ENGINEERING

ENGINEERING $575,900,000

The FY 2005 Budget Request for the Engineering Activity (ENG) is $575.90 million, an increase of $10.77 million, or 1.9 percent, over the FY 2004 Estimate of $565.13 million.

Engineering Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Bioengineering and Environmental Systems	49.45	51.02	49.77	-1.25	-2.5%
Chemical and Transport Systems	68.33	68.92	67.21	-1.71	-2.5%
Civil and Mechanical Systems	63.23	67.17	85.51	18.34	27.3%
Design, Manufacture & Industrial Innovation	64.00	65.81	65.88	0.07	0.1%
SBIR/STTR	90.92	103.59	104.09	0.50	0.5%
Electrical and Communications Systems	73.05	74.58	72.73	-1.85	-2.5%
Engineering Education and Centers	132.72	134.04	130.71	-3.33	-2.5%
Total, ENG[1]	$541.70	$565.13	$575.90	$10.77	1.9%

Totals may not add due to rounding.

[1] The large increase appearing in the Civil and Mechanical Systems Subactivity accommodates the Operations phase of NEES, initiating in FY 2005.

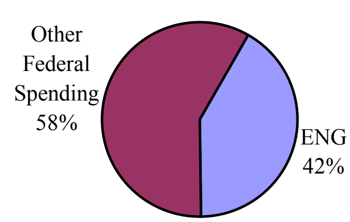
The Engineering Activity (ENG) supports fundamental research on engineering systems, devices, and materials, and their underpinning processes and methodologies. ENG investments help create the engineering workforce and technological innovation vital to the nation's economic strength, security and quality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

RELEVANCE

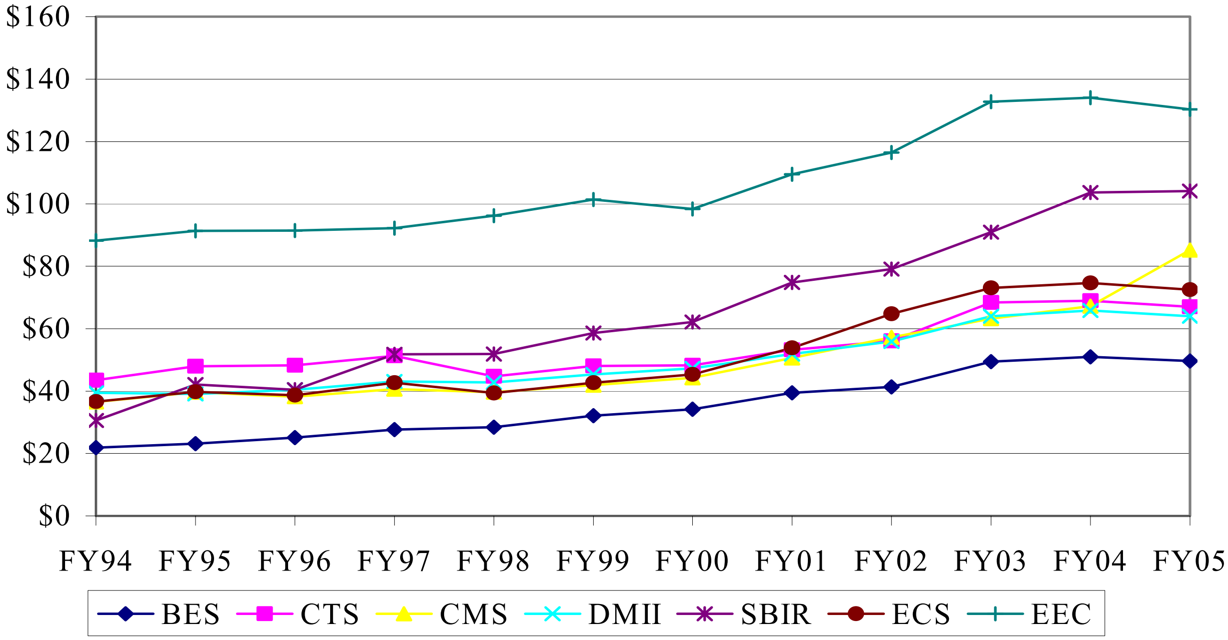
ENG is a principal source of federal funding for university-based fundamental engineering research, providing 42 percent of the total federal support in this area.

ENG promotes the progress of engineering in the United States. Its 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. A major focus of ENG investments is in emerging technologies—nanotechnology, cyberinfrastructure, network systems and biotechnology. Support for research in these areas contributes to major advances in health care, manufacturing, and national security. The Engineering Directorate leads the Foundation's efforts in the area of nanotechnology and works closely with the other NSF Activities in advancing this exciting field. Nanotechnology has the potential to enable revolutionary technologies that can advance a broad spectrum of science and engineering disciplines.

Federal Support of Basic Research in Engineering at Academic Institutions



ENG Subactivity Funding
(Dollars in Millions)



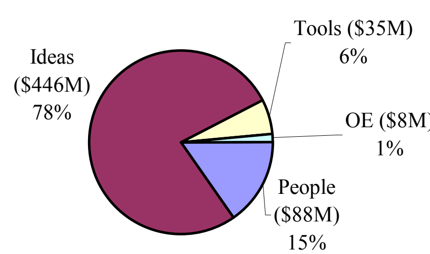
STRATEGIC GOALS

Four strategic outcome goals guide ENG activities:

- People: Activities to better attract students and to ensure the most current and highest quality engineering 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 the engineering graduates who will lead currently emerging technology areas and positions these graduates to be well prepared to push technological frontiers.

- Ideas: Advancement of fundamental engineering knowledge, including support for core research as well as the exploration of new and emerging technologies, high risk and innovative research, and expanding opportunities for discovery.

