ENGINEERING

ENGINEERING $536,570,000

The FY 2004 Budget Request for the Engineering Activity (ENG) is $536.57 million, an increase of $48.59 million, or 10.0 percent, over the FY 2003 Request of $487.98 million.

ENG Funding
(Dollars in Millions)

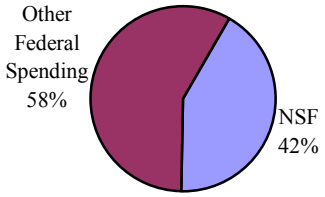
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Bioengineering and Environmental Systems	41.32	43.87	47.91	4.04	9.2%
Chemical and Transport Systems	57.21	58.94	66.20	7.26	12.3%
Civil and Mechanical Systems	56.09	57.75	64.36	6.61	11.4%
Design, Manufacture, and Industrial Innovation[1]	134.99	141.23	163.06	21.83	15.5%
Electrical and Communications Systems	64.75	66.70	70.76	4.06	6.1%
Engineering Education and Centers	116.47	119.49	124.28	4.79	4.0%
Total, ENG	$470.83	$487.98	$536.57	$48.59	10.0%

Totals may not add due to rounding
[1]SBIR/STTR are included in the DMII funding line. DMII increases (excluding SBIR/STTR) equal 7.5%.

The Engineering Activity supports fundamental research on engineering systems, devices and materials, and their underpinning processes and methodologies. ENG investments contribute to technological innovation vital to the nation's economic strength, security and quality of life.

RELEVANCE

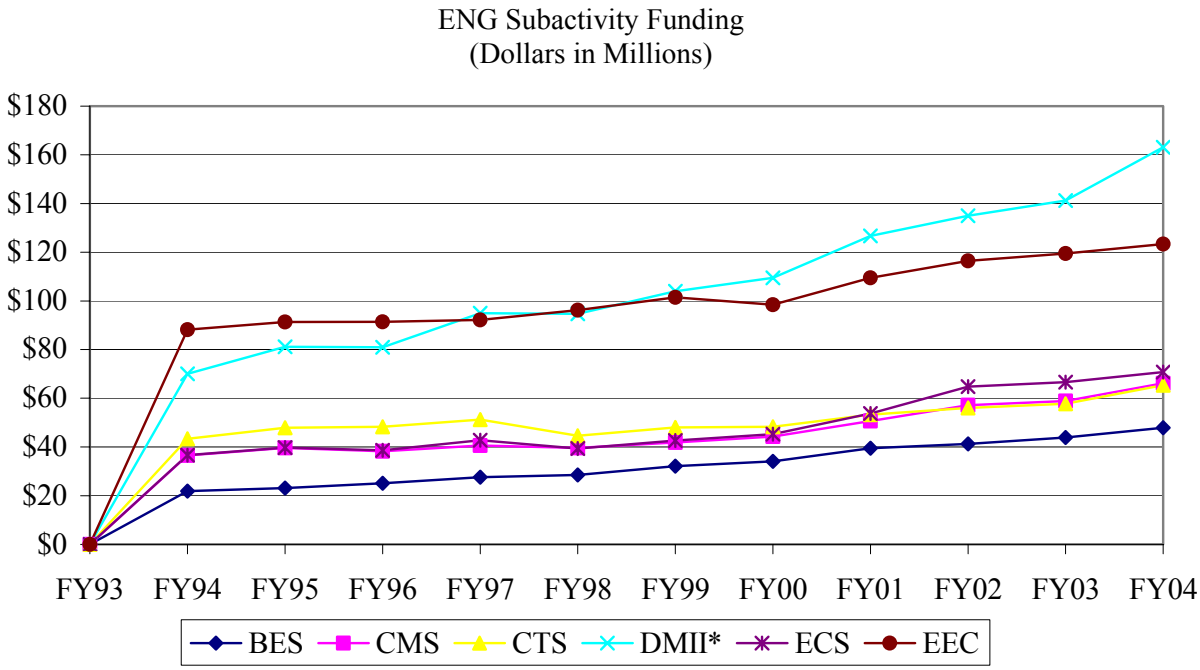
Federal Support of Basic Research in Engineering at Academic Institutions (FY 2000)



ENG is the principal source of federal funding for university-based fundamental engineering research, providing over 42 percent of the total federal support in this area.

NSF uses various internal and external mechanisms to review the relevance of proposed and existing programs and to help the Directorate identify emerging opportunities and goals for the future. These include Advisory Committees, Committees of Visitors, academy and other reports, Blue Ribbon panels, workshops, and long-range planning documents, among others.

ENG promotes the progress of engineering in the United States in order to enable the Nation's capacity to perform. Its investments in engineering research and education aim to build and strengthen a national capacity for innovation that can lead over time to the creation of new shared wealth and a better quality of life. A major focus of ENG investments is in emerging technologies—nanotechnology, information technology and biotechnology. Support for research in these areas contributes to major advances in health care, manufacturing, business, education, and the service industry.



*SBIR/STTR increases 304% over the period; other DMII programs increase 57%

STRATEGIC GOALS

Three strategic focus areas guide ENG activities:

- PEOPLE: Activities to better attract and retain engineering graduates and to ensure that they receive a quality education. ENG plays a key role in promoting curriculum reform to respond to industry's needs, and to emerging technologies that are transforming the economy. ENG supports engineering graduates who will lead currently emerging technology areas, and positions these graduates to push technological frontiers.

- IDEAS: Advancement of knowledge about fundamental engineering research, including support for core research as well as the exploration of new and emerging industrial technologies, high risk and innovative research, and expanding opportunities for discovery in NSF priority areas.

- TOOLS: Enhancement of infrastructure to conduct engineering research, identifying and developing state-of-the-art tools for increasingly collaborative engineering research activities.

Engineering's support for ongoing core and new activities contributes to NSF's efforts to achieve its strategic goals, and to the administration and management activities necessary to achieve these goals.

Summary of ENG Funding by Strategic Goal
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
People	81.66	78.09	83.42	5.33	6.8%
Ideas	376.52	399.11	435.49	36.38	9.1%
Tools	5.77	4.30	10.75	6.45	150.0%
Administration & Management	6.88	6.47	6.90	0.43	6.6%
Total, ENG	$470.83	$487.98	$536.57	$48.59	10.0%

Totals may not add due to rounding.

People (+$5.33 million, for a total of $83.42 million)

People are ENG's most important product. Across its programs, ENG supports more than 14,100 people, including students, researchers, post-doctorates, and trainees. ENG is committed to maintaining this number, while progressing with the NSF goal of longer award durations and larger grants. Support for programs specifically addressing NSF's strategic goal of "People – A diverse, internationally competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens" totals $83.42 million in FY 2004, an increase of $5.33 million, or 6.8 percent over FY 2003. Research grants support researchers and students, including approximately 8,084 postdoctoral researchers, trainees, and graduate and undergraduate students.

