APPENDIX A
BACKGROUND OF ENGINEERING RESEARCH CENTERS

ERCs: Impacts of specific centers

Between 1985 and fiscal year 2006, NSF established 46 ERCs. The second generation of ERCs, which were funded since 1994, has produced graduates who are viewed by 80 percent of their supervisors as more productive than their peers because of their ERC experience. Ninety percent of ERC member firms join the program to gain access to new ideas and know-how from the ERCs, 70 percent indicate that the ERCs have impacted their R&D agendas, and 60 percent indicate that they developed new products or processes as a result of their ERC membership. Similar results were reported in a study of the first generation of ERCs. The history of funding ERCs is shown in Figure 1.

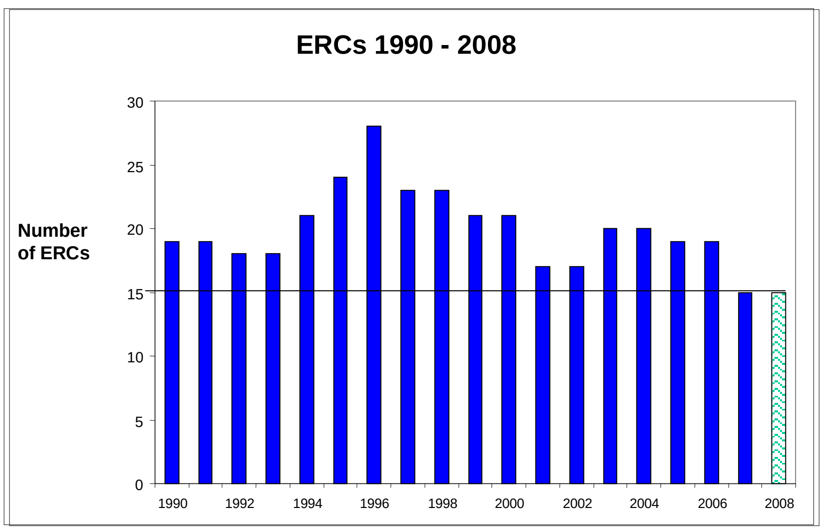

Figure #1

The ERC Program is responsible for the oversight and support of ERCs and Earthquake ERCs (EERCs). Since 1985 these centers have been key in advancing new fields. For example, 10 ERCs have laid the engineering foundation in research and education for bioengineering.

As an example of ERC impacts in the microelectronics field, the Packing Research Center at Georgia Tech brought the systems perspective in electronic packaging to the microelectronics industry, whose products depend on small-scale packaging. In addition, this center had a broad-based economic impact on Georgia. A study commissioned by the

Georgia Research Alliance, an investment partner in the ERC with NSF and industry, found that between 1994 and 2004, the $32.5 million invested by Georgia in the ERC had a quantifiable direct impact on Georgia's economy of nearly $192 million over the 10 years.

The Digital Persona Corp. is an example of the impacts an ERC can achieve through spin-off firms created by innovative students. Two undergraduates from the Caltech Neuromorphic Engineered Systems ERC, Vance Bjorn and Serge Belongie, established Digital Persona in 1996 to commercialize their invention of "U are U" fingerprint identification technology. They won the coveted Best of Comdex award for computer peripherals in 1997, and impacted the market recently by the incorporation of their technology in Microsoft products and in major banks in Mexico and China.

Table (A-1) lists high levels of productivity in the program's quantitative performance indicators, based on a survey of the universities.

Table (A-1) Indicators of ERC Productivity

Outputs	**1985–2005 (41ERCs & EERCs)**	**Per Center**
Curricular Impact		
New Degree Programs	155	4
Courses Impacted	2,156	53
Texts	193	5
Degrees Granted to ERC Students		
B.S.	3759	92
M.S.	3500	85
Ph.D.	3425	84
Total	10684	261
Intellectual Property		
Patents Filed	1045	25
Patents Awarded	528	13
Licenses Issued	1890	46
Spin-off Firms	113	3

The ERC Program also has a long-standing commitment to increasing the diversity of the engineering workforce through the inclusion of women and underrepresented minorities in the ERC cohorts of faculty and students. Viewing the success of the program, and its potential further impact on schools of engineering and science who provide their faculty and students to ERCs, in fiscal year 2004, at the request of Joseph Bordogna, NSF Deputy Director at that time, the ERC program formalized its diversity goals by requiring each ERC to develop a diversity plan in partnership with its deans and department chairs. The ERCs were asked to report annually to NSF on the results, which were benchmarked against national engineering-wide averages. This policy included requirements that at least one of the core or outreach partners be a minority-serving institution, and that the ERCs partner with NSF-supported Louis Stokes Alliances for Minority Participation (LSAMP) and the Alliances for Graduate Education and the Professoriate (AGEP).