FY 2005 ENG Strategic Goals



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

- Organizational Excellence: Organizational Excellence provides for administrative activities necessary to enable NSF to achieve its mission and goals. These investments include support for

Intergovernmental Personnel Act appointments and for contractors performing administrative functions.

Funding by Strategic Goal: Summary
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Percent
People	86.72	87.78	87.96	0.18	0.2%
Ideas	443.66	458.10	445.53	-12.57	-2.7%
Tools	3.90	11.75	34.66	22.91	195.0%
OE	7.42	7.50	7.75	0.25	3.3%
Total, ENG	$541.70	$565.13	$575.90	$10.77	1.9%

PEOPLE (+$180,000, for a total of $87.96 million)

People are ENG's most important investment. Across its programs, ENG supports about 15,000 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, "*People – a diverse, competitive and globally-engaged U.S. workforce of scientists, engineers, technologists and well-prepared citizens,*" totals $87.96 million in FY 2005, an increase of $180,000 from the FY 2004 Estimate.

ENG also invests in focused human resources development and education activities that shape the next generation engineering and technological workforce, and enhance opportunities for women and minorities. Through these investments, ENG cultivates future leaders in engineering research, prepared to explore new and emerging ideas. In FY 2005, ENG supports such focused activities as Faculty Early Career Development (CAREER), Graduate Research Fellowships (GRF), Integrative Graduate Education and Research Traineeships (IGERT), and Research Experiences for Undergraduates (REU).

ENG People Investments
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Percent
Individuals	54.21	56.00	58.50	2.50	4.5%
Institutions	20.95	19.43	17.11	-2.32	-11.9%
Collaborations	11.56	12.35	12.35	0.00	0.0%
Total, ENG People	$86.72	$87.78	$87.96	0.18	0.2%

Highlights of ENG's People investment include:

INDIVIDUALS

- An increase of $2.0 million over the FY 2004 level of $7.30 million for a total of $9.30 million for the IGERT program, enabling funding for about 40 additional graduate students.

- $35.50 million in support of CAREER, an increase of $500,000 over the FY 2004 level of $35.0 million, enhancing opportunities for junior-level engineering researchers to receive support for developing activities.

<u>INSTITUTIONS</u>

- An investment level of $3.50 million for the ADVANCE program, increasing by $240,000 over the FY 2004 level. This inherently flexible funding opportunity increases academic and professional opportunities for women.
- $13.47 million, a decrease of $2.02 million from the FY 2004 level, to support the Engineering Education Reform program. This level of support, while decreasing emphasis on unsolicited proposals, continues to enable engineering departments to develop innovative curricula, incorporating interdisciplinary knowledge and allowing engineering schools to develop active partnerships with schools of education, for their mutual benefit.

<u>COLLABORATIONS</u>

- A continued investment of $3.22 million for the GK-12 program, supporting $30,000 stipends for engineering graduate students.
- Research Experience for Undergraduates (REU) Sites maintain an investment level of $7.0 million.

IDEAS (-$12.57 million, for a total of $445.53 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 selected NSF priority areas. It also provides 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. Improved 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 a 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 the 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 $93.16 million, an increase of $450,000 over the FY 2004 level of $92.71 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.

In FY 2005, ENG will provide $10.93 million, an increase of $50,000 over the FY 2004 level of $10.88 million, for the Small Business Technology Transfer (STTR) program, which partners small businesses with academic institutions to promote industrial innovation.

Total ENG support for the National Earthquake Hazards Reduction (NEHRP) program is $41.0 million, an increase of $16.0 million over the FY 2004 level of $25.0 million, including support for fundamental research that leads to more earthquake-resistant buildings and facilities. Foundation-wide, support for NEHRP in FY 2005 is about $53.0 million, including operations funding for the Network for Earthquake Engineering Simulation.

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 Ideas Investments
(Dollars in Millions)

	FY 2003	FY 2004	FY 2005	Change over FY 2004	
	Actual	Estimate	Request	Amount	Percent
Fundamental Science and Engineering	260.87	249.79	235.98	-13.81	-5.5%
Centers Programs	85.71	98.42	99.46	1.04	1.1%
Capability Enhancement	97.08	109.89	110.09	0.20	0.2%
Total, ENG Ideas	$443.66	$458.10	$445.53	-$12.57	-2.7%

FUNDAMENTAL SCIENCE AND ENGINEERING

- Funding for ENG disciplinary research is decreased by $13.81 million in FY 2005 to reallocate funds to ENG's Tools budget, to support operations of the Network for Earthquake Engineering Simulation. Highlighted areas within ENG ongoing disciplinary support include sensor technologies, core nanotechnology investments, and biotechnology.

CENTERS PROGRAMS

ENG Centers
(Dollars in Millions)

	FY 2003	FY 2004	FY 2005	Change over FY 2004	
	Actual	Estimate	Request	Amount	Percent
Engineering Research Centers	65.72	65.55	63.49	-2.06	-3.1%
Earthquake Engineering Research Centers	6.00	6.00	6.00	0.00	0.0%
Nanoscale Science & Engineering Centers	6.10	18.91	22.01	3.10	16.4%
Science and Technology Centers	7.89	7.96	7.96	0.00	0.0%
Total, Centers Support	$85.71	$98.42	$99.46	$1.04	1.1%

The FY 2005 ENG Budget Request for Centers includes:

- $63.49 million to support 19 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. Engineering Research Centers (ERCs) focus on the definition, fundamental understanding, development, and validation of the 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 current industries. ERC faculty, students and industry partners integrate discovery and learning in an interdisciplinary environment that reflects the complexities and realities of real-world technology and product development. Through their inherently broad reach, ERCs add an integrative dimension to their impact, acting as change agents for academic engineering programs and the engineering community at large. ERC innovations in research and education are expected to impact curricula at all levels from pre-college to life-long learning, to employ and reach out to a population that reflects the diversity of the United States, and to be disseminated to and beyond academic and industry partners.

