, an increase of $2.65 million from FY 2005. This increase combined with reallocation of funds will be accommodated, as follows:

- Support for ERCs will see an increase of $230,000 to provide additional resources for their diversity and outreach programs;

- Funding for the I/UCRC program will increase from $6.0 million to $7.25 million with the funds being used to provide research supplements to advance the underlying fundamental science and technology of the centers;

- EEC is reformulating its current support for engineering education into a new program aimed at defining and elevating fundamental research into how students learn engineering. To date, engineering education reform has been based more on qualitative ideas of how to engage students in their learning and not on fundamental research that integrates an understanding of how students learn, and how the curriculum can be improved to attract more talented and diverse students. The new initiative combines the Department Level Reform program and the unsolicited Engineering Education program into a new Transforming Engineering Education program at $11.82 million.

- Increased investments to implement the recommendations of the Directorate for Engineering Workforce Report, most notably an increase in the Research Experiences for Undergraduates program by $1.50 million to $8.50 million total and the Research Experiences for Teachers program from $2.50 million to $4.0 million.

OFFICE OF INDUSTRIAL INNOVATION $105,330,000

The FY 2006 Budget Request for the Office of Industrial Innovation (OII) Subactivity is $105.33 million, an increase of $2.57 million, or 2.5 percent over the FY 2005 Current Plan of $102.76 million.

Office of Industrial Innovation Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Office of Industrial Innovation	**$103.58**	**$102.76**	**$105.33**	**$2.57**	**2.5%**
Major Components:					
Small Business Innovation Research	92.70	91.97	94.29	2.32	2.5%
Small Business Technology Transfer	10.88	10.79	11.04	0.25	2.3%

About OII:

The Office of Industrial Innovation (OII) is a newly created office, which was housed under the previous Division of Design, Manufacture, and Industrial Innovation (DMII). OII manages two congressionally mandated small business programs, Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, for the entire Foundation. OII is especially well positioned to meet the innovation component of NSF's vision through its broad science and engineering research topics. Solicitation topics are released twice a year for Phase I proposals, which address feasibility research from small businesses that can be carried out within six months for SBIR and within one year for STTR. All SBIR/STTR Phase I grantees have an opportunity to submit Phase II proposals, which describe research plans covering a two-year period leading up to prototypes of products/process/systems. In addition, Phase II proposals contain commercialization plans that propose the transformation of the scientific and engineering research to commercial and/or societal benefits. From the business community perspective, NSF SBIR/STTR investments are considered pre-seed investment, too risky for even early stage investment. The research topics generated in the SBIR/STTR solicitations are grouped into three areas of business opportunities with potential Phase III investments beyond NSF SBIR/STTR funding. These topics are designed to be attractive to and/or meet the needs of capital/investment markets, strategic partners, and national and societal priorities.

Within the SBIR/STTR research topics, Biotechnology, Information Technology, and Electronics Technology are positioned as potentially attractive to the venture capital and angel network communities. Advanced Materials and Manufacturing and Chemical Technology research topics are of interest to the large corporations with potential for strategic partnerships with the small business community. In response to national priorities, Manufacturing Innovation and Security Technology research topics are solicited.

In general, 100 percent of the OII portfolio is available for new awards.

OII Priorities for FY 2006:

In response to the Executive Order 13329 requiring all federal agencies with SBIR programs to emphasize manufacturing research, NSF SBIR/STTR created a special research topic, Manufacturing Innovation in FY 2005. The topic covers the full spectrum of the manufacturing sector from aerospace to pharmaceutical, seeking research proposals in manufacturing processes, machines, systems and their societal implications. Based on the successful response in FY 2005, the topic will be solicited again in FY 2006. In FY 2004, NSF SBIR/STTR defined a new Security Technology topic to seek future innovations from the small business community to meet the needs of national security. The topic is uniquely defined at the intersection of leading discoveries in nanotechnology, biotechnology, and information technology. Based on the successful response, this topic has been refined to be released in FY 2005 for funding in FY 2006. In addition, a focused Chemical Technology topic will be released and funded in FY 2006 for the first time. Additional topics to be released include Biotechnology, Information Technology, and Advanced Materials Technology.

SBIR/STTR grantees have made a mark in their contribution to the innovation capital of the nation appearing in numerous media releases. One noteworthy example is the recognition gained by several grantees by receiving R&D Magazine's prestigious R&D 100 awards. The Office of Industrial Innovation has embarked on an in-depth survey of SBIR/STTR grantees to document economic and social outcomes of NSF investments in these important programs. Simultaneously, the OII is working with the National Academies by providing complete historical data on all SBIR proposals and awards along with complete details on contact information so that the National Research Council can conduct an independent study of the federal SBIR program amongst the top five agencies.

Following the 1990's economic growth and the burst of the technology bubble in the early 21st Century, the small business community found the SBIR and STTR programs as one of the few sources of capital to support and nurture early stage research ideas. Consequently, the volume of proposals grew a dramatic 80 percent with the consequence of low funding rates leaving many excellent research ideas un-funded.

Changes from FY 2005:

- Starting in FY 2005 and continuing in FY 2006, OII has focused on a few select technologies, has aligned the topics to meet national needs, and is focusing on rebuilding eroding funding rates.

- Homeland security is a national priority addressed by several agencies. OII is in a unique position to pull together novel research ideas that intersect the frontiers of research in nano-bio-info technology. With the increase in funding, OII will also target "Security Technology" in its SBIR solicitation.

- The SBIR program increases $2.32 million to a total of $94.29 million.

- The STTR program increases $250,000 to a total of $11.04 million.