ENG also invests in focused human resources development and education activities to develop the next generation engineering and technological workforce and to enhance opportunities for women and minorities. Through these investments, ENG will cultivate future leaders in engineering, anxious to explore new and emerging ideas. In FY 2004, ENG will support such focused activities as Faculty Early Career Development (CAREER), Research Experiences for Undergraduates (REU), Research Experiences for Teachers (RET), Graduate Research Fellowships for Women in Engineering, Integrative Graduate Education and Research Traineeships (IGERT), and Postdoctoral Faculty Fellowships.

Students also benefit from ENG-supported partnerships with industry and from ENG-supported centers. ENG promotes partnerships with industry through the Grant Opportunities for Academic Liaison with Industry (GOALI) program, the Engineering Research Centers (ERCs) and the Industry/University Cooperative Research Centers (I/UCRC) program. These partnerships allow students to interact with industrial researchers and to gain exposure to industrial operations. At ENG-supported centers, students participate in multi-disciplinary research teams and contribute to the development of new technologies.

ENG People Investments
(Dollars in Millions)

	FY 2003 Estimate	FY 2004 Estimate	Percent Change
K-12	2.50	2.50	0.0%
Undergraduate	24.68	23.85	-3.4%
Graduate & Professional	50.91	57.07	12.1%
Total, People	$78.09	$83.42	6.8%

The FY 2004 Budget Request for People is $83.42 million, an increase of $5.33 million over the FY 2003 Request. This funding will support:

- Postdoctoral Faculty Fellowships, a new program funded at $3.0 million, to provide 15 promising postdocs with opportunities to enhance interdisciplinary research expertise and learning pedagogy needed to become outstanding new research faculty;

- The Department-Level Reform of Undergraduate Engineering Education and Bridges for Engineering Education Programs, increasing by $3.0 million over the FY 2003 Request of $6.00 million, to enable engineering departments to develop innovative curricula incorporating interdisciplinary knowledge and allow engineering schools to develop active partnerships with schools of education, for their mutual benefit;

- Engineering graduate students supported by the IGERT, GRF and GK-12 programs, increasing by $3.16 million over the FY 2003 Request of $14.26 million to a total of $17.42 million, to allow higher stipends and to increase the number of students; and

- Centers for Learning and Teaching, increasing by $120,000 over the FY 2003 Request of $1.0 million, to allow for planned scale-up of the activities of the Center for Learning and Teaching of Engineering.

Ideas (+$36.38 million, for a total of $435.49 million)

ENG support for discovery across the frontiers of science and engineering enables continued support of fundamental research in the engineering disciplines and enhanced funding for the NSF priority areas. They also provide enhanced support for research in areas such as nanotechnology, sensors, and multi-hazard engineering using the Network for Earthquake Engineering Simulation (NEES).

In its core programs, ENG supports fundamental research on sensor technologies related to nano/micro-scale sensors; wireless communications; functional materials with selective adsorption capabilities; nondestructive evaluations and remote sensing. An increase in funding for sensor technologies will enhance health and environmental monitoring and the efficiency of industrial processes. It will also augment homeland security capabilities while creating a workforce knowledgeable in the operation and deployment of sensor technologies. These technologies include: sensors with higher sensitivity and lower rate of false alarms in the detection of chemical and biological agents; sensing material properties and processes at the nano and micro scales under extreme conditions; sensors for detection, monitoring and control of engineering operations; sensor arrays for enhanced observation of natural and social environments; and imaging and sensing of complex systems, such as critical infrastructure, health and environment.

The Small Business Innovation Research (SBIR) program provides funding at the mandated level of 2.5 percent of extramural research, as required by P.L. 106-554. It will be funded at $90.93 million, an increase of $11.95 million over the FY 2003 Request of $78.98 million. The program emphasizes commercialization of research results at small business enterprises through the support of high quality research across the entire spectrum of NSF disciplines. Recent improvements to the SBIR program include redefinition of research topics to address significant technologies and more emphasis on "commercialization potential" in the SBIR review process.

In FY 2004, ENG will provide $10.22 million, an increase of $5.55 million over the FY 2003 Request of $4.67 million, for the Small Business Technology Transfer (STTR) program, which partners small

businesses with academic institutions to promote industrial innovation. Recent congressional action raised the mandated agency spending target from 0.15 percent to 0.30 percent of an agency's extramural research budget in FY 2004.

Total ENG support for the National Earthquake Hazards Reduction (NEHRP) program is $24.99 million, an increase of $4.0 million over the FY 2003 Request of $20.99 million, including support for fundamental research that leads to more earthquake-resistant buildings and facilities. Foundation-wide, support for NEHRP in FY 2004 is $45.74 million, including $8.0 million in the Major Research Equipment and Facilities Construction (MREFC) Account for the Network for Earthquake Engineering Simulation (NEES).

The Engineering Research Centers (ERCs) program provides an integrated environment for academe and industry to focus on next-generation advances in complex engineered systems, with synergy among engineering, science, and industrial practice. ERCs integrate research with education at both the graduate and undergraduate levels, producing curriculum innovations derived from the systems focus of the ERCs' strategic research goals. ERCs aim to build trusted partnerships with industry, develop shared infrastructure, and increase the capacity of engineering and science graduates to contribute to the U.S. competitive edge. They provide a system perspective for long-term engineering research and education, enabling fresh technologies, productive engineering processes, and innovative products and services.

ENG Centers
(Dollars in Millions)

	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
Engineering Research Centers & Groups	56.22	60.22	4.00	7.1%
Earthquake Engineering Research Centers	5.99	5.99	0.00	0.0%
Industry/University Cooperative Research Centers	5.29	5.18	-0.11	-2.1%
Nanoscale Science & Engineering Centers[1]	6.10	6.10	0.00	0.0%
State/Industry/University Cooperative Research Centers	0.60	0.00	-0.60	-100.0%
Science and Technology Centers[2]	4.00	8.00	4.00	100.0%
Total, Centers Support	$78.20	$85.49	$7.29	9.3%

[1]Funding for Nanoscale Science and Engineering Centers was previously reported in Engineering Research Centers & Groups.
[2]The increase for STC funding reflects new awards made in September 2002. These funds are shown in Integrative Activities in the FY 2003 Request, and are transferred to the appropriate managing R&RA Activity in the FY 2004 Request.

The FY 2004 ENG Budget Request for Centers involves:

- $60.22 million to support a steady state of 16-17 university-based Engineering Research Centers (ERCs). NSF provides about 30 percent of the total support to the centers, with the remaining funding support coming from industry, other Federal agencies, universities, and the states.