- $6.0 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.

- $22.01 million to support 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, environmental science, and many other fields. These centers have strong partnerships with industry, national laboratories and international centers of excellence.

- $7.96 million to support two Science and Technology Centers (STCs): The University of Illinois' center on Advanced Materials for Water Purification, and Cornell University's STC on Nanobiotechnology.

<u>CAPABILITY ENHANCEMENT</u>

FY 2005 support includes:

- An increase of $450,000 for a total of $93.16 million for the Small Business Innovation Research (SBIR) program, and an additional $50,000 for a total of $10.93 million for the Small Business Technology Transfer (STTR) program. Recent congressional action raised the mandated agency spending target for STTR from .15 percent to .30 percent of the agency's extramural research budget in FY 2004.

- $6.0 million for Industry/University Cooperative Research Centers (I/UCRC). The I/UCRC program will support about 46 I/UCRCs. These highly leveraged centers form close-knit partnerships with their industrial members.

- No investment toward the three State Industry/University Cooperative Research Centers (S/I/UCRCs). FY 2003 marked the final year of funding for these centers.

TOOLS (+ $22.91 million, for a total of $34.66 million)

In FY 2005, ENG support for the enhancement of infrastructure to conduct engineering research is funded at $34.66 million, an increase of $22.91 million over the FY 2004 level of $11.75 million.

ENG Tools Investments
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Facilities	3.90	11.75	34.66	22.91	195.0%
Total, ENG Tools	$3.90	$11.75	$34.66	$22.91	195.0%

<u>FACILITIES</u>

- $20.0 million is invested in operations and maintenance of the George E. Brown, Jr. Network for Earthquake Engineering Simulation, which will become operational in FY 2005. NEES will transform the environment for earthquake engineering research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation at several sites distributed throughout the country to improve the seismic design and performance of U.S. civil and mechanical infrastructure systems.

- An increase of $1.41 million, for a total of $10.81 million, for the National Nanotechnology Infrastructure Network (NNIN), an integrated network of user facilities that supports infrastructure needs for research and education in the burgeoning nanoscale science and engineering field.

- An increase of $1.50 million for a total of $3.85 million for the Network for Computational Nanotechnology (NCN). The NCN increase will focus on modeling and simulation of chemical, biological and pharmaceutical systems, and will include additional network nodes that focus on these areas.

ORGANIZATIONAL EXCELLENCE (+$250,000, for a total of $7.75 million)

ENG investments in Organizational Excellence provide funding for Intergovernmental Personnel Act (IPA) appointments, the IPA's travel and the administrative contracts necessary to conduct the level of program activity. These investments complement the work of the ENG staff, bringing new ideas to the table and enabling a closer connection with the ENG scientific community and a broader range of outreach and oversight activities.

PRIORITY AREAS

In FY 2005, ENG will support research and education efforts related to five broad, Foundation-wide priority areas: Biocomplexity in the Environment, Nanoscale Science and Engineering, Mathematical Sciences, Human and Social Dynamics, and Workforce for the 21st Century.

ENG Investments in Priority Areas
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Percent
Nanoscale Science and Engineering	94.35	108.88	133.81	24.93	22.9%
Biocomplexity in the Environment	6.00	6.00	6.00	0.00	0.0%
Mathematical Sciences	0.91	2.91	2.91	0.00	0.0%
Human and Social Dynamics	N/A	2.00	2.00	0.00	0.0%
Workforce for the 21st Century	N/A	N/A	1.03	1.03	N/A

Highlights include:

The **Nanoscale Science & Engineering (NS&E)** priority area is increased by $24.93 million, for a total of $133.81 million within ENG. NSF leads the Administration's National Nanotechnology Initiative (NNI) and has primary responsibility for fundamental research, education and provision of research infrastructure. The Engineering Activity leads Nanoscale Science and Engineering within NSF and works closely with the other Activities in advancing these cutting-edge, multidisciplinary areas. With this additional investment, ENG will:

- Enhance funding rates for interdisciplinary research awards (currently below 10%) and increase award size and duration;
- Focus additional resources ($16.08 million) in fundamental research areas such as novel tools for manufacturing, nanoelectronics beyond silicon, converging technologies for enhancing human performance, and nanobiosystems;
- Invest $1.75 million in additional support toward education and societal implications through activities such as K-12 nanotechnology education networks, undergraduate education, new curricula and knowledge transfer to enhance public understanding;
- Provide a significant increase ($2.91 million) to the National Nanotechnology Infrastructure Network (NNIN) and the Network for Computational Nanotechnology (NCN); and
- Invest $3.10 million to increase support to existing Nanoscale Science & Engineering Centers (NSEC).

A maintained investment of $6.0 million will support research in the **Biocomplexity in the Environment (BE)** priority area. Funds will support activities in the Materials, Use: Science, Engineering, and Society (MUSES) program.

The **Mathematical Sciences** priority area is level-funded at $2.91 million. Support will be provided to support synergistic collaborations between mathematicians and engineering researchers to strengthen engineering modeling and experimental work and enhance undergraduate and graduate engineering education.

$2.0 million, unchanged from the FY 2004 level, will support research in the **Human and Social Dynamics** priority area. Funds will be invested in Decision Making Under Uncertainty to support studies on the security and reliability of critical infrastructure networks, and in Dynamics of 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.

