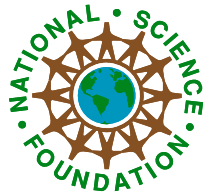
DIVISION PLAN

ELECTRICAL, COMMUNICATIONS AND CYBER SYSTEMS



February 28, 2008

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Preface

The Division of Electrical, Communications and Cyber Systems (ECCS) addresses fundamental research issues underlying device and component technologies, power and energy, controls, computation, networks, communications and cyber technologies. ECCS supports the integration and networking of intelligent systems principles at the nano, micro, and macro scales for a variety of application domains in healthcare, environment, disaster mitigation, homeland security, telecommunications, transportation, manufacturing, and other systems-related areas. ECCS envisions a research community that will address major technological challenges for the next generation of devices, systems and networks due to convergence of technologies and increased emphasis on interdisciplinary research to achieve the goals of the NSF Strategic Plan: Investing in America's Future, and the American Competitiveness Initiative to lead the world in innovation.

ECCS has a goal to integrate education into its research programs to ensure the preparation of a diverse workforce for the 21st Century that can enable innovative advances in emerging technologies as drivers of the global economy. This vision is encouraged and strengthened by the America COMPETES Act, the National Academy of Engineering reports on the Engineer of 2020, and Educating the Engineer of 2020 that foresees a "bewildering array of new technologies" confronting an engineering profession that must be educated in research, design and development, as well as possessing the attributes of strong analytical skills, creativity, ingenuity, professionalism, and leadership.

DIVISION PLAN

ELECTRICAL, COMMUNICATIONS AND CYBER SYSTEMS DIVISION

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I. MISSION, VISION, GOALS and STRATEGIES

The mission, vision, goals and strategies of the Electrical, Communications and Cyber Systems (ECCS) Division are as follows:

Mission

The ECCS mission is to:

- Address fundamental research issues underlying component and device technologies, power and energy, controls, computation, networks, communications and cyber technologies;
- Support integration and networking of intelligent systems principles at the nano, micro, and macro scales for a variety of application domains; and
- Ensure education of a diverse workforce prepared to continue rapid development of emerging technologies as drivers of the global economy.

Vision

ECCS envisions a research community that will address major technological challenges for next generation devices, systems, and networks due to the convergence of technologies and increased emphasis on interdisciplinary research, and that will prepare a future workforce to meet the emerging technological challenges of the 21st Century.

Goals

The ECCS Mission and Vision will be realized through a broad set of goals and strategies. ECCS invests in discovery, learning, research infrastructure and stewardship, in the pursuit of organizational excellence consistent with the goals of the Directorate for Engineering (ENG) at the National Science Foundation (NSF), and of the American Competitiveness Initiative to lead the world in innovation.

ECCS goals include:

- Invest in transformative research;
- Promote innovative, high-risk, high-payoff ideas at the forefront of technologies;
- Increase partnerships within NSF and with other federal agencies;
- Foster outreach to universities, industries, nonprofit organizations and professional societies;
- Increase cooperative activities among academia, industry and national laboratories;
- Enhance diversity within ECCS staff, researchers and reviewers;
- Professional development of ECCS staff;
- Improve organizational excellence through e-jacket processing;
- Promote Integration of education into research programs; and
- Ensure a diverse workforce in the 21st Century that will continue innovative advances for the rapid development of emerging technologies in the electrical engineering disciplines.

These goals are encouraged and strengthened by the NSF Strategic Plan FY 2006-2011, the American Competitiveness Initiative, the America COMPETES Act, the Innovative America National Innovation Initiative, and the National Academies' reports on Rising Above the Gathering Storm, Assessing the Capacity of the U.S. Engineering Research Enterprise, the Engineer of 2020, and Educating the Engineer of 2020.

Strategies

The ECCS goals will be achieved through a set of strategies consistent with current and future NSF priorities, Foundation-wide programs and ENG themes.

(a) Research Areas

The strategic development of ECCS programs in research and education will support current NSF priorities in nanoscale science and engineering, human and social dynamics, cyberinfrastructure, networking and information technology, climate change, and sensors-related research, as well as future priorities in cyber-enabled discovery and innovation, science and engineering beyond Moore's law, adaptive systems technology, and dynamics of water processes in the environment; and ENG themes in cognitive engineering: intersection of engineering and cognitive sciences, competitive manufacturing and service enterprises, complexity in engineered and natural systems, energy, water and the environment, and systems nanotechnology. ECCS will continue to strengthen its programs through linkages to other areas of engineering, science, industry and government.

Consistent with the goals of NSF, the Engineering Directorate and the American Competitiveness Initiative, ECCS reorganized its structure and programs. The reorganization of the ECCS Division has involved program-restructuring, reassignment of program director positions, renaming of programs consistent with the thrust areas of the Division and research themes of the Engineering Directorate, and reorganization of reporting structure of support staff to increase the overall productivity, effectiveness and efficiency of the Division. As a result of this reorganization, ECCS is well positioned to address the broad technological challenges of the future.

ECCS has identified key technology areas as micro and nano systems, hybrid communications systems and cyber systems for substantial growth and development in the future. In addition, ECCS will place increased emphasis on emerging areas, such as nanoelectronics, nanophotonics and nanomagnetics; flexible electronics; diagnostic, wearable and implantable devices and systems; quantum and molecular modeling and simulation of devices and systems; 3D photonics: very large-scale photonic integration; neuromorphic engineering; interdependencies of critical infrastructure in power and communications; and alternate energy sources: generation and integration in the national grid (InterGrid). The anticipated emphasis in emerging technologies will require a delicate balance between the maintenance of currently funded technical areas and the growth of emerging areas to ensure continuity within the ECCS community. Funds will be set aside from FY 2008 - 2010 to support research programs in these areas.

(b) Program Investments

ECCS will provide support for specialized resources and infrastructure that facilitate research and educational activities, including the National Nanotechnology Infrastructure Network

(NNIN), Science and Technology Centers (STC), Engineering Research Centers (ERC), Nanoscale Science and Engineering Centers (NSEC), Nanoscale Science Engineering and Education (NSEE) Centers, and Photonics Technology Access Program (PTAP), as well as other crosscutting activities. ECCS will continue to support people through Foundation-wide programs, such as Faculty Early Career Development (CAREER), Major Research Instrumentation (MRI), and ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers. ECCS will strengthen and enhance support for the Research Experiences for Undergraduates (REU), and Research Experiences for Teachers (RET) by 2 to 4% per year from FY 2007, and will remain committed to developing new programs, including summer programs that assist students and teachers in K-12 with knowledge, education and training. ECCS will continue to participate actively in the development and management of interdisciplinary and crosscutting programs.

To promote the American Competitiveness Initiative to lead the world in innovation, ECCS will continue to place emphasis on industrial collaborations through the Grant Opportunities for Academic Liaison with Industry (GOALI) program. ECCS's investment in GOALI increased by 45% to a total of $1.45M in FY 2005, 55% to a total of $1.55M in FY 2006, and 144% to a total of $2.44M in FY 2007 from $1M in FY 2004. ECCS plans to continue to increase this level of investment in the future. ECCS also encourages international collaborations, including support for International Research and Education in Engineering (IREE) supplements.

Within the scope of transformative research and interdisciplinary technical themes, the ECCS Division will place special emphasis on the identification of high-risk and high-payoff projects in science and engineering through Small Grants for Exploratory Research (SGER), which are a very effective mechanism for this purpose. ECCS's investment in SGER has increased 65% to a total of $1.15M in FY 2005, 96% to a total of $1.36M in FY 2006, and 92% to a total of $1.33M in FY 2007 from $690K in FY 2004. ECCS plans to maintain its FY 2007 level of funding in FY 2008, and expects to increase its level of investment between 5 to 10% per year in the future. Program Directors will be encouraged to seek SGER opportunities, and Division Director's funds will be made available as an incentive for these awards. Group discussions among Program Directors of candidate SGER awards are particularly fruitful in identifying transformative research concepts and high-payoff investments.

(c) Grantees' Workshops

ECCS holds Grantees' Workshops to evaluate research and education outcomes of program investments; to broaden diversity participation; to promote collaborations with minority serving institutions, small colleges, and undergraduate institutions; to encourage collaboration among grantees; and to identify future directions for ECCS programs. ECCS held its FY 2006 Grantees' Workshop to enhance diversity participation at Tuskegee University, Alabama, a minority serving institution; FY 2007 Grantees' Workshop at the University of Nevada, Reno, since statistical analysis revealed that there have been no prior ECCS investments in the State of Nevada; and plans to hold the FY 2008 Grantees' Workshop in North Dakota in August, 2008. Future Grantees' Meetings will be organized on similar concepts to broaden diversity and participation and to promote outreach. ECCS will continue to encourage its grantees to submit highlights of their research to NSF for publication as soon as they become available. ECCS will continue the funding of workshops to advance the frontiers of technology and curriculum development programs in key technical areas to enhance integration of research with education.

(d) Diversity and Outreach Activities

In promoting diversity, ECCS's investment in underrepresented groups has increased 38% to a

total of $4.15M in FY 2005, 37% to a total of $4.13M in FY 2006, and 122% to a total of $6.70M in FY 2007 over FY 2004, and ECCS plans to support similar levels of investment in the future. In FY 2007, the Division had $7.96M investment in EPSCoR (Experimental Program to Stimulate Competitive Research) states and will seek to double this investment by FY 2012.

ECCS also broadens participation through the selection of diverse reviewers from university, industry, and government. In ECCS, the pool of highly qualified reviewer's classifications included: male, female, first-time panelist, current PI, former PI, Caucasian, Asian, African American, Hispanic, American Indian, Historically Black Colleges and Universities (HBCU), Hispanic Association of Colleges and Universities (HACU), Industry and Government. In FY 2006, first-time reviewers increased by 54%, over FY 2005, while in FY 2007, the number of first-time panelists further increased by 18%, over FY 2006. In FY 2007, ECCS succeeded in increasing diversity in the reviewer pool over FY 2006. The diversity of reviewers increased by 226% and 30%, respectively, from HBCU and HACU institutions and 550% from government agencies. In overall Division panels, 16% were female panelists in FY 2007.