- $5.99 million to support three earthquake engineering research centers at approximately $2.0 million each per year to provide knowledge to mitigate damage to the built environment; provide outreach to the private, educational, and government sectors; and educate professionals for cross-disciplinary careers.

- $5.18 million for Industry/University Cooperative Research Centers (I/UCRC). The I/UCRC program as a whole will support about 48 I/UCRCs. These highly leveraged centers form close-knit partnerships with their industrial members.

- FY 2003 marks the final year of funding for the three State Industry/University Cooperative Research Centers (S/I/UCRCs). No funding is requested in FY 2004.

- $6.10 million to support three Nanoscale Science and Engineering Centers (NSEC). Research at these centers aims to advance the development of the ultra-small technology that will transform electronics, materials, medicine, environment, and many other fields. These centers have strong partnerships with industry, national laboratories and international centers of excellence.

- $8.0 million to support two Science and Technology Centers (STCs). The FY 2004 increase of $4.0 million over the FY 2003 Request of $4.0 million represents a transfer into the Chemical and Transport Systems (CTS) Subactivity of annual funding for a new STC on new materials for water purification. ENG also funds an existing STC – within the Electrical and Communications Systems Subactivity – focused on nanobiotechnology.

Priority Areas

In FY 2004, ENG will support research and education efforts related to broad, Foundation-wide priority areas in Biocomplexity in the Environment, Information Technology Research, Nanoscale Science and Engineering, Mathematical Sciences, and Human and Social Dynamics.

ENG Investments in Priority Areas
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Biocomplexity in the Environment	3.60	6.00	6.00	0.00	0.0%
Information Technology Research	10.23	11.17	11.17	0.00	0.0%
Nanoscale Science and Engineering	86.30	94.35	106.85	12.50	13.2%
Mathematical Sciences	N/A	0.91	2.91	2.00	219.8%
Human and Social Dynamics	N/A	N/A	2.00	2.00	N/A

Biocomplexity in the Environment: In FY 2004, ENG will provide a total of $6.0 million, equal to FY 2003, for the Biocomplexity in the Environment priority area. Half of this amount will support the central competition, and the other half will support the Materials Use: Science, Engineering, and Society (MUSES) Program.

Information Technology Research: In FY 2004, ENG will provide $11.17 million, equal to FY 2003, for ITR. Areas for special emphasis within ITR include:

- Computational simulation and modeling of complex materials, structures and processes; and
- Research focused on developing high end computing tools to accelerate the design of next generation IT manufacturing techniques in areas such as photonic crystals, optical and electronic switching devices, sensors and detectors.

ENG also supports a broad range of other IT-related activities, such as quantum computing and molecular logic, domain-specific software, IT for the service sector, modeling and simulation, and real-time sensing and control.

Nanoscale Science and Engineering: In FY 2004, ENG will provide $106.85 million for Nanoscale Science and Engineering activities, an increase of $12.50 million over the FY 2003 Request of $94.35 million. ENG will support comprehensive research on nanotechnology for functional nanostructures, processing and fabrication of nanostructured materials, new devices and architectures, tools for investigation at nanoscale, and technologies with applications ranging from biology to environmental sensing. Requested funds expand research in the following areas:

- Manufacturing processes at the nanoscale;
- Bio-chemical-radiological-explosive detection and protection;
- Infrastructure; and
- Education and societal implications.

Mathematical Sciences: ENG will provide $2.91 million in FY 2004, an increase of $2.0 million over FY 2003, to support synergistic collaborations between mathematicians and engineering researchers to strengthen engineering modeling and experimental work and enhance undergraduate and graduate engineering education.

Human and Social Dynamics: ENG will provide $2.0 million for the Human and Social Dynamics priority area in FY 2004. Of this, $1.0 million will be invested in Complex Systems to support studies on the security and reliability of critical infrastructure networks, and $1.0 million in Enhancing Human Performance to focus on 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.

Tools (+$6.45 million, for a total of $10.75 million)

In FY 2004, ENG support for the enhancement of infrastructure to conduct engineering research is funded at $10.75 million, an increase of $6.45 million over the FY 2003 Request of $4.30 million.

Of this funding, $8.80 million will be provided to the National Nanotechnology Infrastructure Network (NNIN), an integrated national network of user facilities that will support the future infrastructure needs for research and education in the burgeoning nanoscale science and engineering field. The facilities comprising this network will be diverse in capabilities, research areas, and geographic locations, and the network will have the flexibility to grow or reconfigure as needs arise. The NNIN will broadly support nanotechnology activities outlined in the National Nanotechnology Initiative investment strategy. It will provide users across the nation access to leading-edge fabrication and characterization tools and instruments in support of nanoscale science and engineering research, develop and maintain advanced research infrastructure, contribute to the education and training of a new workforce skilled in nanotechnology and the latest laboratory techniques, conduct outreach to the science and engineering communities, and explore the social and ethical implications of nanotechnology. The NNIN will supersede the National Nanofabrication Users Network (NNUN), initiated in 1994 and coming to the completion of NSF support at the end of 2003.

The remaining $1.95 million in ENG Tools funding will initiate support of mid-size infrastructure awards with a total cost of less than $200,000 per award, funded by individual or multiple programs within the Chemical & Transport Systems (CTS) and the Civil and Mechanical Systems (CMS) Subactivities.

Within the Major Research Equipment and Facilities Construction (MREFC) account, $8.0 million is requested to continue the Network for Earthquake Engineering Simulation (NEES), a project to construct, upgrade, network and integrate a complete system of test facilities in earthquake engineering. For additional information on this project, see the MREFC Chapter.

Administration and Management

Administration and Management provides for administrative activities necessary to enable NSF to achieve its strategic goals. Requested funding for FY 2004 is $6.90 million, an increase of $430,000 over FY 2003. This includes the cost of Intergovernmental Personnel Act appointments and contractors performing administrative functions.

QUALITY

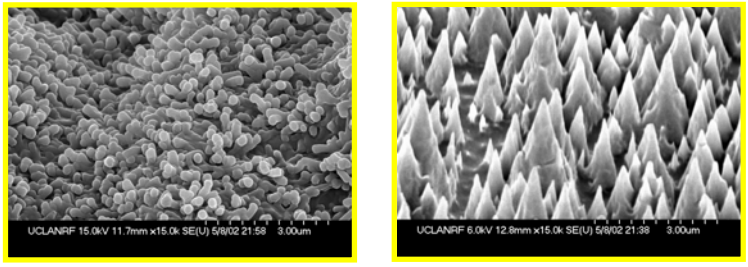
ENG maximizes the quality of its research and development portfolio through the use of a competitive, merit-based review process. In FY 2002, 96 percent of basic and applied research funds were allocated to projects that undergo merit review.