The percentage of underrepresented groups (women, underrepresented racial minorities, and Hispanics/Latinos) among the faculty and graduate and undergraduate students in ERCs exceeded engineering-wide averages by wide margins before the implementation of that policy. These charts also show that since the implementation of the policy, ERC diversity exceeds the national averages by wider margins, especially for undergraduates.

Nanoscale Science and Engineering Programs

The EEC Nanoscale Science and Engineering Research Programs represent EEC's contribution to the research efforts of the 25-agency, $1.3 billion/year National Nanotechnology Initiative (NNI), of which NSF's contribution is approximately $344 million. Within this amount, ENG's contribution is $128 million and EEC's is $28 million (all fiscal year 2006 funds). EEC's $28 million contribution includes approximately $10 million of support for nanoscale science and engineering research provided through EEC's other programs, primarily the ERC Program.

<u>Nanoscale Science and Engineering Centers (NSEC)</u>

The NSECs conduct research and develop educational and outreach materials focusing on phenomena at the nanometer scale. Overall coordination for the NSEC Program is provided by the Division for Materials Research (DMR) in the Directorate for Mathematical and Physical Sciences (MPS). EEC has oversight responsibility for six of the 19 NSECs supported by NSF, with participation by other divisions, as indicated:

- The Center for Affordable Nanoengineering of Polymeric Biomedical Devices at Ohio State University (six divisions).
- The Center for Biological and Environmental Nanotechnology at Rice University (two divisions).
- The Center for Integrated Nanomechanical Systems at the University of California at Berkeley (five divisions).
- The Center for Integrated Nanopatterning and Detection Technologies at Northwestern University (two divisions).
- The Center for Nanoscale Systems in Information Technologies at Cornell University (two divisions).
- The New England Nanomanufacturing Center for Enabling Tools at Northeastern University (seven divisions).

These NSECs received aggregate support of approximately $10 million from EEC in fiscal year 2006, with almost $7 million in additional funding provided by other divisions within NSF. In turn, EEC provided approximately $1.5 million in support to the following NSECs overseen by other NSF divisions, as indicated:

- The Center for Directed Assembly of Nanostructures at Rensselaer Polytechnic Institute (Division of Materials Research and two other divisions).
- The Center for Hierarchical Nanomanufacturing at the University of Massachusetts, Amherst (Division of Civil, Mechanical, and Manufacturing Innovation and five other divisions).
- The Center for Nano Connection to Society at Harvard University (Division of Social and Economic Sciences and two divisions).
- The Center for Nanotechnology in Society at the University of California, Santa Barbara (Division of Social and Economic Sciences and nine other divisions).

Network for Computational Nanotechnology (NCN)

The NCN (approximately $3.86 million total funding in fiscal year 2006, with $550,000 from outside EEC) provides a central focus to connect theory, experiment, and computation so that a broad range of researchers have access to the most up-to-date tools available in nanotechnology. NCN researchers, including researchers at NSECs, produce new algorithms, approaches, and software tools with capabilities not yet available commercially. As part of the NSF's infrastructure for the NNI, the NCN spearheads and maintains the nanohub, a Web-based initiative that is a resource for research and education in the areas of nanoelectronics, nanoelectromechanical systems, and their applications to nano-biosystems. The nanohub provides online simulation services as well as courses, tutorials, seminars, debates, and facilities for collaboration.

Nanoscale Interdisciplinary Research Teams (NIRT)

The NIRT ($4.68 million in fiscal year 2006) program funds interdisciplinary teams of from three to five researchers at a total level of $1.0 to $1.4 million over four years to conduct collaborative research and education in the areas of active nanostructures and nanosystems, and on the long-term societal change associated with these innovations. Active nanostructures change or evolve their structure, property, or function during their operation. The goal of this program is to support fundamental research and catalyze synergistic science and engineering research and education in several emerging areas of nanoscale science and engineering.