Initial funding of $1.03 million is provided for the **Workforce for the 21st Century** priority area, to support integrative institutional collaborations that prepare students for the engineering workforce by leveraging, building on and integrating current programs at collaborating institutions. The collaborations are expected to serve a diverse student population, increase student access to research experiences, and incorporate evaluation of program effectiveness.

QUALITY

ENG maximizes the quality of the research it supports through the use of a competitive, merit-based review process. The percent of basic and applied research funds allocated to projects that undergo merit review was 95 percent in FY 2003, the last year for which complete data exist.

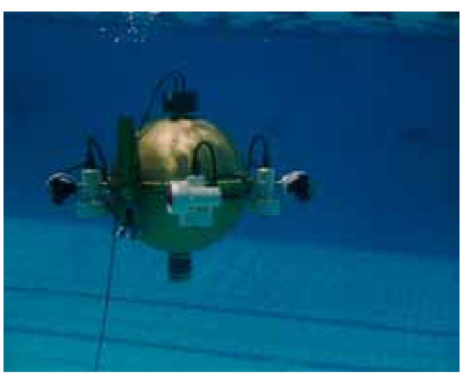
To ensure the highest quality in processing and recommending proposals for awards, ENG convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments.

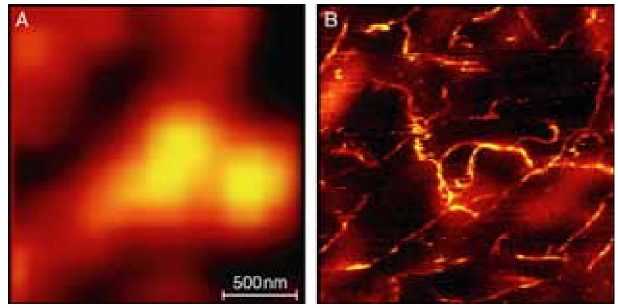
The Directorate also receives advice from the Advisory Committee for Engineering (AC/ENG) on such issues as: the mission, programs, and goals that can best serve the scientific community; how ENG can promote quality graduate and undergraduate education in the engineering sciences; and priority investment 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

ENG performance highlights include:

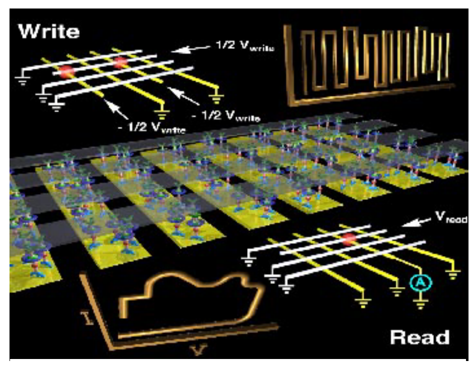
An ENG grant helped develop the **Omni-Directional Intelligent Navigator (ODIN)**, a fully autonomous underwater robot. Featured in Popular Science magazine and on the cover page of IEEE Robotics and Automation magazine, ODIN's primary research objective has been to investigate and develop intelligent control strategies for underwater robotic vehicles (URVs) with manipulator work packages. The motion of the manipulator, attached to the vehicle's main body, affects the motion of the vehicle. Most underwater robot vehicles are built like torpedoes, and cannot perform fine positioning or tracking. ODIN has omni-directional motion in three dimensions, and highly accurate positioning/tracking. The University of Girona in Spain has replicated ODIN's unique features for their vehicle, and the U.S. Coast Guard has expressed interest in this type of robot for harbor/port security.





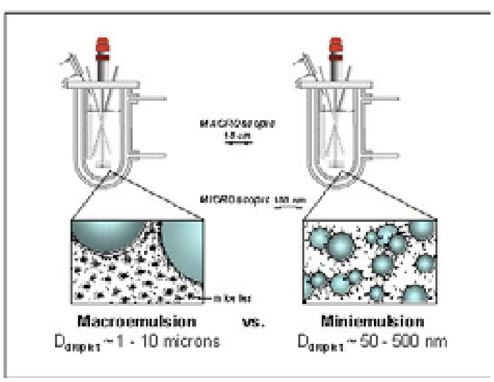
Raman scattering images of carbon nanotubes (A) using standard diffraction limited microscopy and (B) using the near-field Raman microscopy technique developed by Lukas Novotny of the University of Rochester and colleagues. *Credit: The Institute of Optics, University of Rochester*

Lukas Novotny and his University of Rochester team have created the highest-resolution optical image ever, revealing structures as small as carbon nanotubes just a few billionths of an inch across. The new method, developed with colleagues from Portland State University and Harvard University, literally sheds light on previously inaccessible chemical and structural information in samples as small as the proteins in a cell's membrane. This light-based technique, called **near-field Raman microscopy**, allows researchers to glean a great deal of visual information. With it, researchers can determine a material's composition as well as its structure. The grand vision for the project is garnering the information light provides from the proteins on a membrane, which would open the door to designer medicines that could kill harmful cells, repair damaged cells, or even identify never-before-seen strains of disease.



This image depicts a two-dimensional molecular electronic circuit. *Credit: the University of California at Los Angeles*

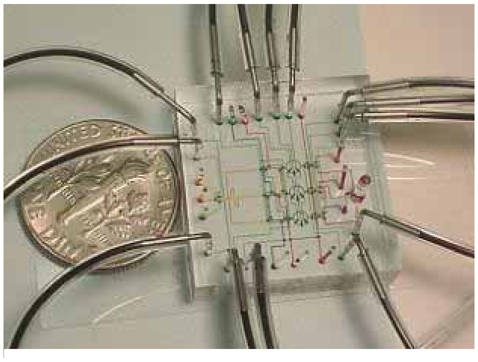
Named *Breakthrough of the Year 2001* by Science magazine, the wiring of the first ever **molecular-scale circuits** pushes the fundamental limits of trends in computing, opening the possibility of a new world of nano-electronics. Computer chips containing components at the molecular scale could accommodate billions of transistors, compared to some 40 million for today's state-of-the-art chips. As the Science article noted, "If researchers can wire these circuits into intricate computer chip architecture, this new generation of molecular electronics will undoubtedly provide computing power to launch scientific breakthroughs for decades."