ECCS has continued to place emphasis on broadening participation of underrepresented Ph.D. students majoring in electrical engineering in its core programs through Graduate Research Supplements (GRS). In FY 2005 ECCS in collaboration with CBET initiated GRS, and invested in 5 supplements in 2005, 13 supplements in 2006, and 16 supplements in 2007, to broaden diversity participation. In FY 2008, ECCS plans to emphasize diversity by supporting additional supplements for graduate students through GRS at a similar level as FY 2007.

In FY 2006, to explore new concepts beyond Moore's Law, i.e. beyond the scaling limits of CMOS (Complementary Metal Oxide Semiconductor) technology, ECCS in collaboration with other Engineering Divisions, NSF Directorates and the Semiconductor Industry Association (SIA), initiated supplements for Graduate Students and Postdoctoral Fellows to NSF Centers in nanoelectronics, and plan to continue this effort for the next several years.

ECCS is addressing trends in funding rates in conjunction with grant size due to increased proposal activity and limited availability of funds, and is taking steps to redress the imbalance between committed NSF and ENG priority areas funds and ECCS core program funds for FY 2008. ECCS will continue to formulate Divisional Strategies consistent with NSF goals with an eye toward the aspirations of the NSF Strategic Plan and the American Competitiveness Initiative in the future.

II. ECCS PROGRAM STRUCTURE

The ECCS Division is organized around the following three programs that focus on research and educational issues of device and component technologies, network and computational technologies, and systems engineering:

(1) Electronics, Photonics and Device Technologies (EPDT)
(2) Power, Controls and Adaptive Networks (PCAN)
(3) Integrative, Hybrid and Complex Systems (IHCS)

Figure 1 lists the technology thrust areas within each program.

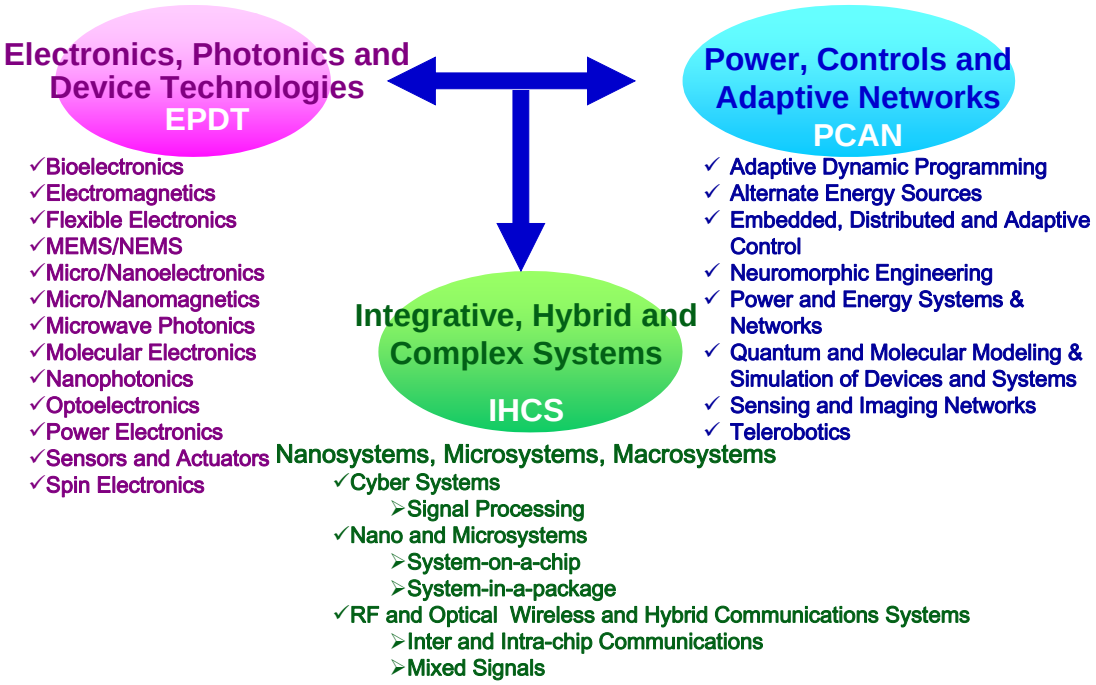

Figure 1. ECCS Programs.

The **EPDT** program will seek to improve the fundamental understanding of devices and components based on the principles of micro and nano electronics, photonics, magnetics, organics, electro-optics, electromechanics, electromagnetics, and related physical phenomena. The program will enable discovery and innovation in advancing the frontiers of spin electronics, molecular electronics, bioelectronics, nonsilicon electronics, flexible electronics, optoelectronics, microwave photonics, micro/nano-electromechanical systems (MEMS/NEMS), sensors and actuators, power electronics, and mixed signal devices. EPDT will further support related topics in quantum engineering and novel electromagnetic materials-based high frequency device solutions, radio frequency (RF) integrated circuits, and reconfigurable antennas needed for communications, telemedicine, and other wireless applications. The program will continue cooperative efforts with the semiconductor industry on new nanoelectronics concepts beyond the scaling limits of silicon technology. EPDT will provide additional emphasis on emerging areas of diagnostic, wearable and implantable devices, and will continue its support for manipulation and measurement with nanoscale precision through new approaches to extreme ultraviolet metrology.

The **PCAN** program will invest in the design and analysis of intelligent and adaptive engineering networks, including sensing, imaging, controls, and computational technologies for a variety of application domains. The program will support distributed control of multi-agent systems with embedded computation for sensor and adaptive networks. PCAN will further invest in adaptive dynamic programming, brain-like networked architectures performing real-time learning, neuromorphic engineering, telerobotics, and systems theory. PCAN will place emphasis on electric power networks and grids, including generation, transmission and integration of renewable, sustainable and distributed energy systems, such as fuel cells and micro-turbines in large power networks; high power electronics and drives; and understanding of associated regulatory and economic structures. The program will also place emphasis on energy scavenging and alternative energy technologies, including solar cells, ocean waves, wind, geothermal, low-head hydro, and the hydrogen economy. In addition, the program will support innovative test beds, and laboratory and curriculum development to integrate research and education. PCAN will provide additional emphasis on emerging areas, such as quantum and molecular modeling and simulation of devices and systems, alternate energy sources: generation and integration in the National Grid (InterGrid), and interdependencies of critical infrastructure in power and communications.

The **IHCS** program is intended to spur visionary systems-oriented activities in collaborative research and education environments for multidisciplinary integrative activities. IHCS will support innovative research in micro and nano systems, communication systems, and cyber systems that integrate physical devices and components with computational intelligence and networks. The goal is to design, develop and implement new nano/micro/macro complex and hybrid systems with engineering solutions for a variety of domain-specific applications in healthcare, environment, communications, disaster mitigation, homeland security, transportation, manufacturing, and other systems-related areas. IHCS will also support integration technologies at both the intra-and inter-chip levels that target new and advanced radio frequency (RF), millimeter wave and optical wireless and hybrid communication systems architectures as well as sensing and imaging at terahertz frequencies. IHCS is committed to support the development of innovative hardware, signal processing and software architectures for emerging areas of cyber systems for design, integration and implementation of multi-scale and multi-level complex systems that will enable visualizing, analyzing and reconfiguring of emergent behavior for various applications. Some examples include system-in-a-package; system-on-a-chip; wireless networks of handheld or wearable computing devices; distributed networks with dynamic allocation of bandwidth and efficient seamless data transference; intra- and inter-chip networking and communications; integrated hybrid optical and electronic systems for high-performance computation and communications; distributed sensing and actuation for telemedicine; ambient intelligence for homes and workplaces of the future; and robust electric power grids integrating power, communication and self-organizing networks. IHCS will offer new challenges, at all levels of systems integration, to address future societal needs.

Proposals in ECCS programs may involve collaborative research to capture the breadth of expertise needed for multidisciplinary integrative activities. ECCS will consider supporting a limited number of small team proposals of three or more Investigators from different disciplines and/or universities.

Submission Windows for Unsolicited Proposals

ECCS has two submission windows for unsolicited proposals: September 7 - October 7; and January 7 - February 7.