The NIRT competition was NSF-wide for awards made in fiscal year 2004 and restricted to ENG in fiscal year 2005 and fiscal year 2006. In both cases, the competition was managed outside of EEC, with representation by every directorate in NSF in fiscal year 2004 and every division in ENG and several divisions outside ENG in fiscal years 2005 and 2006. Funding by at least two divisions was required for each proposal. In fiscal year 2004, EEC provided partial funding to 10 NIRT awards, with oversight responsibility for two awards of specific interest to EEC, including one concerning the response of microorganisms to nanoparticles. In fiscal year 2005, EEC also provided partial funding to 10 NIRT awards, retaining oversight of two, one on toxicity of carbon nanoparticles and the other to develop a quantum dot nanoprobe to enable noninvasive bioimaging. The second was built on advances made in the ERC for Particle Science and Technology at the University of Florida.

In fiscal year 2006, EEC contributed to 17 NIRT awards, retaining oversight of none. None of the candidate proposals directly leveraged expertise within EEC or its centers, but EEC funding enabled several worthy proposals by underrepresented minority investigators and two proposals to study the societal impact of nanotechnology to be made. It is expected that many of the results of these projects will be useful to investigators at our current Centers and that some may result in future proposals to our Centers programs.

APPENDIX B
PAST EEC PLANNING DOCUMENTS: SUMMARY

EEC: A Brief Funding History

The EEC division was formed in 1992 by the merger of the former Office of Engineering Infrastructure Development and the former Division of Engineering Centers. Until 2001, EEC programs were dominated by the ERCs and Engineering Education Coalitions programs, which were allocated the majority of the division's budget, the remainder being applied to the REU Site, Industry and University Cooperative Research Centers (I/UCRC), Combined Research-Curriculum Development Programs, the Action Agenda for Systematic Engineering Education Reform, and ENG commitments to NSF-wide programs, including the Integrative Graduate Education and Research Traineeship (IGERT), Graduate Research Fellowship (GRF), Graduate Teaching Fellows in K–12 Education, and Interagency Education Research Initiative (IERI) programs. Discretionary funds not allocated to any specific program were typically in the range of $1 to $2 million per year and covered panel expenses, IPA salaries, studies, and the funding of a few unsolicited proposals. Planning for individual programs was primarily managed by the program directors overseeing the programs.

Coinciding with the institution of a divisional annual reporting process within ENG in fiscal year 2000, substantial funds became available from the phase-down of the Engineering Education Coalitions program. The availability of these funds allowed the incorporation of elements in the fiscal years 2000 and 2001 annual reports.

Highlights of the Fiscal Years 2000 and 2001 Annual Reports

The plan for EEC proposed to maintain a critical mass of coordinated funding for the transformation of engineering education as the Engineering Education Coalitions phased out, rather than to supplement a number of existing programs or start small, disconnected programs.

An element of the plan was to connect EEC and EHR programs to provide young engineers smooth pathways from middle school through high school, college and graduate school to engineering careers by:

- Creating an Engineering Education Program to receive unsolicited proposals. EEC had never had a mechanism for receiving unsolicited proposals, which typically generate many new ideas by promoting discussion between investigators and program directors.
- Increasing enrollments through engineering-focused curricula in K–12 (Bridges for Engineering Education).
- Reformulating, streamlining and updating engineering programs to increase their relevance to engineering practice and improve retention (Department-Level Reform, Engineering Centers for Learning and Teaching).

Additional funds were made available through the termination of the Action Agenda for Systemic Engineering Education Reform Program, which was intended to directly leverage innovations coming out of the Coalitions but was judged to have produced disappointing results. Funds also were freed with termination of the Combined Research–Curriculum Development Program, a 10-year old program to fund faculty research on the condition that they produce related coursework. It was felt that sufficient faculty interest in engineering education had developed to prefer programs aimed directly at curriculum improvement, without the research component.

The plan for ERCs concentrated on refocusing the program on transforming engineered systems, requiring outreach to K–12 students and teachers, simplifying the ERC solicitation, eliminating any unnecessary or redundant burdens on the ERCs, and increasing funding levels for individual ERCs. The I/UCRC Program concentrated on increasing the fundamental research content of the center programs.