Featuring small droplet size and exceptional stability, miniemulsions have many important industrial applications, such as pill coatings and encapsulation of pigments in latex paints.

Mohamed S. El-Aasser of Lehigh University has been named recipient of the American Chemical Society's *Roy W. Tess Award* in Coatings 2002 for his pioneering work in developing **miniemulsion polymerization**, a technology that has resulted in nine patents, including coatings for pharmaceutical pills and encapsulation of paint pigments.

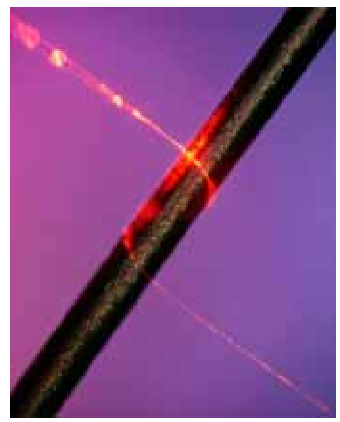
Coined by El-Aasser in 1980, the term "miniemulsions" refers to a type of oil-in-water emulsion characterized by small droplet size (50-500 nanometers) and much higher stability than conventional emulsions (with a typical droplet size of 1-10 microns, i.e., 20 times larger). El-Aasser's research has contributed to fundamental understanding of the mechanics of emulsion polymerization.



Nano-CEMMS pursues nanomanufacturing applications builds on recent advances in microfluidics, such as this integrated microfluidic circuit chip built to isolate DNA. *Credit: Stephen Quake, California Institute of Technology*

The **Center for Nano-Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS)** aims to utilize recent discoveries in nanotechnology to revolutionize the nation's nanomanufacturing capabilities. Nano-CEMMS research will target development of a vanguard commercial-scale manufacturing tool that builds devices and systems at nanometer scale (one inch contains 25.4 million nanometers). Nano-CEMMS, one of two new Nanoscale Science and Engineering Centers, addresses fundamental research barriers to commercial-scale nanomanufacturing. A collaborative effort among the University of Illinois at Urbana-Champaign, the California Institute of Technology, and North Carolina Agricultural & Technical State University (NCAT), Nano-CEMMS will build on two recent discoveries: 'nanogate' technology, and new advances in microfluidics.

Harvard University's Eric Mazur and Limin Tong (also of Zhejiang University in China), with colleagues from Tohoku University in Japan, have developed a process to create **wires only 50 nanometers (one billionth of a meter) thick**. Made from silica, the same mineral found in quartz, the wires carry light in an unusual way: these wires, thinner than the wavelengths of light they transport, serve as a guide around which light waves flow. Smaller fibers will allow devices to transmit more information using less space. The new material may have applications in ever-shrinking medical products and tiny photonics equipment such as nanoscale laser systems, and tools for communications and sensors. Size is of critical importance to sensing—with more, smaller-diameter fibers packed into the same area, sensors could detect many toxins, for example, at once and with greater precision and accuracy.



If suddenly becoming a hospital patient improves a doctor's bedside manner, then coupling engineers with the medical staff that use their products results in better instruments. The Johns Hopkins University Engineering Research Center for Computer-Integrated Surgical Systems and Technology (CISST) and its clinical collaborators proposed this in an innovative course to teach biomedical, mechanical, electrical, and computer science and engineering students the fundamental skills and operative procedures for general surgery. "Surgery for Engineers" engages students in new and exciting learning experiences, fosters relationships between engineers and clinicians, identifies and solves relevant problems with engineering principles, and enhances the undergraduate curriculum for career preparation.

Other Performance Indicators

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

Number of People Involved in ENG Activities

	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate
Senior Researchers	5,146	5,248	5,064
Other Professionals	1,489	1,519	1,466
Postdoctorates	497	507	489
Graduate Students	5,078	5,180	4,999
Undergraduate Students	2,618	2,670	2,577
Total Number of People	14,828	15,124	14,595

ENG Funding Profile

	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate
Statistics for Competitive Awards:			
Number	1,945	1,984	1,915
Funding Rate	21%	20%	19%
Statistics for Research Grants:			
Number of Research Grants	936	955	920
Funding Rate	17%	16%	15%
Median Annualized Award Size	$99,997	$100,000	$100,000
Average Annualized Award Size	$119,476	$119,500	$119,500
Average Award Duration, in years	2.9	2.9	2.9

BIOENGINEERING AND ENVIRONMENTAL SYSTEMS $49,770,000

The FY 2005 Budget Request for the Bioengineering and Environmental Systems Subactivity is $49.77 million, a decrease of $1.25 million, or 2.5 percent, below the FY 2004 Estimate of $51.02 million.

Bioengineering and Environmental Systems Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Bioengineering and Environmental Systems	49.45	51.02	49.77	-1.25	-2.5%
Total, BES	$49.45	$51.02	$49.77	-$1.25	-2.5%

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. 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.

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).

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 support for research on 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. The NSF/DARPA/NIH Biophotonics Partnership 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 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.

Above, a microplantlet of the tropical marine red alga *Ochtodes secundiramea,* about one centimeter in diameter. Greg Rorrer at Oregon State University and Don Cheney from Northeastern University used "bio-prospecting" to produce bioactive metabolites from macrophytic red algae, a class of seaweeds with potent and selective anti-tumor activities.

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 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.