III. PROGRAM MANAGEMENT

ECCS is staffed with ten Program Directors, Senior Engineering Advisor, Division Director, two Science Assistants and a support staff of eight, as shown in Figures 2 and 3. The ECCS team includes:

Program Staff

- Usha Varshney, Division Director, NSF Career Staff
- Lawrence Goldberg, Senior Engineering Advisor, NSF Career Staff
- Radhakisan Baheti, Program Director, NSF Career Staff
- Pradeep Fulay, IPA, University of Pittsburgh
- Yogesh Gianchandani, IPA, University of Michigan
- Eric Johnson, IPA, University of North Carolina
- Rajinder Khosla, Program Director, NSF Career Staff
- Scott Midkiff, IPA, Virginia Polytechnic Institute and State University
- Dagmar Niebur, IPA, Drexel University
- Paul Werbos, Program Director, NSF Career Staff
- Vacant (2), Program Directors
- Graham Giovanetti, Science Assistant
- Calvin Zulick, Science Assistant

Support Staff

- Alicia Harris, Program Support Manager
- Vacant, Operations Specialist
- Cassandra Queen, Secretary to Division Director
- Delores Plater, Program Specialist
- Tyffani Smith, Senior Program Assistant
- Angelo Horton, Senior Program Assistant
- Pamela Sumpter, Senior Program Assistant
- Omar Ahmed, STEP Student

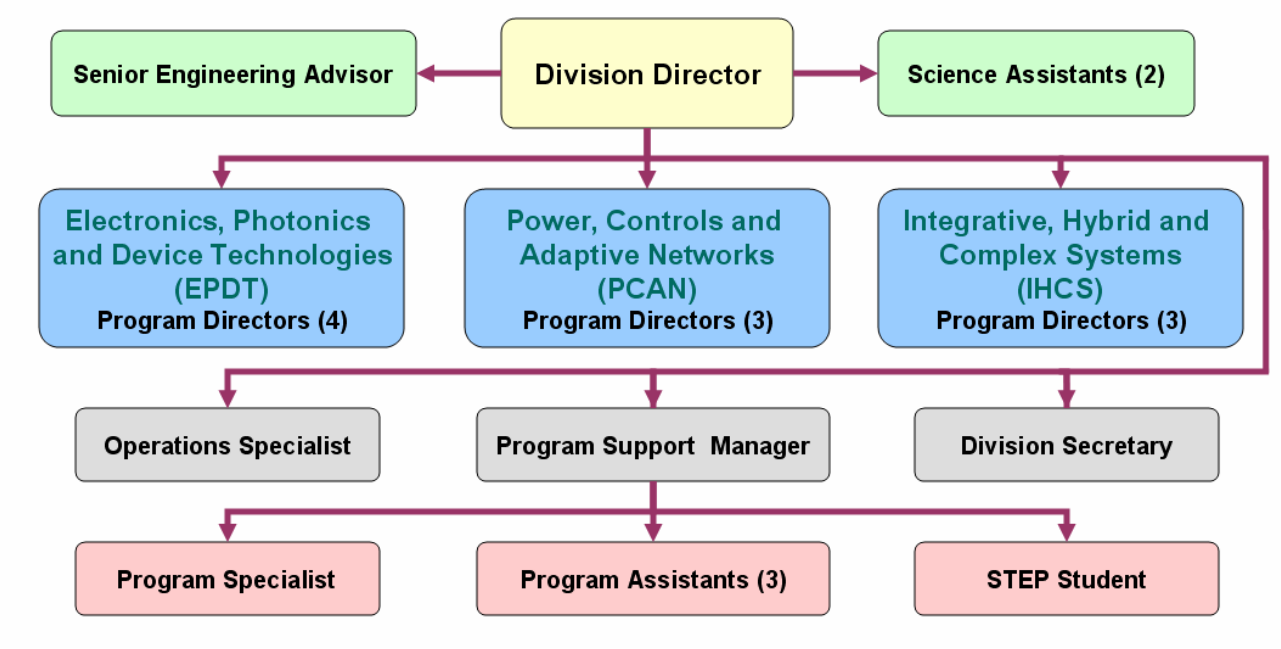

Figure 2. ECCS Organization Structure.

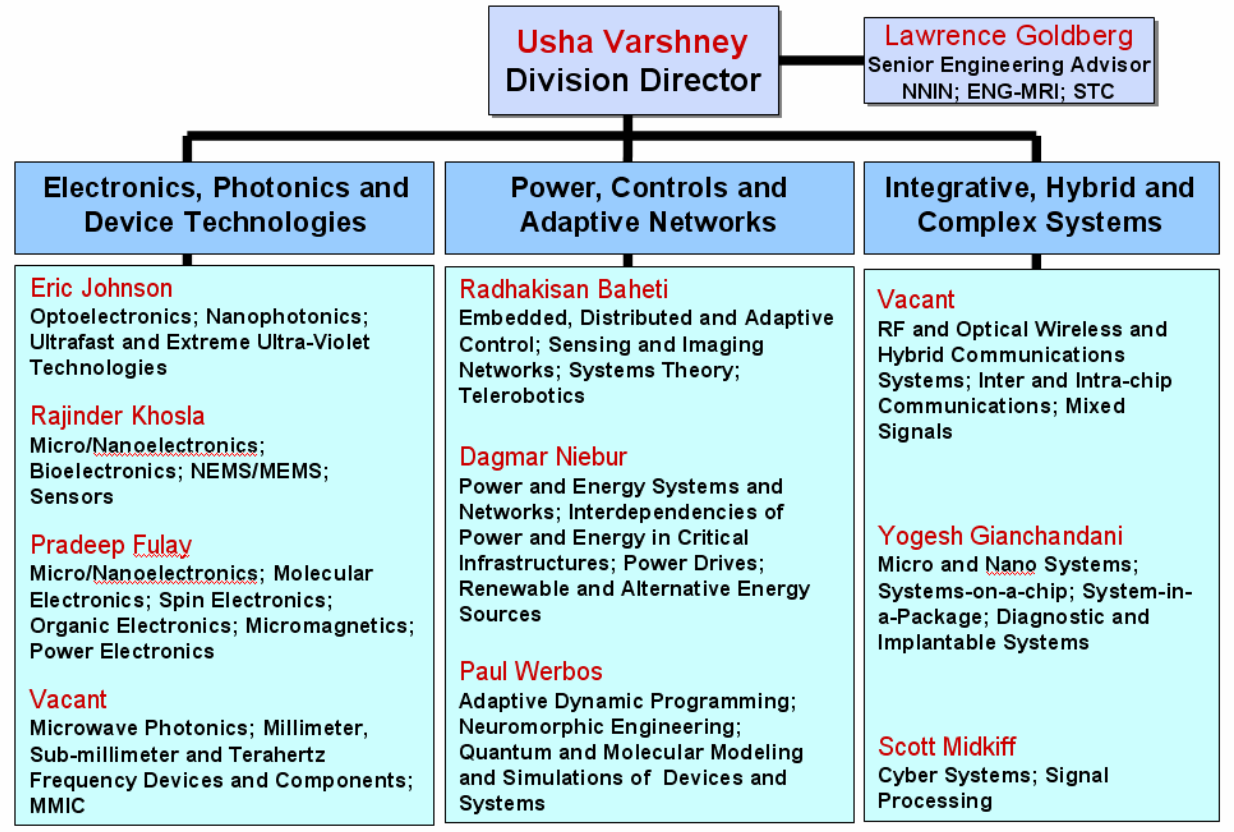

Figure 3. ECCS Program Directors with Program Thrust Areas.

IV. COLLABORATIVE ACTIVITIES WITH ENG DIVISIONS, NSF DIRECTORATES, AND FEDERAL AGENCIES

Collaborative activities with other ENG Divisions and NSF Directorates include Foundation-wide Networks and Centers, Workshops, Program Initiatives and World Technology Evaluation Center studies as follows:

(a) Networks and Centers

ECCS provides financial as well as technical support for selected Industry-University Cooperative Research Centers (I/UCRC). ECCS also has lead-management oversight for the following Networks and Centers:

- NCN: Network for Computational Nanotechnology at Purdue University; Norfolk State University; University of Texas-El Paso; Stanford University; University of Florida; Northwestern University; University of Illinois, (Dr. Rajinder Khosla).

- STC: Nanobiotechnology Center at Cornell University, (Dr. Lawrence Goldberg).

- SLC: Center of Excellence for Learning in Education, Science and Technology at Boston University, (Dr. Radhakisan Baheti, technical coordinator).

- Cyber Center: Trustworthy Cyber Infrastructure for Power Grid (NSF, DOE, DHS) University of Illinois; Dartmouth College; Cornell University; Washington State University, (Dr. Scott Midkiff).

- NNIN: National Nanotechnology Infrastructure Network at Cornell University; Stanford University; University of Michigan; Georgia Institute of Technology; University of Washington; Pennsylvania State University; University of California-Santa Barbara; University of Minnesota; University of New Mexico; University of Texas-Austin; Harvard University; Howard University; North Carolina State University, (Dr. Lawrence Goldberg).

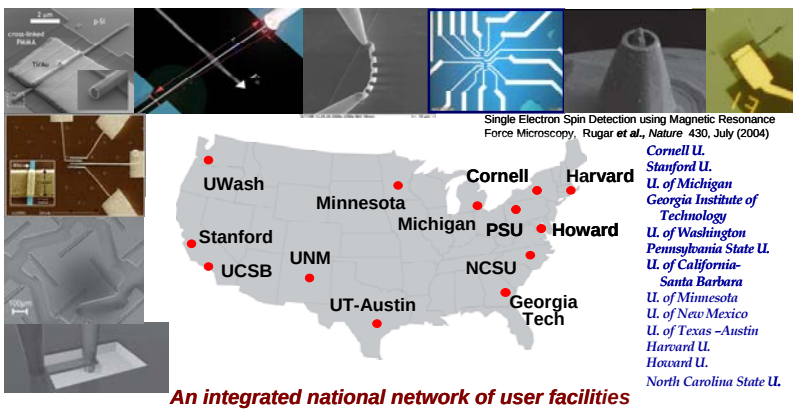

Figure 4. National Nanotechnology Infrastructure Network.

The National Nanotechnology Infrastructure Network (NNIN), established in FY 2004, by ENG in partnership with other NSF Research and Education Directorates (BIO, CISE, EHR, GEO, MPS, and SBE), is an integrated network of 13 university user facilities that provides users with access to leading-edge tools, instrumentation, and expertise within all of the many disciplines that can benefit from nanotechnology, as shown in Figure 4. These capabilities enable the Nation's researchers from academia, small and large industry, and government to pursue transformative research, enable new discoveries and applications in diverse domains of nanoscale science and engineering, and help stimulate technological innovation. Education and training of a diverse science and engineering workforce is also a part of the core mission of NNIN. In FY 2007, the cumulative number of users for all NNIN sites totaled 4,531, which included 3,742 academic users (primarily graduate students, as well as undergraduates and postdoctoral associates), 466 small company users, and 225 large company users. Approximately 1,000 graduate students earning Ph.D. degrees each year depend on NNIN facilities for conducting an important part of their research. Over $400 million in research investment nationwide is leveraged by use of NNIN facilities.