The human resources portion of the plan was to increase REU stipends from $5,000 to $6,000 per year and conduct an REU Grantees Workshop.

Highlights of the Fiscal Year 2005 Division Plan

No annual reporting process existed for fiscal years 2002 through 2004. Program reporting was limited to the submission of project summaries (nuggets) to the Office of the Director. In fiscal year 2005, ENG instituted a divisional planning process.

The goal for fiscal year 2005 was to advance the United States into emerging technology areas by examining assumptions underlying the ERC programs. Specific tactics included:

- Investigating a new organization of the ERC program to allow a full range of innovation.
- Investigating moving educational initiatives from the ERCs to the engineering education component of EEC.
- Developing a blue-ribbon panel to review and assess the proposed changes.
- Developing a World Technology Evaluation Center study on how ERCs are run and operated worldwide.
- Developing a vision ERCs that will be as effective in the next 20 years as in the last 20 years.
- Developing a transition plan for the suggested changes.

The goal of the fiscal year 2005 plan for the engineering education component of EEC was to transform engineering education to produce an engineering workforce that is diverse and creative, understands the impacts of its solutions on both technical and social systems, and possesses the ability to adapt to the rapidly evolving technical environment.

The first strategy for achieving this goal was to develop an understanding of how students learn engineering to better inform engineering curriculums. Specific tactics included:

- Bringing the best scholars on engineering education together in workshops to define a research agenda based on how students learn.
- Developing a solicitation to support the research agenda.
- Working with other agencies and ABET, Inc. to implement a new curriculum based on findings of the workshops and funded research.

The second strategy was to attract and retain talented students and faculty, particularly women and underrepresented minorities, to all levels of engineering education. Tactics to implement this strategy included:

- Expanding the RET and REU programs.
- Establishing an AP course in engineering.
- Examining the engineering education culture and pedagogy as a means for increasing diversity.
- Partnering with other agencies in areas of their interest.
- Developing opportunities for networking and mentoring of graduate students.
- UseERC experience for developing a graduate curriculum that focuses on the knowledge and skills all engineering Ph.D.s should possess.
- Investigating a requirement that all ENG grants demonstrate effective mentoring and advisement of graduate students for careers in engineering or academe.
- Developing support networks for women and minority faculty, leveraging CAREER awards.
- Examining new entry paths for women and minorities into the engineering professoriate, either from other disciplines or from industry.

The goal of the fiscal year 2005 plan for organizational excellence was to become the top division at NSF in the development, processing and guiding of engineering programs. The first strategy for achieving this goal was to make full use of all available tools. Tactics to implement this strategy included:

- Examining and developing a plan for electronic processing of all proposals.
- Examining and developing a plan for work distribution that defines primary and secondary responsibilities for all programs.

The second strategy was to develop EEC staff to their full potential. Tactics to implement this strategy included:

- Investigating how staff functions would change to use new systems and develop new responsibilities accordingly.
- Ensuring that staff members take full advantage of professional development opportunities.