Increased funding with reallocation within the BES budget request will support the Nanoscale Science and Engineering priority area. The National Nanotechnology Infrastructure Network (NNIN) totals $13.61 million, increasing by $3.25 million over the FY 2004 level of $10.36 million. Continuing emphases will include detection of and protection from biological and chemical agents critical to homeland security, general environmental nanotechnology, and nanobiotechnology.

CHEMICAL AND TRANSPORT SYSTEMS $67,210,000

The FY 2005 Budget Request for the Chemical and Transport Systems Subactivity is $67.21 million, a decrease of $1.71 million, or 2.5 percent, below the FY 2004 Estimate of $68.92 million.

Chemical and Transport Systems Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Chemical and Transport Systems	68.33	68.92	67.21	-1.71	-2.5%
Total, CTS	$68.33	$68.92	$67.21	-$1.71	-2.5%

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 a reallocation of funds within the four core research areas to support high-potential proposals, the FY 2005 Request includes funding in the following key areas:

Nanoscale Science and Engineering: NSE support totals $32.66 million, an increase of $8.76 million over the FY 2004 level of $23.90 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. In order to accelerate the benefits from increased investments in fundamental research on these topics, CTS will allocate funds for infrastructure investment to address issues that deal with scale-up of the synthesis processes, development of new instrumentation, and refined methods for characterization.

Environmental Technologies: CTS will continue support of environmentally relevant technologies, primarily projects aimed at pollution prevention and containment of greenhouse gases. Research leading to products and processes that avoid negative environmental impact will 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. These topics are strongly embedded in the core of CTS programs. CTS programs participate in the MUSES component of the Biocomplexity in the Environment (BE) priority area, which involves development of new materials, instrumentation and processes. The funding of the Science and Technology Center (STC) on New Materials for Water Purification, a topic that has direct relevance to several of the CTS program areas, is included in the CTS budget.

A laboratory scale reactor system consisting of an anaerobic digester with an external tubular ultrafiltration membrane.

Sensor Technologies: Funding for sensor technologies totals $6.0 million, unchanged from FY 2004. 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.

CIVIL AND MECHANICAL SYSTEMS $85,510,000

The FY 2005 Budget Request for the Civil and Mechanical Systems Subactivity is $85.51 million, an increase of $18.34 million, or 27.3 percent, above the FY 2004 Estimate of $67.17 million.

Civil and Mechanical Systems Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Civil and Mechanical Systems	63.23	67.17	85.51	18.34	27.3%
Total, CMS	$63.23	$67.17	$85.51	$18.34	27.3%

The Civil and Mechanical Systems (CMS) Subactivity has two major goals: to support research and workforce development that provides the fundamental and quantitative basis for civil and mechanical systems and the built environment, and to support the rapid development and deployment of new knowledge and technology for the public 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 information technology to enhance reliability and performance of critical infrastructure systems. The CMS mission is to improve understanding and design of materials and structures across all physical scales, from nano-level to mega-system integration-level. CMS research activities include integrated modeling and experiments to enhance the fundamental understanding of complex structures and systems, including nonlinear dynamic behaviors and processes. The linkage between physical model experimentation and computational model simulation demands development of the sensor technologies necessary for measurement and observation of fundamental processes. New sensors are also needed for "smart" civil and mechanical systems and for application of 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.

In addition, recent events have brought focus on the nation's increasingly interdependent, complex and vulnerable human, social, natural and physical systems. The nation needs better databases and tools for prediction, risk, decisions and uncertainty, and CMS pursues cross-directorate and interagency partnerships that provide 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 U.S. or abroad. Interdisciplinary and international studies involving hazard assessment, response, societal and economic impacts, and decision sciences are supported in coordination with the Geosciences and the Social, Behavioral, and Economic Sciences Activities of NSF.

The $18.34 million increase in the CMS budget will be combined with $6.24 million from core funding reallocations to support expanded research in the following areas:

Nanoscale Science and Engineering: Increases by $4.27 million over the FY 2004 level will support integrated design and simulation of the behavior of nanomaterials and nanostructures. Such research is

Laser scan of construction site contains high resolution 3-D "map" of excavation

needed for the development of new technologies for use in civil and mechanical systems, and for understanding long-term performance and durability of new materials in new applications and extreme environments. The 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.

NEES Operations and Grand Challenge Research: The remaining $20.0 million, together with additional core reallocations, will support the operations and research of the Network for Earthquake Engineering Simulation (NEES). The construction of NEES, funded during FYs 2000-2004 within the Major Research Equipment and Facilities Construction (MREFC) Account, will be completed by October 2004. NEES is a project to construct, upgrade, and network an innovative system of geographically distributed test facilities in earthquake engineering. NEES system integration is accomplished via NEESgrid, which utilizes innovative grid computing technologies. NEES also promotes international collaborations for earthquake engineering research, as well as education and outreach opportunities.

Nine-meter centrifuge at the Center for Geotechnical Modeling at UC Davis, a host facility in the Network for Earthquake Engineering Simulation, funded by the National Science Foundation.

The non-profit NEES Consortium, Inc. has been established 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.

CMS plans to use $9.0 million to support research in multi-hazard engineering involving experimental and theoretical simulations at the NEES facilities. NEES research will enable important new research challenges in earthquake engineering to be addressed. These are described in the recent National Research Council study entitled *Preventing Earthquake Disasters; The Grand Challenge in Earthquake Engineering*, National Academies Press, 2003. The CMS research focus is on basic research aimed at developing new technologies and design tools needed to identify and communicate infrastructure system vulnerabilities under risk of extreme events.

DESIGN, MANUFACTURE, AND INDUSTRIAL INNOVATION — $169,970,000

The FY 2005 Budget Request for the Design, Manufacture, and Industrial Innovation Subactivity is $169.97 million, an increase of $570,000, or 0.3 percent, over the FY 2004 Estimate of $169.40 million.