(b) Workshops

ECCS supports research and education workshops in collaboration with other Divisions and Directorates at NSF and with other Federal agencies to strategize future funding investments and to develop initiatives at the forefront of visionary technologies. Some typical workshops supported and planned during FY 2005, FY 2006, FY 2007, and FY 2008 are as follows:

- From Macro to Nano: Challenges and Opportunities in Integrative Complex Systems Engineering, Arlington, VA, March 7-8, 2005.
- US-Korea Workshop on Nano and Micro Integrative, Hybrid and Complex Systems, Seoul, South Korea, October 25-27, 2005.
- Understanding and Preventing Cascading Failures in Power Systems, Denver, CO, October 27-28, 2005.
- The Impact of Globalization on Electrical and Computer Engineering Curricula of the Future, organized by the Electrical and Computer Engineering Department Heads Association (ECEDHA), Washington DC, November 13-15, 2005
- Cyber-Physical Systems (ENG/ECCS, CNN/CISE), NSF, Arlington, VA, September 21, 2006.
- Wearable and Implantable Devices and Systems for Health Monitoring and Diagnostics (NSF, USDA, FDA, NIBIB/NIH), NSF, Arlington, VA, November 13, 2006.
- Workshop for Middle and High School Students and Teachers in Cross-Boundary Nature of Decision and Controls (NSF, IEEE), San Diego, CA, December 13, 2006.
- Large-Scale Photonic Integration, NSF, Arlington, VA, March 19-20, 2007.
- Quantum and Molecular High Performance Modeling and Simulation of Devices and Systems, NSF, Arlington, VA, April 16-17, 2007.

- Engineering of Cyber-Physical Systems Roundtable, NSF, Arlington, VA, May 17, 2007.
- Adaptable Multi-scale Engineered Systems for Biomedical Applications, NSF, Arlington, VA, July 9-10, 2007.
- Workshop on the Future Power Engineering Workforce, Arlington, VA, November 29-30, 2007
- Challenges of Spin Electronics Integrated Systems, NSF, Arlington, VA, September 6-7, 2008.
- Nanotechnology Devices and Systems for Power Generation, Distribution and Storage, NSF, Arlington, VA, May 2008.
- Cyber Physical Systems for Automotive (ENG/ECCS, CISE/CNS), NSF, Arlington, VA, April 3-4, 2008.
- Cyber Physical Systems for Power and Energy (ENG/ECCS, CISE/CNS), NSF, Arlington, VA, June 2008.
- Opportunities and Challenges beyond Moore's Law (ENG, MPS), NSF, Arlington, VA, July 2008.

(c) Division Grantees' Workshops

ECCS holds Grantees' Workshops to evaluate research and education outcomes of program investments; to broaden diversity participation; to promote collaborations with minority serving institutions, small colleges, and undergraduate institutions; to encourage collaboration among grantees; and to identify future directions for ECCS programs. ECCS has organized the following Grantees' Workshops:

- Grantees' Workshop for the Electric Power Networks Efficiency and Security, Washington DC, December 5-6, 2005.
- ECCS GOALI Grantees' Workshop, Arlington, VA, February 16-17, 2006.
- ECCS Grantees' Workshop to Broaden Participation, Tuskegee University, Tuskegee, AL, June 27-29, 2006.
- ECCS Grantees' Workshop to Broaden Participation, University of Nevada, Reno, NV, April 30-May 2, 2007.
- ECCS Grantees' Workshop to Broaden Participation, University of North Dakota, Fargo, ND, August, 2008.

(d) Program Initiatives

ECCS has an established record of collaboration with other Divisions and Directorates at NSF and with other Federal agencies to develop initiatives in cutting-edge technology areas.

i. Solicitations

ECCS has the lead responsibilities on the following initiatives:

- Emerging Frontiers in Research and Innovation: Autonomously Reconfigurable Engineered Systems Enabled by Cyberinfrastructure (NSF 06-596), with EFRI/ENG.

- Emerging Frontiers in Research and Innovation: Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology (NSF 07-579), with EFRI/ENG.

- Joint Domestic Nuclear Detection Office/National Science Foundation: Academic Research Initiative (NSF 08-543), with other ENG Divisions, CISE, EHR, MPS, OCI, OISE, and DNDO/DHS.

In FY 2005, 2006, and 2007, several active ECCS awards have been made, under foundation-wide programs as well as the following initiatives.

- Technological Challenges in Organic Electronics, Photonics and Magnetics (NSF 04-554), with ENG/CMS, ENG/CTS, ENG/BES, ENG/DMII, DARPA and AFOSR.

- Sensors and Sensor Networks II and III (NSF 04-522, NSF 05-526), with other ENG Divisions, OPP and GEO.

- Nanoscale Science and Engineering, NSF-wide Yearly Solicitation, Centers, Interdisciplinary Teams, Exploratory Research, Undergraduate Education.

- Major Research Instrumentation (MRI), NSF-wide Yearly Solicitation.

- Technological Challenges in Hybrid Communications Systems (NSF 06-547) with ENG/CTS, ENG/DMI and OISE, ONR.

ii. Photonics Technology Access Program (PTAP)

The PTAP, an infrastructure program funded by NSF/ECCS and DARPA since FY 2002, enables systems researchers in U.S. universities to obtain from industry for their research, state-of-the-art pre-commercial prototypes in photonics technology through a brokering process. This program helps promote rapid implementation of the technology, student training, and industry-university cooperation.

iii. NSF-SIA/NRI Graduate Student and Postdoctoral Fellow Supplements to NSF Centers in Nanoelectronics

NSF under ECCS leadership is continuing a cooperative effort begun in FY 2006 with the Semiconductor Industry Association (SIA), through the industry's Nanoelectronics Research Initiative (NRI), to provide supplemental funding opportunities to NSF Centers involved in long-term nanoelectronics research (NSF 06-051, NSF 07-051). This supplemental funding supports additional graduate students and postdoctoral fellows to work in collaborative efforts with participating NRI company assignees on exploring new logic and architecture concepts beyond the scaling limits of CMOS (Complementary Metal Oxide Semiconductor) technology. Such efforts are intended to enhance nanoelectronics research and education, strengthen industry linkages with NSF Centers, and develop future cadres of industry and faculty researchers to help drive the field.

iv. Graduate Research Supplements (GRS) to Current ENG Awards to Broaden Participation

The long-term goal of Graduate Research Supplements (GRS) is to increase the number of persons from underrepresented groups in advanced academic and professional careers. The establishment of GRS reflects the continuing effort by ENG to promote increased participation of underrepresented students in all fields of engineering research. According to the NSF 2003 Survey of Doctorate Recipients (SDR), among teaching faculty in engineering, there are 10.3% women, 3.9% African American, 3.3% Hispanic, 0.4% American Indian/Alaskan Native and 7.1% persons with disabilities. With such exceedingly low levels of faculty from underrepresented groups, ENG recognizes that these underrepresented groups represent a significant untapped technical resource for the Nation.

In FY 2005 and FY 2006, the Division of Electrical, Communications and Cyber Systems (ECCS), in collaboration with the Division of Chemical, Bioengineering, Environmental and Transport (CBET) initiated GRS as a two-year pilot program to encourage increased participation of women and minority Ph.D. students in on-going research programs (NSF 05-586, NSF 06-532). In FY 2005, five supplements were awarded, including four females, one African American female, and one Hispanic male. In FY 2006, ECCS invested $462K in 13 GRS supplements, including eight females, three African American males, two Hispanic males and one Hispanic female. Following the success of the pilot, and recognizing the importance and impact of the program, the Directorate for Engineering extended GRS to its Divisions of ECCS, CBET, CMMI, EEC and IIP. In FY 2007, ECCS invested $558K in 16 GRS supplements, including 13 females, one African American female, and one physically disabled African American male (NSF 07-023).

ENG plans to announce GRS for an additional year in 2008. It is anticipated that GRS will help in the development of intellectual synergy between faculty and students, will provide faculty with the opportunity to involve additional graduate students in on-going research programs, will lead to greater retention of students in the targeted populations, and will foster a learning and career advancement environment that supports students from underrepresented groups to broaden participation.

(e) World Technology Evaluation Center (WTEC) Studies

ECCS assesses scientific progress internationally through World Technology Evaluation Center (WTEC) studies, in collaboration with NSF Divisions and Directorates and other Federal Agencies. The goal of the studies is to measure U.S. Global R&D competitiveness to assist ECCS in strategizing future investments. ECCS has recently sponsored the following WTEC studies.

- Assessment of International Research and Development in Robotics; conducted in East Asia and Europe, supported by NSF (ENG, CISE, OISE), NASA, and NIBIB. (concluded)

- Flexible Electronics (being organized for FY 2008-2010).

V. REORGANIZATION OF THE ECCS DIVISION

During the period FY 2005 – 2007, the ECCS Division has undergone a top-down evaluation aided by divisional retreats and weekly staff meetings, to include vision and strategy, program analysis and alignment, budgetary considerations, personnel workload distribution, and interdivisional, interdirectorate and interagency programs and activities. As a result of this evaluation, ECCS has reorganized its programs and structure consistent with the goals of NSF, the Engineering Directorate and the American Competitiveness Initiative. The reorganization of ECCS has involved program-restructuring, reassignment of Program Directors, renaming of programs consistent with the research themes of the Engineering Directorate, and reorganization of the reporting structure of the support staff to increase the overall productivity and efficiency of the Division. This has provided clear vision for future investments. The anticipated outcomes of this reorganization are highlighted in this section of the Division Plan.