ENG Committees of Visitors, composed of expert external peer evaluators, 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 a breadth of issues: the mission, programs, and goals to best serve the scientific community; methods of improving the quality of engineering graduate and undergraduate education; and priority research investments, to name a few. AC/ENG meets twice yearly. Its membership represents a cross section of engineering's diverse workforce and geographical orientation, as well as its diverse sub-disciplines and institutions.

PERFORMANCE

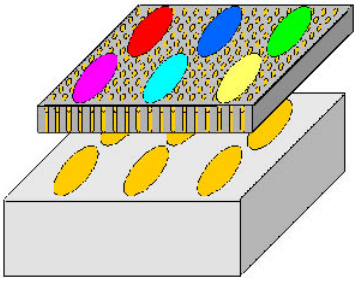
- Chang-Jin Kim of UCLA created a nearly frictionless surface using "nanoturf" and "nanopebble" technology. These surfaces will cut costs in devices with moving parts, lubricants, or liquid components by saving energy usually lost to friction. http://cjmems.seas.ucla.edu/



Scanning electron micrographs of a lotus leaf surface (left) and the first-generation, nano-engineered surface (right). Such low-friction surfaces are needed for the development of practical, energy-efficient microfluidic devices such as labs-on-a-chip.

- Alok Chaturvedi of Purdue University developed software to simulate certain business operations. The program has now demonstrated usefulness for homeland security. In cooperation with state emergency officials in Indiana, Chaturvedi's research team demonstrated the effects of an outbreak of small pox in an Indiana city. http://www.mgmt.purdue.edu/MIS/alok.htm

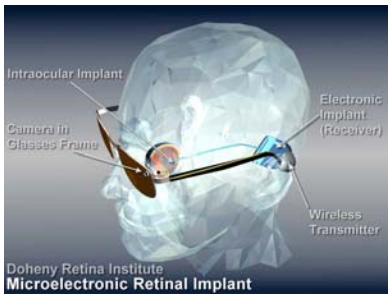
- Charles Martin of the University of Florida combined nanometer-scale tubes, wires and enzymes directly onto a chip. The result is an array of sensors that may be able to detect a variety of biological warfare agents. http://www.chem.ufl.edu/~crmartin/contact.html

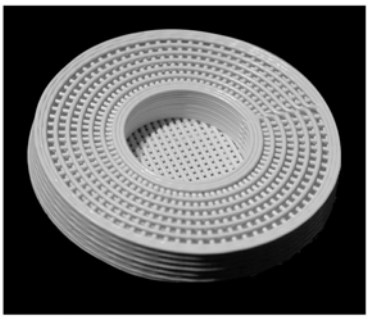


Schematic of the multifunctional biosensor on a single chip. Such bio/nano assemblies of immobilized enzymes on top and nanostructures transmitting signals to a computer chip below have demonstrated their potential to act as highly sensitive and selective biological detectors.

- Matthew Tirrell and his team at the University of California, Santa Barbara and at the University of Delaware, collaborating on the project *Creating Functional Nano-Environments by Controlled Self Assembly,* are advancing the science for the self-assembly processing of nano-scale materials and devices in this NIRT project. Molecular structures, such as the triple helix shown, have been designed to arrange themselves spontaneously into bilayer walls of structures, such as tubules, vesicles, and micelles. These structures, which mimic effects found in nature, can be synthesized to produce useful chemical and mechanical interactions because the functional groups appearing on the outer surfaces of the structures control external interactions. Thus, this NIRT group is producing advanced biomimetic materials as well as components for micro-machines. Potential biomedical implications include controlled release of drugs with more specificity, embedded biological signaling, and many other therapeutic approaches.

- Mark S. Humayun of the Doheney Eye Institute, Keck School of Medicine, University of Southern California, has been testing an implantable chip that may restore vision in patients rendered blind by disease. NSF was the first federal agency to support this "high risk" project, beginning with an SGER award in 1996. In 2002, with additional funding from the National Eye Institute (BRP Award) and DARPA, the efforts resulted in the successful implantation of a test version of the wireless, artificial retina. http://www.usc.edu/hsc/doheny/





- J.A. Lewis of the University of Illinois has been working on a project entitled: Directed Colloidal Assembly of Mesoscale Periodic Composites. The goal of this research was to develop fundamental process knowledge required to reliably manufacture mesoscale periodic composites. The PI has developed a direct assembly approach that relies on robotic deposition of concentrated colloidal gel-based inks. This technique allows for the facile fabrication of complex 3-D structures, such as the ferroelectric lattice shown. These structures, when infiltrated with a polymeric resin, serve as piezoelectric composites. This research is likely to lead to new deposition schemes and colloidal inks that will enable the next generation of functional ceramics.

Other Performance Indicators

The tables below show the growth in the number of people benefiting from ENG's funding, and trends in growth of award size, duration and number.

Number of People Supported in ENG Activities

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Senior Researchers	4,402	4,025	4,427
Other Professionals	1,160	925	1,218
Postdoctorates	491	550	565
Graduate Students	4,315	4,425	4,485
Undergraduate Students	2,952	2,500	3,150
K-12 Students		100	
K-12 Teachers	250	115	265
Total Number of People	13,570	12,640	14,110

ENG Funding Profile

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Number of Requests for Funding	8,389	7,800	8,580
Dollars Requested (in millions)	$3,488	$3,500	$3,850
Total Number of Awards	3,204	3,100	3,550
Statistics for Competitive Awards:			
Number	1,726	1,525	1,765
Funding Rate	25%	25%	24%
Statistics for Research Grants:			
Number of Research Grants	1,021	850	1,015
Median Annualized Award Size	$83,965	$83,000	$85,000
Average Annualized Award Size	$102,075	$105,000	$107,000
Average Award Duration, in years	2.7	3.0	3.0

BIOENGINEERING AND ENVIRONMENTAL SYSTEMS $47,910,000

The FY 2004 Budget Request for the Bioengineering & Environmental Systems Subactivity is $47.91 million, an increase of $4.04 million, or 9.2 percent, above the FY 2003 Request of $43.87 million.

Bioengineering and Environmental Systems Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Bioengineering and Environmental Systems	41.32	43.87	47.91	4.04	9.2%
Total, BES	$41.32	$43.87	$47.91	$4.04	9.2%

The Bioengineering and Environmental Systems (BES) Division supports research and education in the rapidly evolving fields of bioengineering and environmental engineering. BES has two principal objectives: enabling and facilitating the deployment of new technologies in these fields for society's use in the medical, biotechnology, and environmental arenas; and advancing bioengineering and environmental engineering education, particularly through the development of innovative programs by new faculty.