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Design, Manufacture and Industrial Innovation	64.00	65.81	65.88	0.07	0.1%
SBIR/STTR	90.92	103.59	104.09	0.50	0.5%
Total, DMII	$154.92	$169.40	$169.97	$0.57	0.3%

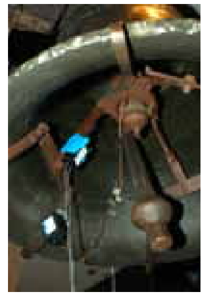
The Design, Manufacture, and Industrial Innovation (DMII) Subactivity supports academic research and education for discovery and innovation in new enterprises, and enhances productivity and global competitiveness in a broad range of U.S. industries. Supporting the development of a diverse human resource base and education of an adaptable and knowledge-enabled workforce complements this vital role in promoting U.S. global competitiveness. The core DMII programs in engineering design, operations research, manufacturing enterprise systems, service enterprise engineering, nanomanufacturing, materials processing and manufacture, and manufacturing machines and equipment, support the discoveries and major advances that create the nation's 21st century manufacturing enterprises. In FY 2005, DMII plans to continue exploring and investing in sustainable environmentally benign design and manufacture systems, engineered service systems for health care delivery, and additive hybrid processes that will be needed for micro and nanoscale products.

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. While nanoscience is uncovering novel physical, mechanical, electrical, magnetic, chemical and biological properties and materials, a range of manufacturing discoveries and innovations are needed to design the systems and processes to deliver these 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 bring to fruition many exciting opportunities opened by nanotechnology. Nanomanufacturing is the focal point of DMII's investment in NSE, as well as knowledge gained within all the fields supported in DMII.

DMII supports the Materials Use: Science, Engineering, and Society (MUSES) program, 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. BE's Collaborative Large-scale Engineering Assessment Network for Environmental Research 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 also supports the Mathematical Sciences priority area, which offers multidisciplinary opportunities for advances in distributed sensors systems, scalable manufacturing enterprise systems, managing and modeling uncertainty in complex systems, and new modeling techniques that predict processing behavior and product performance on scales ranging from the molecular to the macro. DMII's engineering design program has established a foundation of knowledge on design decisions under uncertainty, for which the mathematics priority area expands, and addresses issues from product design to manufacturing enterprise system protection to decrease the vulnerability of this part of the national infrastructure.

Major components of DMII activity include the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs that provide support to small businesses for research in advanced materials and manufacturing, biotechnology, electronics and information technology. With a goal of converting scientific discoveries to innovations for the benefit of society, these programs play a critical role in complementing NSF investments in discovery and learning. The result: today, more scientists and engineers are employed in high technology small businesses than in large businesses. The Small Business Innovation Research (SBIR) Program and the Small Business Technology Transfer (STTR) Program increase by $500,000 in FY 2005, to $104.09 million.



A close-up view of the spider, a structural brace that helps the Liberty Bell support its own weight. Also visible is the wireless transmitter that conveys the signals from the sensors on the crack to the computer that is recording the stresses (black box on top in blue tape) and a MicroStrain G-link sensor that detects rocking motion (black box near lip of Bell).

DMII promotes partnerships between industry and university through both the Grant Opportunities for Academic Liaison with Industry (GOALI) program and the STTR program. DMII, in collaboration with the Social, Behavioral and Economic Sciences (SBE) Activity, expects to continue supporting research in understanding of the innovation process through the Innovation and Organizational Change (IOC) program, but at a reduced level.

Retrospective assessments have found that DMII grants have resulted in fundamental contributions either to the creation of new research fields or seminal knowledge in design, manufacturing, and service, the knowledge resource for 21st Century enterprises. These studies have also documented the long-term 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, the establishment of supply chain management as a research field, and integrated solid modeling systems that carry the data and knowledge of today's global enterprises.

By reallocating base funds, investments in FY 2005 will include an increase of $4.19 million for the Nanoscale Science and Engineering priority area. This will enable:

- Research on nanomanufacturing, covering three dimensional nano-feature enhancement in micro/meso products and devices, nano-assembly and connectivity, nano-process control and nano-system integration;
- Support for the National Nanotechnology Infrastructure Network to ensure a full array of interconnected resources to address synthesis and scale-up of nano-sized materials and structures into functional devices, architectures and integrated systems across dimensional scales, leading eventually to useful products and services; and
- Continued support of research on improving human physical and mental abilities through the integration of nanotechnology, biotechnology, information technology and cognitive science, as well as a new generation of tools and processes to achieve this goal.

ELECTRICAL AND COMMUNICATIONS SYSTEMS $72,730,000

The FY 2005 Budget Request for the Electrical and Communications Systems Subactivity is $72.73 million, a decrease of $1.85 million, or 2.5 percent, from the FY 2004 Estimate of $74.58 million.

Electrical and Communications Systems Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Electrical and Communications Systems	73.05	74.58	72.73	-1.85	-2.5%
Total, ECS	$73.05	$74.58	$72.73	-$1.85	-2.5%

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 through support of 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 application. 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 Complementary 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 that 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. ECS provides coordination for the foundation wide Sensors solicitation.

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 management support for specialized resources and infrastructure that facilitate research and educational activities, such as the National Nanotechnology Infrastructure Network (NNIN), and NSF oversight for the Science and Technology Center on Nanobiotechnology at Cornell University, Engineering Research Centers at the University of Michigan, Johns Hopkins University and Colorado State University. ECS also actively participates in the development and management of cross-disciplinary programs, industry-related programs and graduate traineeship programs, and provides significant support to the Nanoscale Science and Engineering priority area.