(a) Integrative, Hybrid and Complex Systems (IHCS) Program

Due to demand for interdisciplinary and multidisciplinary approaches to new research areas as a result of the convergence of micro/nano/info/bio/cogno technologies, and increasing emphasis on integrative and complex systems engineering research in the 21st Century, it became critical that the ECCS Division reorganize its programmatic structure. A new program "Integrative, Hybrid and Complex Systems (IHCS)" was established in the Division to provide greater visibility to systems engineering research related to the electrical engineering discipline. Three key technology areas have been identified to address fundamental research issues in systems engineering; namely, micro and nano systems, communications systems, and cyber systems. Three Program Director positions were assigned to the IHCS program. Two Program Director positions for IHCS were taken, one each, from the EPDT and PCAN programs, and a third Program Director position was newly approved. Hiring of new Program Directors will have been consistent with the needs of the IHCS key technology areas.

(b) Power, Controls and Adaptive Networks (PCAN) program

ECCS has renamed the Controls, Network and Computational Intelligence (CNCI) program to Power, Controls and Adaptive Networks (PCAN) program. The new program name provides better definition of the technological challenges supported by the program at all levels of networks and computational research, and highlights the need for interdisciplinary and multidisciplinary approaches to research and education. Further, PCAN has been consistent with the research themes of the Engineering Directorate in energy, water and the environment, cognitive engineering, and competitive manufacturing and service enterprises.

(c) Electronics, Photonics and Device Technologies (EPDT) program

To address the emerging field of microwave photonics and high-frequency electromagnetic devices a Program Director position is planned in the EPDT program. Microwave photonics is an inter-disciplinary area that studies the interaction between microwave and optical signals for microwave/millimeter-wave signal generation, distribution, control and processing by means of photonics. Microwave photonics for applications in telecommunications and radar demand ever-increasing speed, bandwidth and dynamic range. Next generation signal processing for applications in communications, millimeter wave radio, and broadband video, require devices that are inherently small size, light weight, and tunable with low power consumption capability. Digital electronics is currently limited by switching speeds and sampling rates; however, microwave photonics offers a promising alternative for signal processing with unique ultra wideband and high-frequency capabilities for applications such as spectrum analysis, time delay, frequency conversion, signal synthesis, filtering, channeling, and data conversion. This new Program Director will develop the program on next-generation high frequency

electromagnetic devices and components, including spectrometers, terahertz devices, microwave instruments, sub-wavelength imagers, monolithic microwave integrated circuits (MMIC), microwave sources and detectors, antennas, mixers, and amplifiers, among others, for integration at microwave, optical and terahertz frequencies (100-3000GHz).

(d) Reporting Structure of Support Staff

To improve the efficiency, effectiveness and productivity of the Division, the reporting structure of the support staff was reorganized. The Center Manager position was reclassified as a Program Specialist position. The Support Staff, previously reporting to the Center Manager currently reports to the Administrative Officer of the Division. These changes have resulted in streamlining the overall operation of the Division.

(e) Addition of Science Assistant Positions

Two new Science Assistant positions reporting to the Division Director have been added to the Division. These positions have supported the Division in securing and preparing highlights of ECCS investments for GPRA reporting, updating ECCS website, assisting Program Directors in planning and evaluation of the interdisciplinary proposal review process, and assisting with the organization of the Division's Grantees' Workshops.

(f) Outcomes of Division Reorganization

As a result of the Division reorganization, ECCS is now well positioned to address and invest in the emerging areas of electrical engineering and related disciplines. Long term benefits will accrue as follows:

- ECCS now has a balanced portfolio consisting of three active research programs.
- The increased emphasis on systems research within IHCS has brought the ECCS Division more in line with the research priorities of the Engineering Directorate and the American Competitiveness Initiative.
- The new micro and nano systems, communications systems and cyber systems thrust areas within IHCS have defined systems technologies at the micro, nano and macro scales in the ECCS Division, and for the external community.
- The name change for the PCAN program provides more focus on future ECCS investments and Engineering themes, and has been well received by the research community.
- The addition of two Science Assistant positions has made the Division more responsive to community needs, and improved Division activities related to investment highlights, web site and Grantees' Meetings.
- The reorganization strategy has substantially increased productivity, effectiveness, and efficiency of the ECCS Division, as evidenced by substantial improvement in meeting GPRA guidelines. In FY 2006 and FY 2007, 98% of proposals were processed within GPRA guidelines.

VI ECCS FUTURE INVESTMENTS IN EMERGING TECHNOLOGIES

ECCS future investments will have a significant technological impact in meeting ENG and NSF objectives, and will include the thrust areas discussed below. In FY 2008, ECCS will invest $2M in cyber systems, $2M in alternate energy sources: generation and integration in the national grid (InterGrid), and $1M for diagnostic, wearable and implantable devices and systems. In FY 2009, ECCS will invest $2M in neuromorphic engineering, $2M in flexible electronics, $1.6M in science and engineering beyond Moore's law, $1M in adaptive systems technology, and $250K in dynamics of water processes in the environment. As new focus areas emerge, ECCS will announce them through web postings.

(a) Alternate Energy Sources: Generation and Integration in the National Grid (InterGrid)

To improve the share of secure, distributed, and renewable energy in the Nation's electric power and energy grid, this thrust area encourages research pertaining to the development and integration of alternate types of electricity generation, such as new approaches in solar power, energy harvesting or energy scavenging. Nanotechnology offers new research opportunities in energy generation and storage including nanopatterned materials for energy scavenging, power beaming, photovoltaics, and thermoelectrics, among others. Efficient electric energy conversion of small volume, volatile renewables within mixed energy hubs that include traditional and alternative fuels, wind, ocean, photovoltaics, and heat recycling as well as energy storage are expected to improve secure, reliable and economic grid operation and delivery. Advances in power electronics for semi-autonomous AC/DC system coupling will facilitate integration of volatile renewable energy sources into the grid. Core competencies in this thrust area include breakthroughs in micro and nano-sensor device development as well as adaptive, decentralized, intelligent, hybrid optimization, monitoring and control algorithms. Environmental sensor placement in the power and energy system will enable real-time, spatial and time-varying, multi-frequency system monitoring, control and operation of the modern reconfigurable power grid, which is robust under disturbances and resilient under emergencies.

(b) Cyber Systems

Cyber Systems seek to focus on design, integration and implementation of multi-scale and multi-level complex systems. Research activities in Cyber Systems will catalyze and integrate physical devices with distributed sensing and actuation controls, communications, storage and computation with domain-specific engineered systems and the physical environment. Cyber Systems will enable visualizing, analyzing and reconfiguring of complex systems to develop reliable and agile infrastructures. Cyber Systems will leverage the broad strengths of ECCS to advance enabling technologies for next-generation cyberinfrastructure. Through partnerships with other ENG Divisions, NSF Directorates, and other Federal Agencies, Cyber Systems research in ECCS will focus on integrating computation, communication, and storage capabilities with domain-specific algorithms to create reliable and agile engineered systems. Other ENG divisions will have a greater focus on application-specific systems research supported by their disciplinary programs. Cyber-physical systems jointly optimize the computational and communication capabilities and domain-specific algorithms to meet the challenges of physical constraints, reliability, scale, and complexity in engineered systems. Cyber Systems also considers the effective and innovative use of current- and next-generation cyberinfrastructure to advance engineering research and education. ECCS will also collaborate with other ENG divisions and NSF directorates to establish further research directions.

(c) Diagnostic, Wearable and Implantable Devices and Systems

Research support for diagnostic, wearable and implantable devices and systems will enable medical offices to collect the most comprehensive medical data from at-home patients in order to aid patient diagnosis for improved quality of life. Advances in material science, electronics, computational intelligence, networking and wireless communications will lead to major breakthroughs in the development of devices and systems that will connect general-purpose computing systems with in-vivo (implantable) or in-vitro (wearable) engineered systems. This thrust area will challenge scientists and engineers in the design and development of intelligent wearable and implantable systems that are biocompatible, adaptable, multi-scale, and have extended operational life. These systems are expected to have the capability to transmit and process information remotely as well as on-site for monitoring patient health on a continuous basis. This thrust area will address integration of device technologies with biology, chemistry, materials science, biomedical engineering, computer science, and medicine for healthcare applications.

(d) Flexible Electronics

Flexible electronics, also referred to as plastic electronics, organic electronics, polymer electronics, flexionics or polytronics, represents a highly promising interdisciplinary area that will provide greatly increased functionality and potential to meet future challenges of scalability, flexibility, low power consumption, light weight, ruggedness, transparency, environmental compatibility, manufacturability and reduced cost. Flexible electronics integrated to intrinsic and hybridized systems, will virtually revolutionize information technology, telecommunications, transportation, wearable microprocessors, solid-state lighting, alternate energy, entertainment, defense and healthcare systems. Continued advances in organic-based systems are critically important in sustaining the Nation's economic growth, particularly in applications, such as flexible displays for mobile phones, digital cameras, media players, televisions, electronic books and papers, personal digital assistants (PDA) and computers, game platforms and dynamic signage. Applications, such as radio frequency identification (RFID) tags, electromagnetic interference (EMI) shielding, electrochromic camouflage coatings, wearable microprocessors, organic memories, automotive subsystems, photovoltaic devices, organic batteries and fuel cells, injection lasers, and sensors, will have significant societal impact. Scientific issues and technological challenges associated with the underpinnings of flexible electronics include theoretical and experimental aspects of charge-transport properties and device physics, processing techniques, interface engineering, device and circuit design, patterning, metrology and diagnostic tools, packaging, architectures, systems engineering and manufacturing technologies.

(e) Hybrid Communications Systems and Networks

Research support in hybrid communications systems and networks will enable seamless integration of optical and RF/microwave wireless systems and network technologies for continued growth of bandwidth, and secure information for national needs in a globally connected society. An ideal approach to maximize networks utilization will be to integrate various communications systems into hybrid configurations, to increase data capacity while providing seamless integration of an efficient agile network with embedded existing infrastructures. Advances in novel materials-based structures and devices, optics, electromagnetics, and electronics would lead breakthroughs in integrative technologies, including combination of components, sub-system and system functions, chip-level assembly, and other architectures targeted to network applications as well as packaging, and low power consumption strategies. This thrust area will challenge engineers and scientists in new concepts and design methodologies, such as the creation of new techniques for integration of sub-systems' and systems' architectures for various operational environments. These challenges

further include integration technologies having improved performance, reduced component size and new functionalities that address existing discontinuities in hybrid systems and their effect upon overall system performance.