BES focuses these objectives through three program clusters:

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

Current BES high-emphasis research and education areas include post-genomic engineering, tissue engineering, biophotonics, nano-biosystems, and engineering environmental assessment 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 (http://tissueengineering.gov), and the Metabolic Engineering Working Group (http://www.epa.gov/opptintr/metabolic/index.htm). The NSF/DARPA/NIH Biophotonics Partnership (http://www.nsf.gov/pubs/2003/nsf03005/nsf03005.htm) is another joint effort initiated by BES.

Scientific drivers and opportunity areas for BES include:

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 the nature of their function, 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.

Research to provide access to affordable municipal sanitation services to underserved communities worldwide, such as Trinidad & Tobago (as shown). Support development of theory in risk assessment and performance evaluation and disseminate best practices to assure the sustainable capacity for safe, reliable, and affordable municipal systems for under-served communities worldwide.

Engineering Environmental Assessment and Problem-Solving Options Development: Rapidly expanding cyberinfrastructure capabilities are enabling the potential for developing radically new approaches to engineering assessment of environmental problems. Building on such new assessment 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.

Increases in the BES budget request, combined with reallocation of base funds, are summarized below:

- Sensor research totals $5.0 million, an increase of $1.0 million over the FY 2003 level of $4.0 million, with particular emphasis on homeland security;
- Support for the Nanoscale Science and Engineering priority area and National Nanotechnology Infrastructure Network (NNIN) totals $9.10 million, increasing by $2.40 million over the FY 2003 level of $6.70 million. Emphasis will be on detection of and protection from biological and chemical agents critical to homeland security;
- Collaborative Large-scale Engineering Assessment Network for Environmental Research (CLEANER) planning, with initial support of $200,000, will focus on potential avoidance and mitigation of anthropogenically induced environmental problems; and
- Support for the Mathematical Sciences priority area increases by $400,000 to a total of $630,000, focusing on modeling research of multi-scale biosystems.

CHEMICAL AND TRANSPORT SYSTEMS $66,200,000

The FY 2004 Budget Request for the Chemical and Transport Systems Subactivity is $66.20 million, an increase of $7.26 million, or 12.3 percent, above the FY 2003 Request of $58.94 million.

Chemical and Transport Systems Funding
(Dollars in Millions)

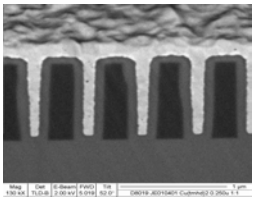
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Chemical and Transport Systems	57.21	58.94	66.20	7.26	12.3%
Total, CTS	$57.21	$58.94	$66.20	$7.26	12.3%

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-funded research in areas such as fluid flow, combustion, heat transfer, catalysis, fuel cells, sensors, and membranes contribute to advances that are important for the environment, energy, transportation, information technologies, and other areas that impact our daily lives.

CTS will continue to support research in traditionally important areas such as chemical reaction engineering, interfacial phenomena and separations, fluid dynamics and particle processes, and combustion and thermal processing. 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 addition to sustaining the vitality of these core research areas, the Division actively supports the following key areas of particular NSF emphasis.

In addition to a redistribution of funds within the four core research areas to support high-potential proposals, requested FY 2004 funding will be distributed among:

Nanoscale Science and Engineering: NSE support totals $21.88 million, an increase of $1.50 million over the FY 2003 level of $20.38 million. Funding will allow expansion of research in the synthesis and processing of matter at the nanometer-length scale, producing materials with novel physical, optical, chemical, and biological properties. Understanding structural morphologies and properties from the molecular scale up to bulk scale via new experimental tools and simulation capabilities will permit major advances in many areas central to CTS. The fields of catalysis, microfluidics, electronic materials, membranes and adsorption media for selective chemical and biochemical separations, fuel cells, plasma processing, sensors, and environmental technologies will be significantly impacted. The synthesis 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 area for CTS. Furthermore, in order to accelerate the benefits from increased investments in fundamental research on these topics, CTS will allocate funds for infrastructure



Nanoscale copper interconnects formed by chemical-fluid deposition from solutions in supercritical carbon dioxide to achieve very compact printed circuits.

investment to address issues that deal with scale-up of the synthesis processes, development of new instrumentation, and refined methods for characterization.

Information Technology Research (ITR): ITR funding totals $2.56 million, an increase of $250,000 over the FY 2003 level of $2.31 million. Continuing support will enhance computational tools (algorithms, data mining and visualization) and infrastructure, coupled with advances in basic science. New investments will permit more robust and precise modeling and simulation of complex materials processing and manufacturing techniques. Such improved simulations are enabled by a significant increase in the breadth and depth of the CTS research portfolio in ITR-related areas. The target applications include the design and utilization of next-generation chemical and plasma vapor-deposition techniques for microelectronics manufacturing; analysis of growth mechanisms of next-generation photonic crystals leading to better control of microstructure formation and segregation of dopants and impurities; the manufacturing of optical fibers needed in wide-band networking applications with optimum product quality; and the processing of high-performance polymers (plastics) that involves chemical reactions and multi-scale flow phenomena of non-Newtonian fluids. In addition to reducing the time required to introduce new products and processes, advances in process modeling result in more efficient and environmentally sound processing and manufacturing systems.

Environmental Technologies: Support for environmentally relevant technologies totals $2.24 million, increasing by $1.50 million over the FY 2003 level of $740,000, primarily in the areas of MUSES, CLEANER, and projects aimed at pollution prevention and containment of greenhouse gases. Research leading to products and processes that avoid negative environmental impact will continue to be a CTS priority. Examples of CTS interest areas are 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. Novel techniques for control of greenhouse gases will receive increased emphasis. These topics are strongly embedded in the core of CTS programs. By participating in the MUSES component of Biocomplexity in the Environment, which involves development of new materials and processes, CTS will provide enhanced funding to these environmental technology areas.

Sensor Technologies: Funding for sensor technologies totals $5.0 million, an increase of $1.0 million over the FY 2003 Request. As part of its programs related to chemical-process control as well as interfacial phenomena and catalysis, CTS has invested in development of various types of sensors for monitoring levels of specific chemicals and biochemical materials, temperature, pressure, and flow conditions. With the increased needs for improved sensors arising from security requirements, CTS will expand its investments in this area. Developments in nanotechnology have opened many new opportunities for the creation of more selective and sensitive sensors, including detectors for target biological materials that will be extremely valuable for security applications as well as in the safe and efficient operation of industrial processes.

A major increase of $4.0 million in FY 2004 represents the transfer into ENG of the annual funding for a new Science and Technology Center (STC) on New Materials for Water Purification, a topic that has direct relevance to several of the CTS program areas. The award was made in September 2002. These funds are shown in Integrative Activities in the FY 2003 Request and are transferred to the appropriate managing R&RA Activity in the FY 2004 Request.

CTS will also participate in the Mathematical Sciences priority area at a level of $630,000. Research will focus on quantitative modeling of multi-scale molecular and processing systems.