APPENDIX C
EEC PROGRAM ASSESSMENTS

Program Evaluations and Studies Conducted by EEC: 1990 to March 2007			
Title	Initiator(s); Year Completed	Purpose	Use of Results
EEC Studies			
1. Engineering Research Centers Studies			
Industry Perceptions of ERC Graduates: An Examination of Employers of ERC Graduates. Evaluating outcomes in science education: A survey of employers of NSF center graduates PI: Craig Scott, University of Washington	ERC Program 1990	The purpose was to examine employers of ERC graduates of four ERCs. Employers reported that ERC graduates are generally better at demonstrating key skills than are non-ERC graduates from otherwise comparable institutions. Also, ERC graduates tend to demonstrate greater understandings of concepts that are important to industry than do non-ERC graduates from otherwise comparable institutions.	Results and recommendations were presented at the 1991 ERC meeting in Boulder, Colo.
Job Performance of Graduate Engineers who Participated in the NSF ERC Program Results in Chapter 5 of http://www.nsf.gov/pubs/1998/nsf9840/nsf9840.htm Conducted by Abt Associates PI: Stephen Fitzsimmons	ERC Program 1996	Study of former graduate students at the first 14 ERCs to evaluate the impact of the ERC research and education experience on the effectiveness of masters and doctoral graduates working in industry, academia, and other sectors relative to contemporaries.	Results presented at ERC Annual Meeting; initiated Student Leadership Councils at all ERCs to provide center identity and cohesion to students involved in ERCs; initiated Student Retreat day at the ERC Annual Meetings; provided each center with center-level results and study briefing materials to help ERCs enhance the impact on students of ERC involvement.
The Impact on Industry of Interaction with Engineering Research Centers http://www.sri.com/policy/stp/erc/ Conducted by SRI International PI: Cathie Ailes	ERC Program 1997	Identify the types of results and value to industry of interaction between ERCs and their industrial sponsors; determine which types of interaction are most useful to industry, estimate the frequency of occurrence of the most useful types in different settings, and examine the process by which firms make use of results of ERC research.	Results presented at ERC Annual meeting; Initiated training visits to Industrial Liaison Officers (ILOs) at new ERCs by experienced ERC ILOs to jumpstart development of strong industrial partnerships; Provided each center with center-specific results and study briefing materials to enhance impact of industry partnerships.
Documenting Center Graduation Paths Two annual reports Conducted by SRI International PI: Cathie Ailes	ERC Program 1999, 2000	Evaluate the extent to which centers that graduate retain the characteristics that made them ERCs, e.g., engineering systems approach to research, interdisciplinarity, industrial collaboration, testbeds, team-based research, and involvement of graduate and undergraduate students in ERC activities.	Results presented at ERC Annual Meeting and provided to centers to use with their industrial partners; caused introduction of required graduation plan in 6th year renewal proposals; focused attention on importance of university support in retention of ERC education an outreach activities after graduation.

The Impact on Institutions of Hosting and ERC Report Conducted by SRI International PI: Cathie Ailes	ERC Program 2001	Examine the extent to which the ERC awards were agents of change in the awardee engineering schools, particularly through the emphasis on being interdisciplinary, on undergraduate research, and on long-term collaborations with industry.	The results pointed to the engineering education impacts as being often the most profound. This was important in light of results of the ERC Graduation studies that pointed to ERC education programs being the most vulnerable when centers moved to self-sufficiency. The centers have been made aware of the need to prepare for the education programs, not just the research, to be self-sufficient.
An Analysis of Industry Support for the NSF's Engineering Research Centers Results in Doctoral Dissertation of Jonathon Tucker PI: Christopher Hill, George Mason University	ERC Program 2003	As follow-on to grant research funded by the Science and Technology Studies program in SBE, the project team examined the veracity of prevailing views among ERC personnel that industry funding was scarce and only available for short-term proprietary research.	The study identified important differences among ERCs and the technology sector and characteristics of firms that were most likely to be interested in supporting the centers. The most important distinction among ERCs was whether they were paradigmatic — working in mature technical areas of interest to large, established firms—and pre-paradigmatic—centers working in new areas not relating to existing firms' product lines or established firms with a tradition of R&D support. Subsequent studies of the ERC Program have used this distinction in designing studies and analyzing results. This study's findings were also instrumental in explaining in a policy paper to the DRB the need for expecting differing levels of industrial support to ERCs based on the characteristics of each center and the firms that would be attracted to it.
The Economic Impact on Georgia of Georgia Tech's Packaging Research Center Report Available Conducted by SRI International PI: David Roessner	Georgia Research Alliance 2004	Evaluate the Direct and indirect economic impact of the investment in the NSF Packaging Research Center, an ERC at Georgia Tech, on the state of Georgia.	Found a 6 to 1 direct economic impact on Georgia as a result of a $32.5 million investment in the PRC by the Georgia Research Alliance. Direct impact from jobs created spin-off and spin-in companies, jobs created, technical assistance to GA companies, cost savings to GA firms by hiring PRC grads, benefits to member firms
The Impact on Industry of Interaction with ERCs, Repeat Study Report in Word Conducted by SRI International PI: David Roessner	ERC Program 2005	Examine how member firms in mature second-generation ERCs benefit from ERC collaboration and underlying dynamics that affect if/how firms are positioned to take advantage of ERC research, students, emerging technology, engineered systems, etc.	A comparison of results from this study and the original study of first-generation ERCs is in progress. The results will be provided at the 2004 ERC annual meeting and the base study results were provided at the 2003 meeting at the invitation of the ERC Industrial Liaisons, who use them to assist in positioning their centers to attract more firms and to inform their Industrial Advisory Boards about program-level impacts on industry.
Report on Knowledge Transfer Activities in Connection with Nanoscale Science and Engineering Report Conducted by SRI International PI: David Roessner	NSF-wide Nanoscale Science and Engineering (NSEC, NIRT,NCN 2006)	Provides a comprehensive evaluation of quantitative outputs related to the research, collaborations, economic impacts, interdisciplinary nature, education and training, and the societal, ethical, environmental, health, and safety implications of the NSF NS&E Programs	**Completed in December 2006**
ERC Strategic Planning Best Practices Report in draft PI: Steve Currall, Rice University	ERC Program underway	Grant to business school faculty members to determine how the ERC Program's three-plane strategic planning construct is used in ERCs and to determine lessons learned to strengthen ERCs and the ERC Program	**in progress**