(f) Interdependencies of Critical Infrastructure in Power and Communications

Core competencies within this thrust area lie at the center of research in protecting and upgrading the Nation's critical infrastructure, including technologies that support electric power, telecommunications, Internet and general commerce. Advances in control, communications and computational intelligence for predicting and responding to threats for critical infrastructure will form the basis of robust and secure systems. Sensors and sensor networks are vital for monitoring real-time systems identification and model-prediction for control of complex interdependent discrete and continuous system dynamics. Local decentralized intelligence will support flexible reconfiguration of critical infrastructure, thus improving security, efficiency and economics of operation and decreasing vulnerability to disasters and sabotage. This thrust area will address fundamental knowledge, design and decision methodologies and architectures for interdependency in communications and power infrastructures for robustness, resilience, flexibility, agility, adaptability and evolvability. Reconfigurability and efficiency of the critical infrastructure will be central to the ability to accelerate the deployment of renewable energy. Breakthroughs in power electronics offer crucial opportunities for prediction and mitigation of disasters in this thrust area. Consequently, ECCS will seek collaborations with other NSF Divisions and Directorates, as well as with other Federal agencies.

(g) Micro and Nano Systems

Research in micro and nano systems and their integration into complex systems have transformed the ability to provide advanced engineering solutions and have spawned a vast variety of information-based and intelligent technologies. The goal of this thrust area is to design and develop a new generation of micro and nano systems that will integrate physical devices with mechanical, biological, chemical, and optical sensing, actuation, control, computation, communication, learning and cognitive capabilities to achieve new functionalities for applications in healthcare, global warming, environmental monitoring, hazards mitigation, transportation, manufacturing and homeland security. The focus of this area is also to design micro and nano systems as critical elements for information systems and networks. In addition, this thrust area will address challenges in complex systems that will combine sensors, actuators, micropower circuits, embedded computing and wireless interfaces to realize implantable systems for drug delivery on-demand, image-guided microsurgical tools, wearable health monitors, and low-cost diagnostic devices for medical applications.

(h) Nanoelectronics, Nanophotonics and Nanomagnetics

Nanoscale electronics, photonics and magnetics are at the core of enabling an era of remarkable advances in information technologies. Research will explore fundamental understanding of novel material-based structures and devices, processes, and design and architecture challenges faced by the semiconductor industry at, and beyond Moore’s Law, and the time horizons of the International Technology Roadmap for Semiconductors. Further research will determine ultimate limits to scaling of features and alternative physical principles and technologies for devices employed in sensing, storage, communication, and computation, including novel biological, molecular, electronic, photonic, magnetic, and quantum structures and systems. To enable discovery and innovation of new approaches in electronics beyond the limits of CMOS technology and to strengthen industry linkages, NSF (ENG, MPS, CISE), under ECCS leadership, is pursuing collaborative efforts with the semiconductor industry and the Semiconductor Research Corporation (SRC) on the themes of Silicon Nanoelectronics and Beyond (SNB) and the industry’s Nanoelectronics Research Initiative (NRI).

(i) Neuromorphic Engineering

Neuromorphic engineering takes inspiration from biology, physics, mathematics, computer science and engineering to design artificial neural systems, such as vision systems, head-eye systems, auditory processors, and autonomous robots, whose physical architecture and design principles emulate biological nervous systems. This thrust area will support efforts to establish new connections between ECCS technologies and studies of the brain, and includes new physical technology, to mimic the massively parallel architecture of the brain. The thrust area will include efforts to harness the understanding of neurons, in order to build new learning systems beyond the capacity of artificial neural networks, control theory and signal processing. Research challenges focus on the ability of the brain to handle complexity across space and time. Test beds for such new general-purpose learning systems include facial recognition, strategic games and optimal management of complex infrastructures.

(j) 3D Photonics: Very Large-scale Photonic Integration

Photonics has revolutionized communications, solid state lighting, data storage and displays and is also at the forefront of basic research by providing enabling tools to investigate fundamental phenomena in biology, chemistry, and physics. However, many applications have been inhibited by the high cost, large size, and often limited functionality of photonic circuits. The development of 3D (three-dimensional) Photonics and very large-scale photonic integration (VLSPI) analogs to very large-scale integrated circuit (VLSIC) electronics will be key to revolutionizing the field of optoelectronics. 3D Photonics will enable many new and non-traditional applications, with major impact on the economy and quality of life. This thrust area will support research in VLSPI with emphasis on silicon photonics, innovative photonic circuit concepts and structures, nano-photonic fabrication techniques, three-dimensional photonic integration, thermal management, photonic field-programmable-gate-arrays (FPGA), on-chip photonic signal processing, and theoretical modeling of highly complex photonic integrated circuits.

(k) Quantum and Molecular Modeling and Simulation of Devices and Systems

The quantum and molecular modeling and simulations (QMMS) thrust area will support the development of new mathematical models and analytical methods to enable breakthroughs in design of novel classes of electronic devices and systems. As design scales shrink to the nanoscale, new opportunities will arise in computing and communication including high-density, massively parallel computation or switching, where device characteristics and architecture require integrated analysis for quantum or molecular modeling and simulations. To realize these opportunities, QMMS will stimulate: general-purpose modeling and simulation of devices and systems; greater understanding and use of fundamental, many-body principles from quantum theory in electronics; and development and use of high-performance computing, such as algorithms or architectures for massively parallel computation.

VIII. STATISTICAL ANALYSIS OF ECCS DIVISIONAL INVESTMENTS

The section provides a brief statistical analysis of ECCS investments. In strategizing future activities of the Division, it is informative to evaluate the status and trends of ECCS programs in the recent past. Several examples are given in Figures 5-10, for ECCS performance relative to the ENG Directorate and NSF as a whole.

ECCS had a 29% increase in budget from FY 2002 to FY 2007, as shown in Figure 5. ECCS has made progress in redressing the budget imbalance between committed and discretionary funds that existed in FY 2004. In FY 2006 the percentage increased to 47% from 33% in FY 2002, but decreased again to 42% for FY 2007. ECCS hopes to realize improvement in FY 2008 and in the future.

Figure 6 shows the CAREER proposal-funding rate decreasing from 29% in FY 2002 to 12% in FY 2005. ECCS made a conscious effort to improve the funding rate to 16% in FY 2006 and 2007. ECCS expects to increase the funding rate by two to five percent per year.

Figure 7 shows a decline in funding rates for research grants from 27% in FY 2002 to 13% in FY 2005; however, there was an increase in the funding rate to 17% in FY 2006 and 18% in FY 2007. Similar trends are observed for both ENG and NSF. ECCS expects to maintain the funding rate at a similar level for FY 2008.

Figure 8 shows that the average grant size in ECCS is consistently lower than the average grant size in ENG and NSF. The average grant size for three years, specifically of unsolicited proposals, was increased by approximately 10% annually from $240,000 in FY 2005 to $270,000 in FY 2006 to $300,000 in FY 2007. For FY 2008, ECCS plans to increase the grant size by another 10% to $330,000 for three years. The Division mean grant duration was observed to be 3.04 years with an increase in the annual research grant size from $101,253 in FY 2006 to $107,250 in FY 2007, according to data obtained from the NSF Enterprise Information System (EIS). The overall Division funding rate for competitive awards increased from 17% in FY 2005 to 19% in FY 2006 to 21% in FY 2007, by strategizing long-term programmatic balance.

ECCS expects to fund a limited number of unsolicited, multi-investigator, group proposals to promote interdisciplinarity and innovation. Division Director's funds will be made available as an additional incentive for large awards involving three or more investigators from different disciplines and/or universities.

Figure 9 shows ECCS investments in Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) supplements, Small Grants for Exploratory Research (SGER), Grant Opportunities for Academic Liaison with Industry (GOALI), EPSCoR (Experimental Program to Stimulate Competitive Research) and in Underrepresented Groups (UG).

ECCS will strengthen and enhance the Research Experiences for Undergraduates (REU) by an increase of two to four percent per year from an investment of $538K in FY 2007, and Research Experiences for Teachers (RET) by two to four percent per year from an investment of $70K in FY 2007.

ECCS investment in SGER has increased 65% to a total of $1.15M in FY 2005, 96% to a total of $1.36M in FY 2006, and 92% to a total of $1.33M in FY 2007 from $690K in FY 2004. ECCS plans to increase its level of investment between three to seven percent in the future.

ECCS investment in GOALI increased by 45% to a total of $1.45M in FY 2005, 55% to a total of 1.55M in FY 2006, and 144% to a total of $2.44M in FY 2007 from $1M in FY 2004. ECCS plans to increase this level of investment in the future.

In FY 2007, the Division had $7.96M investment in EPSCoR states and will seek to double this investment by FY 2012. ECCS's investment in underrepresented groups has increased 38% to a total $4.15M in FY 2005, 37% to a total of $4.13M in FY 2006, and 122% to $6.70M in FY 2007 over FY 2004, and ECCS plans to support similar levels of investment in the future.

Figures 10. (a), (b) and (c), depict percentage of ECCS FY 2005, FY 2006, and FY 2007 budget in research grants by the academic department of the principal investigator. The decrease in the percentage of investment in the electrical & electrical and computer engineering departments from 65% in FY 2005 to 63% in FY 2006 to 58.5% in FY 2007, supports the engineering trend of increasing investments in interdisciplinary research.