CIVIL AND MECHANICAL SYSTEMS $64,360,000

The FY 2004 Budget Request for the Civil and Mechanical Systems Subactivity is $64.36 million, an increase of $6.61 million, or 11.4 percent, above the FY 2003 Request of $57.75 million.

Civil and Mechanical Systems Funding
(Millions of Dollars)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Civil and Mechanical Systems	56.09	57.75	64.36	6.61	11.4%
Total, CMS	$ 56.09	$ 57.75	$ 64.36	$ 6.61	11.4%

The Civil and Mechanical Systems (CMS) Subactivity has two major goals: investing in research and workforce development that provides the fundamental and quantitative underpinning for the engineering profession in application to civil and mechanical systems and the built environment; and supporting the rapid development and deployment of new knowledge and technology to decrease vulnerability to natural and technological hazards.

CMS research increases the knowledge base and intellectual growth in the disciplines of construction, geotechnology, structures, dynamics, sensors and control, engineering mechanics and materials, as well as the application of IT to enhance reliability and performance of critical infrastructure systems. At the heart of the CMS mission is the improved understanding and design of materials and structures across all physical scales, from nano-level to mega-system integration-level. Research activities funded by CMS include a strong focus on integrated experiments and modeling to enhance the fundamental understanding of complex structures and systems, including nonlinear dynamic behaviors and processes. Linking physical model experimentation and computational model simulation demands sensor technologies to measure and observe fundamental processes. New sensors are also needed for "smart" civil and mechanical systems, and for applying the information technology required to sustain the nation's infrastructure. Real-time data acquisition and visualization will enhance critical infrastructure performance analysis and prediction.

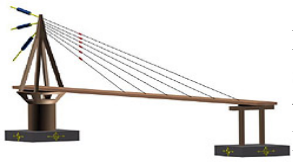
CMS encourages cross-disciplinary research and education investments to produce innovative and integrated engineered services. Recent events have underscored the nation's increasingly interdependent, complex and vulnerable human, social, natural and physical systems. The U.S. needs better databases and tools for prediction, risk, decisions and uncertainty, and CMS pursues cross-directorate and interagency partnerships that promise the requisite knowledge and advanced tools for vulnerability assessment.

In support of NSF's participation in the National Earthquake Hazards Reduction Program (NEHRP), CMS invests in research on the mitigation of impacts from natural and technological hazards on constructed, natural, and human environments. CMS funds rapid-response reconnaissance investigations following extreme events in the U.S. and abroad. Interdisciplinary and international studies involving hazard assessment, preparedness and response, societal and economic impacts, decision sciences are supported in coordination with NSF's Geosciences and the Social, Behavioral, and Economic Sciences Activities.

The $6.61 million increase in the CMS budget will be combined with $690,000 from core funding reallocations to support expanded research in the following:

Sensor Technologies: Increases by $1.30 million over the FY 2003 level of $4.0 million to enhance research on sensor technology and applications. CMS investments include research on miniaturization, new device sensitivities and enhanced reliability, improved active sensors and robotic devices for rapid detection and search and rescue application, and intelligent deployment of sensor arrays. CMS also invests in complex and distributed systems of sensors, and systems integration for seamless and real-time use of information, including study of changing attributes of materials, understanding of basic mechanics and chemistry of processes, and life-cycle performance under conditions of exposure, operation and aging. Compelling applications include real-time assessment of damage and repair to reduce recovery periods after disasters; rapid real-time assessment of critical system vulnerabilities; and removal of personnel from hazardous operations and maintenance roles.

Nanoscale Science and Engineering: Increases by $1.20 million over the FY 2003 level of $5.27 million to support integrated design and simulation of the behavior of nanomaterials and nanostructures. This research leads to development of new technologies in civil and mechanical systems, and for understanding long-term performance and durability of new materials in new applications and extreme environments. Computational and experimental advances in model-based simulation, when integrated with physical testing and system simulation software in a virtual test environment, will reduce development time and cost. CMS will also invest $200,000 of the total increase into the National Nanotechnology Infrastructure Network (NNIN).



The State University of New York at Buffalo is building a new NEES facility at which complex large-scale experiments are combined with real-time computer simulations for the most complete picture of how earthquakes affect large buildings and bridges.

NEES Grand Challenge Research: Initial support of $4.0 million will support research in multi-hazard engineering involving experimental and theoretical simulations at one or more of the Network for Earthquake Engineering Simulation (NEES) facilities that will be brought on line during FY 2004. This research will focus on new technologies and design tools to identify and communicate infrastructure system vulnerabilities under risk of extreme events. Within the Major Research Equipment and Facilities Construction (MREFC) Account, $8.0 million has been requested to complete NEES, a project to construct, upgrade, and network an innovative system of test facilities in earthquake engineering, as well as promote international collaborations for earthquake engineering research. Oversight of this project is provided through CMS.

Complex System Vulnerabilities and Interdependencies: Initial support of $890,000 will enhance systems research on the nation's complex and interdependent physical infrastructure, leading to scalable systems of high reliability, decreased vulnerability, and decreased life-cycle cost and environmental impact. With the Human and Social Dynamics priority area, CMS will support new paradigms and IT-tools for information interpretation and decision-making, leading to systems models that efficiently simulate complex phenomena and that improve performance prediction of complex infrastructure service.

Engineering and the Environment: Initial support of $200,000 introduces the CMS research community to the CLEANER program, concerned with anthropomorphically stressed environments.

Mathematical Sciences: Initial support of $400,000 involves interdisciplinary research leading to knowledge and development of tools for the analysis, design and control of complex and nonlinear materials, processes and systems.

DESIGN, MANUFACTURE, AND INDUSTRIAL INNOVATION $163,060,000

The FY 2004 Budget Request for the Design, Manufacture, and Industrial Innovation Subactivity is $163.06 million, an increase of $21.83 million, or 15.5 percent, above the FY 2003 Request of $141.23 million.

Design, Manufacture, and Industrial Innovation Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Design, Manufacture and Industrial Innovation	55.88	57.58	61.91	4.33	7.5%
Small Business-Industrial Innovation	79.11	83.65	101.15	17.50	20.9%
Total, DMII	$134.99	$141.23	$163.06	$21.83	15.5%

The Design, Manufacture, and Industrial Innovation (DMII) Subactivity supports research and education activities that spur innovation and enhanced productivity in a broad range of U.S. industries. DMII also supports the development of a well-educated and diverse human resource base, vital to U.S. global competitiveness. DMII identifies the underlying design and manufacturing theories for the innovation of new products, processes and systems in a wide variety of enterprises. The DMII core is comprised of discoveries and major advances in engineering design, operations research, manufacturing enterprise systems, service enterprise engineering, nanomanufacturing, materials processing and manufacturing machines and equipment.