ERC Economic Impact Conducted by SRI International PI: David Roessner	ERC Program underway	Study of the state economic impacts of Georgia Tech's Packaging Center, commissioned by the state of Georgia, is being expanded by the ERC Program to examine the regional and national economic impact of three graduating and graduated ERCs.	**in progress**
International Study of Research Centers Programs Similar to the ERC Program Conducted by STPI/IDA PI: Bhavya Lal	ERC Program underway	To study the operating characteristics of centers established around the world in configurations similar to ERCs to determine best practices for the ERC Program	**in progress**
2. Education Programs Studies			
Progress of the Engineering Education Coalitions Program http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf00116 Conducted by SRI International PI: Cathie Ailes	Engineering Education Program 2000	Examine the results of the program within the participating universities and more broadly after first five years of operation and identify areas in which improvements could be made.	Study took place after decision to make no more awards was made. Study results used to focus final years of the Coalition awards on identifying the best curricular products, evaluating them, implementing them beyond the originating institution, and dissemination of them beyond the originating Coalition.
CRCD Evaluation pilot test Hardcopy Report Conducted by Abt Associates PI: Stephen Fitzsimmons	EEC Education Program 2000	Examine how successful awards in the first three award years, FY 1992-94, had been in developing and implementing courses and curriculum that improve and make more relevant the content of engineering courses and serve as a means to engage and retain students in engineering degree programs.	Curricular materials developed by early awardees were provided for evaluation to an expert panel convened by the contractor. Not all awardees had materials to provide, so the project shifted to be a pilot test of the methodology, since there had been no previous study conducted in this fashion with EEC-funded engineering education curricular materials.
3. Human Resources Programs Studies			
Graduate Engineering Education (GEE) Traineeship Program Hardcopy report Conducted by Abt Associates PI: Ellen Schiffer	EEC Human Resources Program 2000	The goal was to learn what institutional collaborations brought about increased production of doctorates to women and underrepresented minorities.	This study was conducted after GEE was discontinued due to the creation of the NSF-wide IGERT program. However, the final report was very useful to program officers in EHR's HRD division who were beginning to fund similar collaborations to increase the production of doctorates to underrepresented groups and wanted understand what worked and what didn't work as well with collaborations funded by GEE in terms of achieving the goal of increasing doctorates to underrepresented groups.
Evaluation of the Research Experiences for Teachers (RET) Program: 2001-2003 Awards http://www.sri.com/policy/csted/reports/university/documents/reteval2005.pdf Conducted by SRI International PI: Susan Russell	EEC Human Resources Program 2005	Study the first three years of the RET Site and Supplement mechanisms to determine what the teachers did and circumstances that correlate with clear impact of the RET experience on the content and methods of teaching.	Results about duration of average RET experience, nature of activities, and extent of follow-on relationship during academic year led to changes in the RET program announcement and subsequent funded awards.
Evaluation of ENG's Research Experiences for Teachers (RET) Program, 2001-2005 http://www.sri.com/policy/csted/reports/university/documents/RET2%20FINAL%20REPORT%20June%2030%2006.pdf Conducted by SRI International PI: Susan Russell	EEC Human Resources Program 2006	Study covers awards in FY 2004-2005 to build trend data and to examine the results of changes to the RET program solicitation made as a result of the study of 2001-2003 awards. In addition, the study analyzes data from all four initial award years: 2001-2005.	Review criteria for proposals and subsequent program announcement updated.