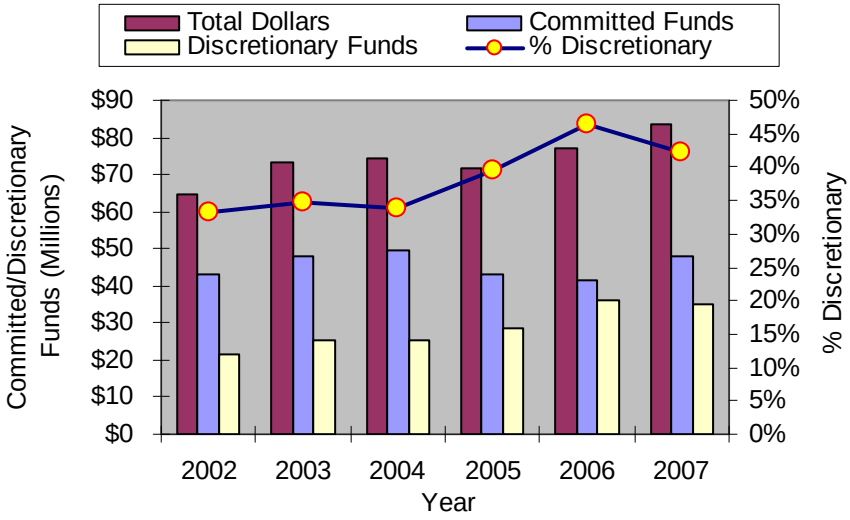

Figure 5. ECCS Budget Profile

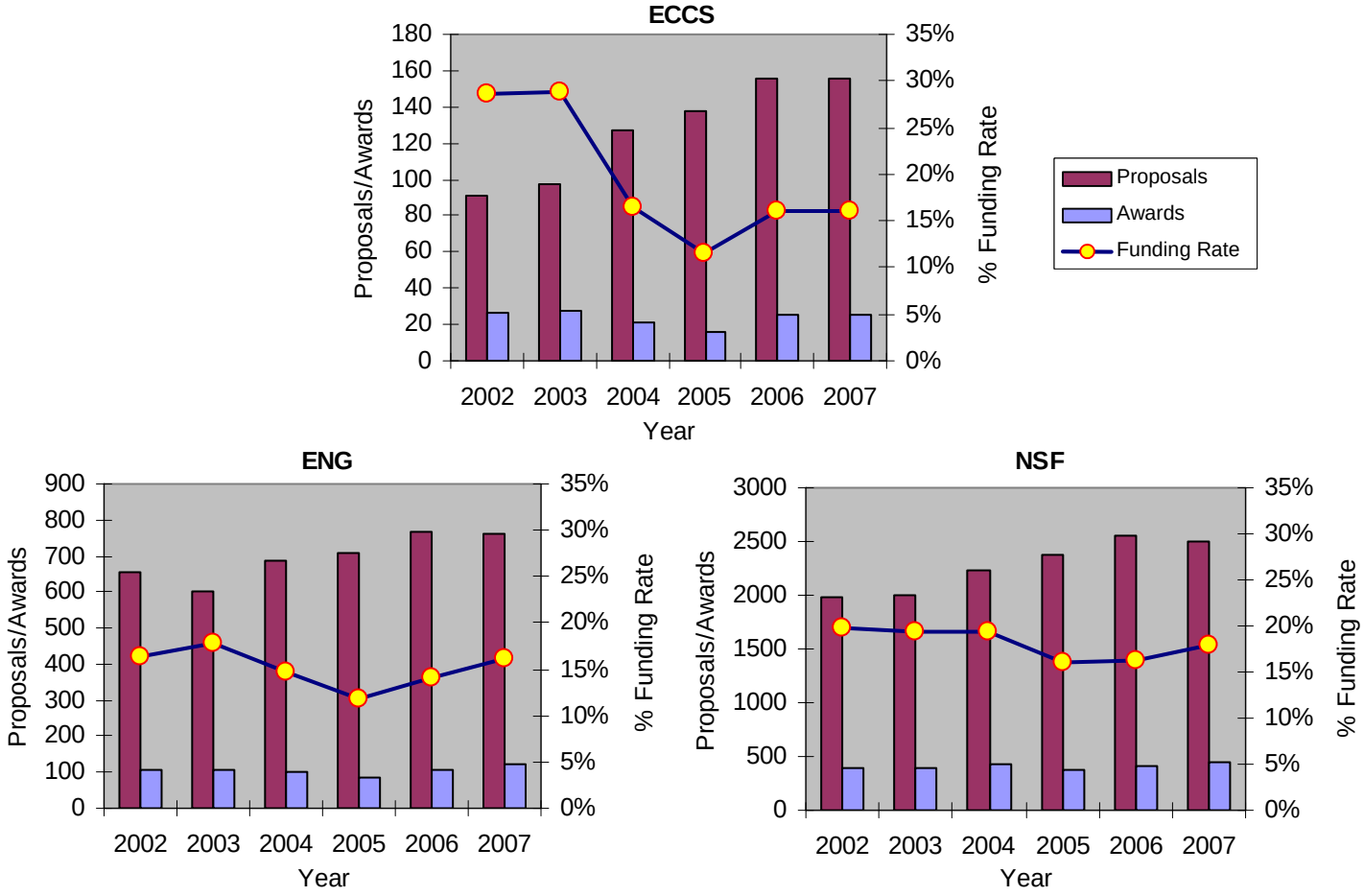

Figure 6. CAREER Awards

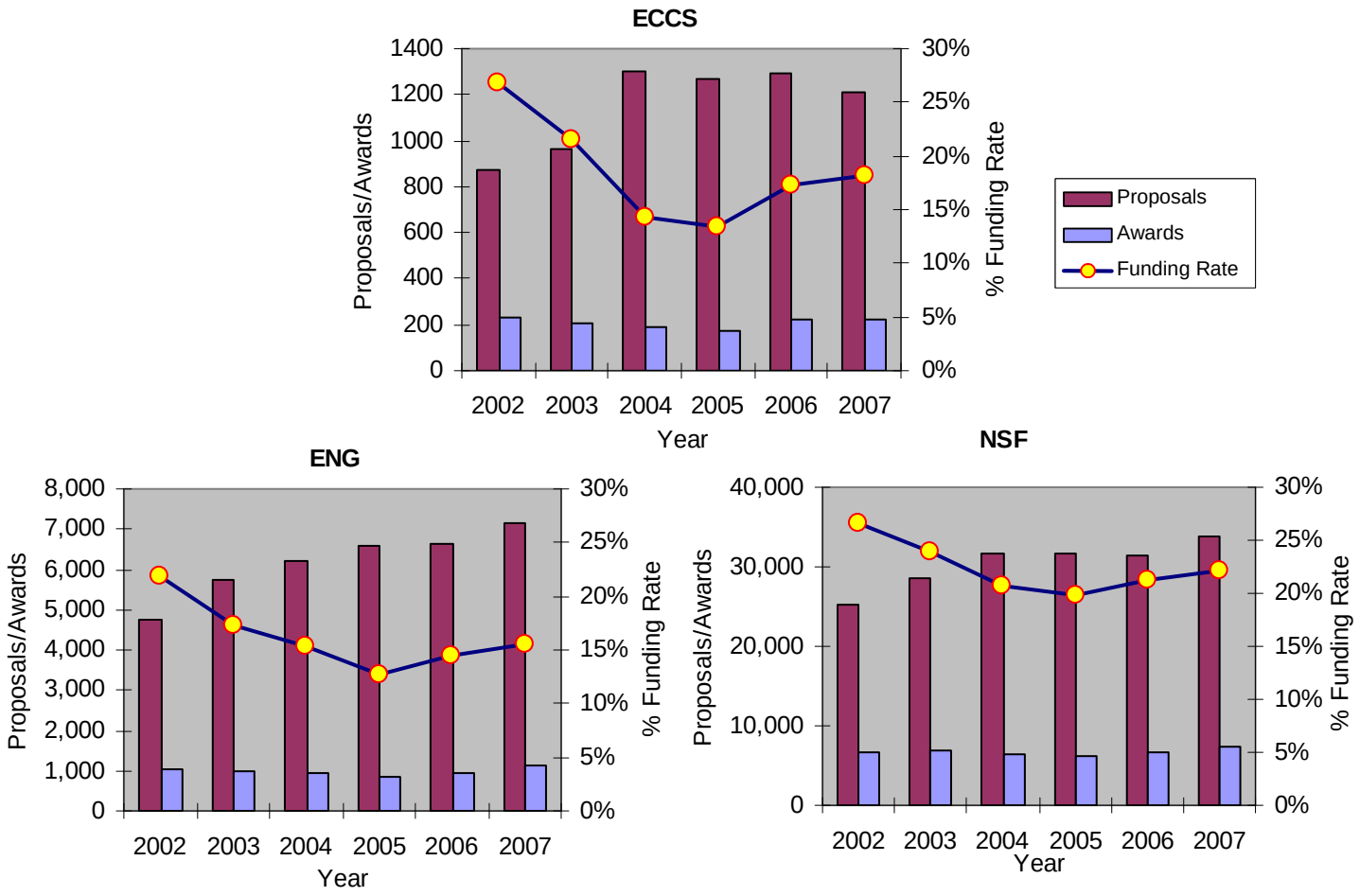

Figure 7. Funding Rates for Research Grants.

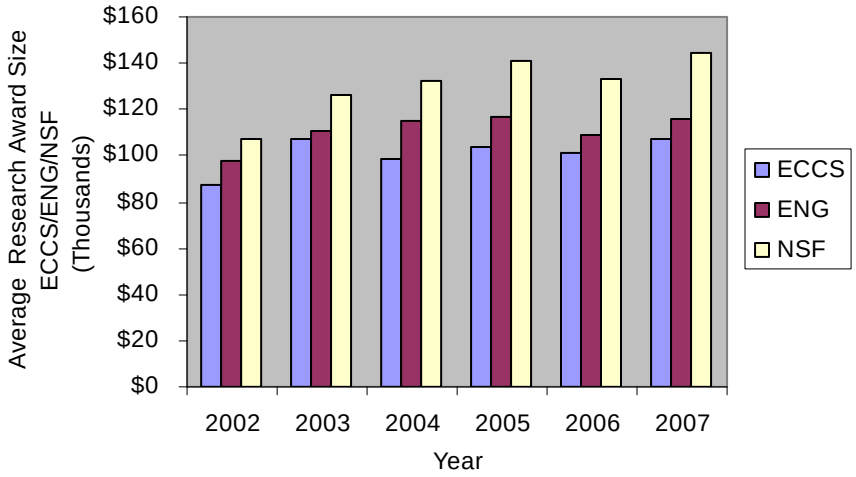

Figure 8. Awards Size.