Nanomanufacturing, a key component of the Nanoscale Science and Engineering priority area, focuses on converting discoveries from nanoscience into new products for the benefit of society. While nanoscience is uncovering novel physical, mechanical, electrical, magnetic, chemical and biological properties, many broad manufacturing issues need to be addressed to build products, devices and components that take advantage of these unique properties. Simultaneously, an entirely new manufacturing workforce needs to be educated and trained in nanotechnology to pursue its exciting opportunities.

The Materials Use: Science, Engineering, and Society (MUSES) Program is an area within the Biocomplexity in the Environment (BE) priority area, supporting the design and synthesis of new materials with environmentally benign impact on biocomplex systems. The Collaborative Large-scale Engineering Assessment Network for Environmental Research (CLEANER) also aligns with DMII's focus on environmentally benign design and manufacture. Opportunities exist to integrate life cycle product design methodologies with manufacturing enterprise systems to realize benefits of reduced energy consumption without adverse environmental impact.

DMII support for service processes as engineered systems contributes to enhanced productivity. Optimizing container ship design reduces labor costs and has the potential to increase the rate of return for this sector by 25 %.

Information Technology Research (ITR) applied to production systems has reaped significant economic benefits in manufacturing, such as applications of Supply Chain Management. Engineering research has an opportunity to make similarly significant contributions to the fast growing service sector such as health care delivery systems.

More scientists and engineers are now employed in high technology small businesses than in large businesses. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs support small businesses for

research in advanced materials and manufacturing, biotechnology, electronics and information technology, aiming to convert scientific discoveries to innovations for society via job and wealth creation.

The orbiTouch is the first 128-character keyboard with an integrated mouse that uses the hands and arms, instead of the fingers, to type. Enabled by a series of SBIR awards, the research results provide a solution for people unable to use traditional keyboards due to disability or injury.

DMII promotes partnerships between industry and university through the Grant Opportunities for Academic Liaison with Industry (GOALI) program, as well as the STTR program. DMII, in collaboration with the Social, Behavioral and Economics (SBE) Activity, will continue to support research in understanding of the innovation process through the Innovation and Organizational Change (IOC) program.

Retrospective assessments have found that DMII grants have resulted in fundamental contributions and, in some cases, led either to the creation of new research fields or the production of seminal knowledge in design and manufacturing. These studies have also documented the eventual commercialization and economic impact of many DMII investments. Results include breakthrough advances in solid free-form fabrication technology, pioneering work in nanotechnology for mass storage devices, and the establishment of supply chain management as a bonafide research field.

FY 2004 plans, with some reallocation of base funds, include new funds for:

- The Nanoscale Science and Engineering priority area, increasing by $2.40 million over the FY 2003 level of $10.72 million, for nanomanufacturing, covering nano-features enhancement in micro/meso products and devices, nano-assembly and connectivity, nano-process control and nano-system integration; initial support of $900,000 for the National Nanotechnology Infrastructure Network will ensure a full array of interconnected resources to address synthesis and scale-up of nanosized materials and structures into functional devices, architectures and integrated systems across dimensional scales, leading eventually to useful products and services;
- The Human and Social Dynamics priority area; initial support of $1.00 million with a focus on 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;
- The Mathematical Sciences priority area is funded at $630,000 in FY 2004, to support synergistic collaborations between mathematicians and engineering researchers to strengthen engineering modeling and experimental work and enhance undergraduate and graduate engineering education;
- The Sensors and Sensor Networks for Information, Decision and Action research totals $5.0 million, an increase of $1.0 million over the FY 2003 level to support new discoveries and methods to design and manufacture products that are self-protecting and correcting;
- The Collaborative Large-scale Engineering Assessment Network for Environmental Research, with initial funding of $200,000, will support one proposal on the industrial ecology impact on watersheds;
- The Small Business Innovation Research (SBIR) Program is funded at $90.93 million, an increase of $11.95 million over the FY 2003 Request of $78.98 million; and the Small Business Technology Transfer (STTR) Program is funded at $10.22 million, an increase of $5.55 million over the FY 2003 Request of 4.67 million. Recent congressional action raised the mandated agency spending target from 0.15 percent to 0.30 percent of an agency's extramural research budget in FY 2004.

ELECTRICAL AND COMMUNICATIONS SYSTEMS $70,760,000

The FY 2004 Budget Request for the Electrical and Communications Systems Subactivity is $70.76 million, an increase of $4.06 million, or 6.1 percent, over the FY 2003 Request of $66.70 million.

Electrical and Communications Systems Funding
(Millions of Dollars)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Electrical and Communications Systems	64.75	66.70	70.76	4.06	6.1%
Total, ECS	$64.75	$66.70	$70.76	$4.06	6.1%

The Electrical and Communications Systems Subactivity (ECS) addresses the fundamental research issues underlying both the device technologies and the engineering systems principles of complex systems and applications. It also seeks to ensure the education of a diverse workforce prepared to support the continued rapid development of these technologies as drivers for the global economy. The research and education supported by ECS are key to enabling the synergy between micro/nanotechnology, biotechnology, and information technology by supporting programs that address the technological challenges facing the economy of the 21st Century.

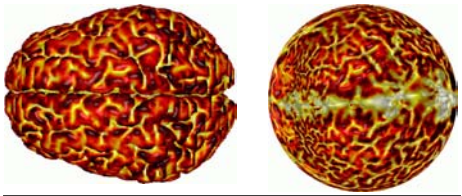
The study of microelectronic, nanoelectronic, micromagnetic, photonic, and micro-electromechanical devices - and their integration into circuits and microsystems - is rapidly expanding in technical scope and applications. New generations of integrated microsystems incorporate microchip technology with mechanical, biological, chemical and optical sensors, actuators and signal processing devices to achieve new functionality. Modern computing and communications systems are based on these devices. Due to trends toward smaller and faster devices and to address the challenges posed by the physical limitations to Complimentary Metal Oxide Semiconductor (CMOS) technologies, ECS is funding programs in new molecular based nanoscale electronic devices and storage technologies and understanding of the quantum principles which dominate their behavior. These programs will play a key role in addressing the challenges identified in the Semiconductor Technology Roadmap.

ECS has provided leadership in initiating new research directions for intelligent sensing systems with wireless, reconfigurable, agile networks of sensor arrays for interpretation, decision and action. These systems, which learn new functions and adapt to changing environments, are of special relevance to the monitoring of the nation's critical infrastructure and security.

The integration of device research and systems principles has broad applications in telecommunications, power and energy, environment, transportation, medicine, agriculture, manufacturing, and other areas.