Evaluation of the Research Experiences for Teachers (RET) Program: Second Follow-on Study Conducted by SRI International PI: Susan Russell	EEC Human Resources Program underway	The program director wanted to see whether changes to the annual program announcement and review criteria were bringing about the desired changes in what teachers did during and after RET and whether teachers and their RET PIs were building durable relationships between the teachers' schools and PIs' school or department for the benefit of the students.	**in progress**
Evaluation of the NSF-NIBIB Bioengineering and Bioinformatics Summer Institutes (BBSI) Program Conducted by SRI International PI: Jongwon Park	EEC Human Resources Program; NIH/NIBIB underway	Examine the activities of undergraduate and graduate students involved in the first group of three-year BBSI awards that provide intensive summer research and classroom education in the emerging areas of bioengineering and bioinformatics, the effect of the students' experiences on career decisions, and whether some aspects of the program's design were more successful than others.	**in progress**
Evaluation of the Research Experiences for Undergraduates (REU) Program in the Directorate Conducted by SRI International PI: Mary Hancock	EEC Human Resources Program; O/AD	Program directors wished to learn details about the undergraduate research experiences they were supporting across engineering and in a variety of academic research settings, e.g., similarities and differences across settings, institution size, students' home institution size and nature, recruitment patterns and student selection criteria.	**in progress**

APPENDIX D
CONNECTIONS AND RELEVANCE OF EEC PLANS

2004 EEC Committee of Visitors (COV) Report

In March 2004, a Committee of Visitors evaluated the processes, outcomes and direction of EEC programs. In order to best respond to COV findings, EEC summarized and grouped the 27 COV findings into eight broad findings/recommendations that captured the essence of the resulting COV report. Of those eight findings, four relate directly to EEC Division Plan initiatives.

2004 COV Finding	2007 EEC Division Plan Initiative
Finding 3: The COV found that the EEC portfolio of awards is consistent with program guidelines and reviewer recommendations. While praising the ERC program for its innovative awards, integration of research and education, and identification and support of new investigators, the COV recommends that smaller, interdisciplinary teams be funded in preference to increasing the size of individual ERC awards.	This division plan proposes to hold small center EPSCoR competitions. These centers would be smaller in scale, timeline and funding than the traditional ERCs but still maintain the ERC feature of interdisciplinary research, focused on engineered systems.
Finding 5: The COV observed that the majority of EEC awards are to research-intensive institutions and that more capacity needs to be built at other institutions.	The small center EPSCoR competitions should allow traditionally non-research intensive institutions to build their research capability.
Finding 6: The COV recommends that EEC undertake a comprehensive study to answer the following questions: What will ERCs look like in 5 to 10 years? What are the overarching goals of the EEC Education and Human Resources Development Programs?	ERCs have issued a new Generation III solicitation and EEC plans EPSCoR competitions for ERCs. This plan sets goals to increase the number of students matriculating in engineering programs and to increase the percentage of students completing engineering degrees and going on to graduate study.
Finding 7: The COV requests that increased attention be paid to planning and assessment of the education and human resource assessment programs, including cross-project evaluation.	SRI International study of the Engineering RET Program in 2004 and 2006: http://www.sri.com/policy/csted/reports/university/index.html#ret2006. The NIBIB-NSF Bioengineering and Bioinformatics Summer Institutes (BBSI) Program evaluation is due in the summer of 2007.

ENG 2005 Division Plan and 2007 EEC Plan

The 2005 Directorate for Engineering Division Plan focused on five overall goals:

1) Effectively invest in frontier engineering research that has potential for high impact in meeting national and societal needs;
2) Effectively invest in fundamental engineering innovation that has potential for high impact in meeting national and societal needs;
3) Effectively invest in frontier engineering education and workforce advancement that has potential for high impact;
4) Effectively invest in and seek partnerships to educate the public about the values of engineering research and education; and
5) Effectively organize the directorate to provide agile, multidisciplinary leadership in engineering research and education.

The 2007 EEC objectives connect very well with the goals of Fundamental Engineering Innovation (2) and Frontier Engineering Education (3).

2005 ENG Plan	**2007 EEC Plan**
(b) Fundamental Engineering Innovation	(4) Build a culture of Discovery and Innovation in Engineering through Multidisciplinary Centers. • Develop a special EPSCoR ERC competition
(c) Effectively Invest in Frontier Engineering Education. • Increase K–2 support by 25% • Ally with partners to revamp engineering education • Increase participation by women, minorities and the disabled	(1) Enhance the K–12 pipeline. (2) Promote the success of the undergraduate learning experience.