ECS holds a number of grantee 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. This past year, ECS convened a workshop for 42 heads of Electrical and Computer Engineering departments on strategies for recruiting and retaining women and minority faculty.

Recent achievements of ECS grantees include:

- Adaptive CMOS: from biological inspiration to system on a chip - starting from a CAREER PECASE award, this technology has lead to the formation of a new $30.0 million venture company, Impinj, with production rights assigned to National Semiconductor and Asahi Kasei. The ECS grantee's doctoral research was also funded by an NSF ERC grant and the doctoral advisor, a National Medal of Technology recipient, is a cofounder of the new venture.

- An FY 2003 ECS grant has resulted in the development of the first anthropomorphic robot that can walk and run with actuated knees and torso. Potential applications are to rehabilitation and design of prosthetics.

- New sensors based on Electrical Impedance Tomography have been developed for *in situ* imaging of silicon wafer surfaces during manufacturing processes. The technique also has applications for inexpensive approaches to biomedical *in vivo* imaging.

- In January 2004, the Cornell Nanobiotechnology Center's "It's a Nano World" exhibit will be viewed by several hundred thousand visitors at Disney's Epcot Center. NSF is also supporting an external evaluation of the public's reaction to the exhibit in the theme park setting as compared to a more traditional science museum.

- An ECS award for research on Extreme Ultraviolet (EUV) photonics has resulted in the development of compact, table-top, coherent light sources from 80eV to ≈ 1keV. Coherent light sources in this region of the spectrum have exciting applications in EUV imaging, spectroscopy, lithography, and microscopy.

Some of the special research foci funded by ECS are in Organic Electronics and Photonics, co-funded with other ENG divisions and DARPA.

Reallocation within core areas encompasses funding of $36.41 million, an additional $4.74 million over the FY 2004 Estimate of $31.67 million, to support Nanoscale Science and Engineering research on manipulation of nanostructures, and modeling and simulation of new device architectures and systems. ECS has invested an additional $1.0 million towards funding of Nanoscale Exploratory Research (NER) proposals that address challenges to CMOS technology. Increased investments will also support the new NNIN for shared instrumentation facilities for nanoscale research, characterization and nanomanufacturing.

ENGINEERING EDUCATION AND CENTERS $130,710,000

The FY 2005 Budget Request for the Engineering Education and Centers Subactivity is $130.71 million, a decrease of $3.33 million, or 2.5 percent, from the FY 2004 Estimate of $134.04 million.

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change over FY 2004 Amount	Change over FY 2004 Percent
Engineering Education and Centers	$132.72	$134.04	$130.71	-$3.33	-2.5%
Total, EEC	$132.72	$134.04	$130.71	-$3.33	-2.5%

The Engineering Education and Centers (EEC) Subactivity supports the efforts of U.S. engineering schools, in partnership with government and the private sector, to adapt the engineering education and research enterprise to technological, economic, and social change. This evolution is required to ensure a diverse and highly capable technical workforce, provided by giving students early experience in discovery through research, fabrication and design, and by incorporating new learning theories, teaching methods, and new scientific disciplines into engineering curricula. EEC programs address interdisciplinary research, systemic curriculum and workforce development issues critical to all engineering, 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.

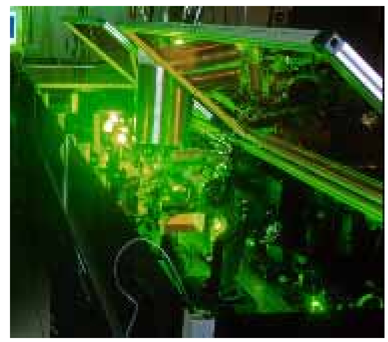
In FY 2005, EEC will provide support for Engineering Research Centers (ERC), Nanoscale Science and Engineering Centers (NSEC), Earthquake Engineering Research Centers (EERC) and Industry/University Cooperative Research Centers (I/UCRC). Industry and universities develop long-term, interdisciplinary partnerships in NSF-supported centers and groups, which spin off a broad range of fundamental knowledge and new invention. The stream of advanced technologies emanating from the centers is carried into industry by new generations of graduating engineers who have learned the skills needed to be effective leaders in technology innovation.

In 2003, 15 ongoing and four newly established Engineering Research Centers conducted 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, systems for detection of severe storms, computer-integrated surgical systems, biotechnology, biofilms, biomaterials for implants, advanced biocatalysts, 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 pre-college to the graduate level designed to develop a highly skilled workforce and advance pre-college training and the public understanding of science and engineering.

In FY 2003, 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 develop innovative 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.



The new Extreme Ultraviolet Engineering Research Center brings together researchers from Colorado State University, the University of Colorado, the University of California, Berkeley and industry partners to develop short wavelength laser light sources that can be used to create advanced nanotechnologies, including the smallest, most powerful computer circuits ever developed.

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. Experiments are being conducted to expose pre-college students and their current and future teachers to the challenges and rewards of engineering at the pre-college level and give undergraduates 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.

The FY 2005 Budget Request for EEC is $130.71 million, a decrease of $3.33 million from FY 2004. To accommodate this decrease, some reallocations in the FY 2004 base include:

- Engineering Research Centers, reduced by $2.06 million from the FY 2004 level of $65.55 million, to $63.49 million. $3.10 million have been reallocated to expand nanoscale funding activities;
- Funding for engineering students supported by the IGERT, GRF and GK-12 programs, totaling $19.42 million, an increase of $2.0 million over the FY 2004 level of $17.42 million; and
- A new investment of $1.03 million in the Workforce for the 21st Century priority area, enabling institutions with a proven track record of innovation to encourage U.S. citizens to complete advanced engineering degrees.