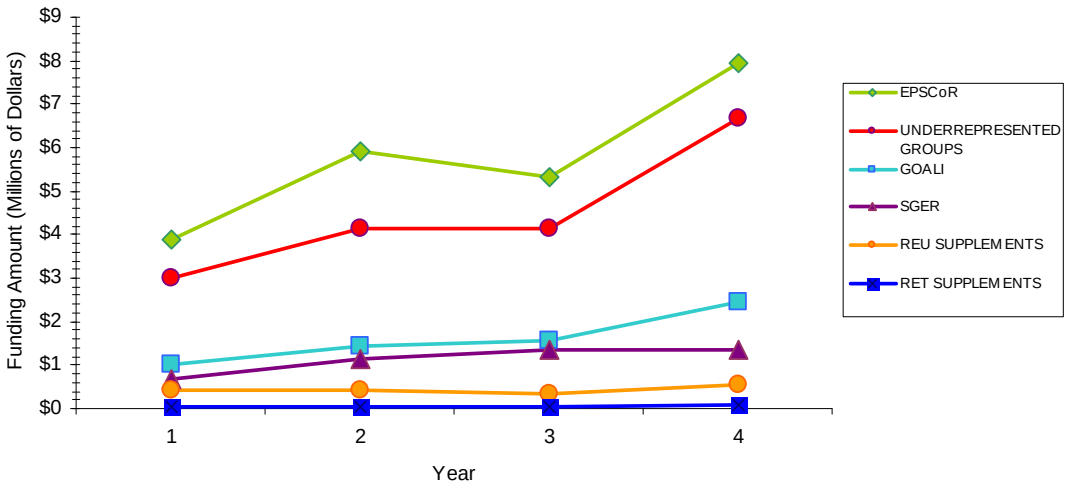

Figure 9. Investments in REU and RET Supplements, SGER, GOALI, EPSCoR and UG.

- Research Experiences for Undergraduates (REU) Supplement
- Research Experiences for Teachers (RET) Supplement
- Small Grants for Exploratory Research (SGER)
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Experimental Program to Stimulate Competitive Research (EPSCoR)
- Underrepresented Groups (UG)

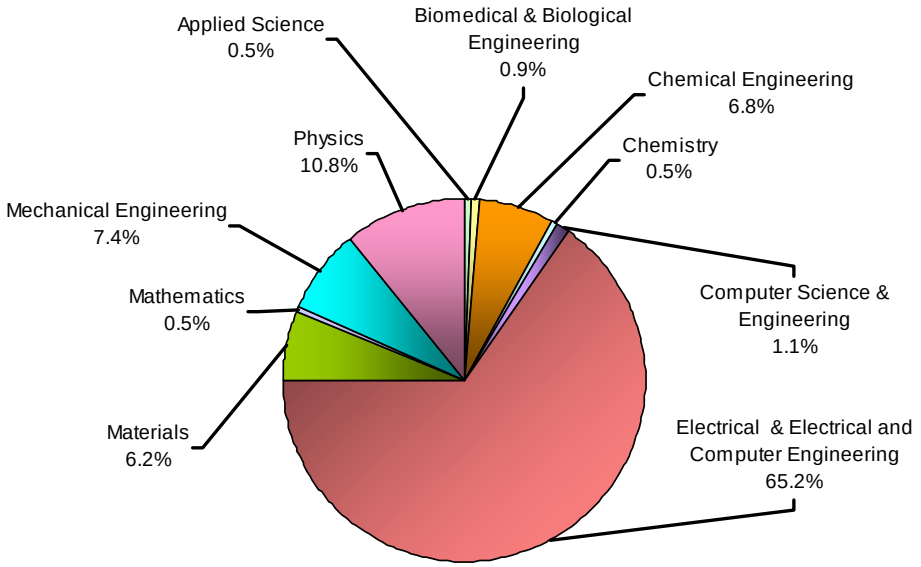

Figure 10 (a). Percentage of ECCS FY 2005 Budget in Research Grants by Academic Department of Principal Investigators.

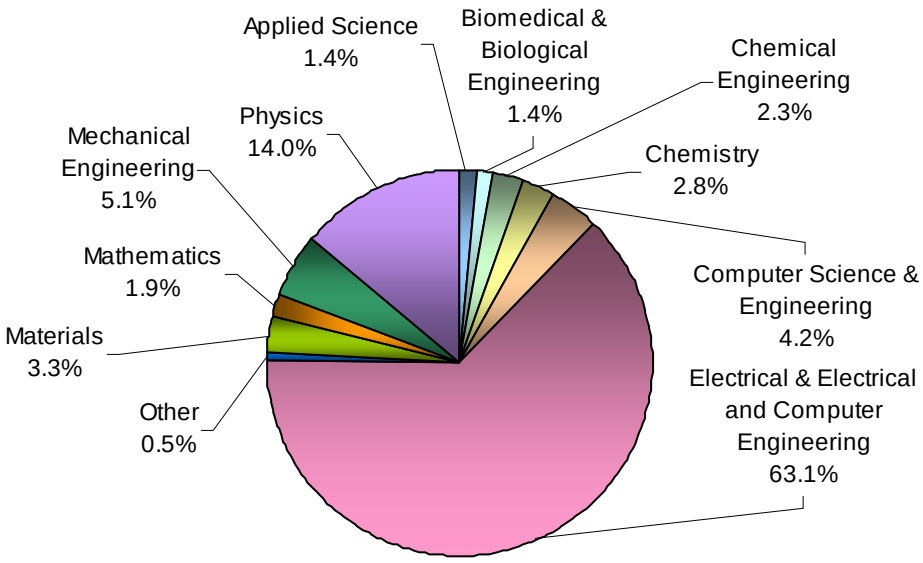

Figure 10 (b). Percentage of ECCS FY 2006 Budget in Research Grants by Academic Department of Principal Investigators.

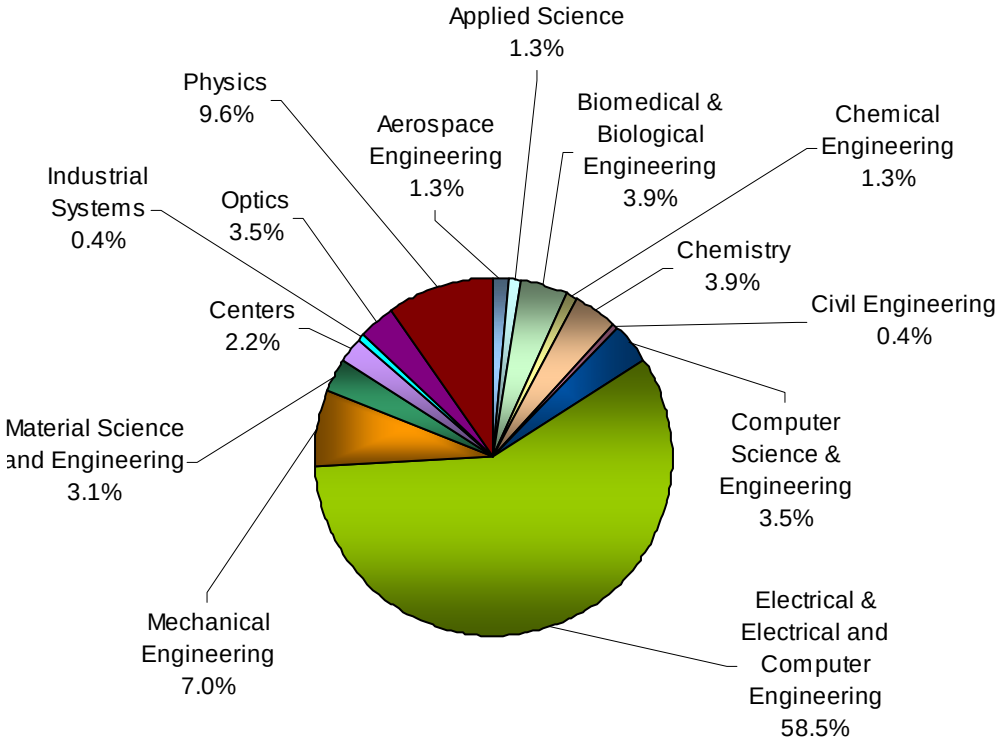

Figure 10 (c). Percentage of ECCS FY 2007 Budget in Research Grants by Academic Department of Principal Investigators.

IX. FUTURE CHALLENGES

Even though ECCS has made substantial gains in all of its programmatic areas and has improved the efficiency of its operations substantially in the preceding fiscal years, there remain a number of challenges that the Division must address in the immediate future. Several of these are as follows:

- Continue to redress the imbalance between committed and discretionary funds.
- Maintain the overall productivity and efficiency of the Division by continued improvement in protocols for streamlining Divisional operations.
- Improve evaluation, acquisition and dissemination of quality highlights of Divisional investments through organization of Grantees' Workshops.
- Provide visibility to the research community for ECCS thrust research areas, consistent with research priorities of ENG, NSF and ACI, through web sites and presentations at conferences, workshops, symposia and university visits.
- Strategize future funding for small group proposals in the Division.
- Increase partnerships with other ENG divisions, NSF directorates and Federal agencies.

X. ACKNOWLEDGEMENTS

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