ECS also provides support for specialized resources and infrastructure that facilitate research and educational activities, such as the National Nanotechnology Infrastructure Network (NNIN), the Science and Technology Center on Nanobiotechnology at Cornell University and the Major Research Instrumentation program. ECS also actively participates in the development and management of cross-disciplinary programs, industry-related programs and graduate traineeship programs and research centers. ECS provides significant support to the Nanoscale Science and Engineering and Information Technology Research priority areas.

ECS holds a number of grantees workshops to assess the results of research and education grants it funds and to encourage interaction among the Principal Investigators. In addition, ECS holds a number of workshops to evaluate and assess the technologies of current and future importance.



Flat rendering of brain images for improved visualization of the cortical surface in magnetic resonance imaging.

Recent achievements of ECS grantees include:

- Ultrafast Photoconduction Techniques have enabled electronic transport in Carbon Nanotubes;
- Construction of Nanoscale Molecular Sorters powered by F1-Atpase Biomolecular Motors;
- High resolution Bio-medical imaging using Ultra-short Pulsed Lasers;
- Development of extreme UV lasers;
- Advanced computational models for high-density photonic integrated circuits;
- "Chip Camps" that open young minds to the wonders of nanotechnology for over 400 middle and high school students using the National Nanofabrication Users Network (NNUN);
- NNUN supported the experimental education of over 1100 graduate and undergraduate students and over 300 PhD awards depended on the use of NNUN resources;
- Summer programs have motivated over 200 African American and Hispanic high school students to pursue electrical engineering degrees at some of the top schools in the nation;
- The Photonics Technology Access Program (PTAP) is enabling researchers to have access to leading-edge prototype photonics devices and fabrication facilities in industry; and
- Development of a highly sensitive acoustic wave biosensor array for identification and quantification of bacterial pathogens.

Some of the special research foci funded by ECS are:

- Enabling Technologies for Space Solar Power (SSP) co-funded by NASA and EPRI
- Electric Power Network Security and Efficiency (EPNES) co-funded by ONR
- Spin Electronics co-funded by ONR
- Integrated Sensing for Decision and Action.

Reallocation within core areas and increases in the FY 2004 request encompass:

- Funding of $25.61 million, an additional $1.50 million over the FY 2003 level of $24.11 million, will support Nanoscale Science and Engineering research on fundamental principles of electronic and photonic devices, manipulation of nanostructures, and modeling and simulation of new device architectures and systems. Nanodevices and nanosystems will create opportunities for new electronics, biotechnology, bioengineering, and information and communications systems. Increased investments are planned in support of the new National Nanotechnology Infrastructure Network (NNIN) for shared instrumentation facilities for nanoscale research, characterization and nanomanufacturing;
- Research on sensors totals $5.0 million, an increase of $1.0 million over the FY 2003 level;
- A research emphasis in the area of Organic Electronics and Photonics to address the challenges in flexible, inexpensive, mass manufacturable electronics and solid-state lighting; and
- A small grants program to develop 'out of the box' research ideas far beyond CMOS technologies.

ENGINEERING EDUCATION AND CENTERS $124,280,000

The FY 2004 Budget Request for the Engineering Education and Centers Subactivity is $124.28 million, an increase of $4.79 million, or 4.0 percent, over the FY 2003 Request of $119.49 million.

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Engineering Education and Centers	$116.67	$119.49	$124.28	$4.79	4.0%
Total, EEC	$116.67	$119.49	$124.28	$4.79	4.0%

The Engineering Education and Centers (EEC) Subactivity funds U.S. engineering schools to adapt the engineering education and research enterprise to technological, economic, and social change, in partnership with government and the private sector. This evolution is required to ensure a diverse and highly capable technical workforce, achieved by providing early experience in discovery through research and creation through design and by incorporating new learning theories, teaching methods, and new scientific disciplines into engineering curricula. EEC programs address interdisciplinary research, pursue systemic curriculum and workforce development issues critical to all fields of engineering, engage centralized management, and complement the research and education portfolios of other ENG divisions. 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 FY 2004, EEC will support the 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 and groups, which spin off a broad range of fundamental knowledge and new invention. The stream of advanced technologies these centers produce is carried into industry by new generations of graduating engineers, well equipped to lead technological innovation.

In FY 2002, the 16 Engineering Research Centers conducted research and developed educational materials on key technologies related to the engineering of living tissues, marine bioproducts, computer-integrated surgical systems, biotechnology, biofilms, biomaterials for implants, semiconductor manufacturing, advanced fibers and films, ultrafine particles, reconfigurable manufacturing systems, advanced semiconductor packaging, wireless integrated microsystems, subsurface sensing and imaging, integrated media systems, and power electronics. These centers bring together faculty and students from multiple disciplines and leverage industry expertise and resources to define areas of critical need.

The six 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. 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.

In FY 2002, 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 in local economic development.

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. 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 policy-makers in the development of hazard mitigation strategies for communities with earthquake risks.

EEC-funded educational innovations and human resource development programs attract students to engineering, implement new educational technologies to give students greater flexibility in how, where and when they learn, and give them the capacity to learn, lead, and innovate throughout their careers. Pre-college students and their current and future teachers are exposed to the challenges and rewards of engineering at the pre-college level and, undergraduates are given earlier and more relevant design and research experiences. Successful engineering education innovations are being disseminated to and adopted by a broad range of universities. Efforts are also directed at attracting underrepresented groups to engineering careers and increasing retention and graduation rates.

Recent graduates of the Manufacturing Engineering Program at the Greenfield Education Coalition.

The FY 2004 Budget Request for EEC is $124.28 million, an increase of $4.79 million over the FY 2003 Request. This growth, along with reallocations in the FY 2003 base, will support:

- Engineering Research Centers, increasing by $4.0 million over the FY 2003 level of $56.22 million, to a total of $60.22 million. This encompasses $1.0 million to expand nanoscale simulation network activities and $3.0 million to increase ERC award size, outreach and educational activities;

- Postdoctoral Faculty Fellowships to increase opportunities in the Engineering Professoriate, a new program funded at $3.0 million, to provide 15 promising postdocs with opportunities to enhance interdisciplinary research expertise and learning pedagogy skills needed to become outstanding new faculty and researchers;

- The Department-Level Reform of Undergraduate Engineering Education and Bridges for Engineering Education Programs, increasing by $3.0 million to a total of $9.0 million, to enable engineering departments to develop innovative curricula incorporating interdisciplinary knowledge and allow engineering schools to develop active partnerships with schools of education, for their mutual benefit;

- Funding for engineering students supported by the IGERT, GRF and GK-12 programs totals $17.42 million, increasing by $3.16 million over the FY 2003 level of $14.26 million, to allow higher stipends: and

- Centers for Learning and Teaching, increasing by $120,000 to a total of $1.12 million, to allow for planned scale-up of the activities of the Center for Learning and Teaching of Engineering.