NSF 2006 –2011 Strategic Plan

The fundamental theme of the latest NSF Strategic Plan is "Investing in America's future." It recognizes that scientific and engineering discoveries are taking place at an *accelerated pace* and that such discoveries are occurring in a *dynamic, complex and competitive international environment*. To meet these challenges, the strategic plan is designed to provide leadership in sustaining the nation's competitive edge through innovation, exploration and ingenuity. As the plan covers the entire NSF, only those goals that are relevant to EEC division are identified.

<u>Overall Relevance to EEC Vision and Mission</u>

The EEC mission of "Supporting the development of creative, innovative, and globally competitive engineers" closely aligns with the overall NSF strategic plan and its two cross-cutting objectives ***"****To Inspire and Transform"* and "*To Grow and Develop."*

NSF has specifically identified four areas for increased emphasis and additional funding. These are compared with EEC objectives:

<u>NSF Strategic Plan</u>	**<u>EEC Objectives</u>**
Discovery Promote transformational, multidisciplinary research, investigate human and social dimensions of new knowledge, further U.S. economic competitiveness	Build a Culture of Discovery and Innovation in Engineering through multidisciplinary centers.
Learning Improve K-12 teaching, advance the fundamental knowledge base on learning, develop methods to effectively bridge critical junctures in STEM education pathways, prepare a diverse, globally engaged STEM workforce, integrate research with education, and build capacity.	Enhance the K–12 pipeline; Promote the Success of the undergraduate learning experience
Research Infrastructure Fill the gaps in *enabling research infrastructure*, and strengthen the *nation's collaborative advantage* by developing unique networks and innovative partnerships.	Formalize partnerships with organizations both within and external to NSF

Stewardship Strengthen the traditional partnerships and develop new collaborations with other agencies, organizations and corporations, identifying common goals that can unite and focus partnerships, expand efforts to broaden participation from underrepresented groups and diverse institutions.	Formalize partnerships with organizations both within and external to NSF; Develop EEC team capabilities

NSF Fiscal Year 2008 Budget

The following chart shows how the objectives of the 2007 EEC Division Plan are connected to the ENG and NSF budget themes in the recently announced NSF budget for fiscal year 2008. Among the six objectives of the EEC Plan (see Executive Summary), Objectives (1), (2), (4) and (5) are especially relevant.

NSF FY 08 Budget Emphases	**2007 EEC Plan**
NSF: "…the agency will use the funds to build on recent advances and to support promising initiatives to strengthen the nation's capacity for discovery and innovation."	(4) Build a culture of discovery and Innovation in our Engineering Research Centers: • Transition ERC to Gen-3 (5) Formalize Partnerships with both external as well as internal NSF organizations: • Transition IREE from EEC pilot to regular program.
NSF: "NSF works at the frontier of knowledge where high risk, high-reward research can lay the foundation for revolutionary technologies and tackle difficult problems that challenge society…"	(4) Build a culture of discovery and innovation in our Engineering Research Centers: • Focus Gen-3 ERCs and NCN on revolutionary technologies (5) Formalize partnerships with both external as well as internal NSF organizations: • Emphasize research and education related to revolutionary technologies in IREE partnerships with ENG divisions.
NSF: "…the new budget emphasizes new research on.…international collaborations."	(4) Build a culture of discovery and innovation in our Engineering Research Centers:

	• Support international partnerships in Gen-3 ERC; add foreign core partners into Gen-2 ERCs. (5) Formalize partnerships with both external as well as internal NSF organizations: • Support international partnerships through IREE
NSF: “International partnerships allow U.S. students, scientists and engineers to stay knowledgeable about new concepts and technologies emerging around the world, and provide the experience needed to operate effectively in from different nations and cultural backgrounds.”	(5) Formalize Partnerships with both external as well as internal NSF organizations: • Support international partnerships jointly with OISE and ENG divisions through IREE.
ENG: “Discovery Research for Innovation.”	(4) Build a culture of discovery and innovation in our Engineering Research Centers: • Enhance NCN • Fund Gen-3 ERCs (5) Formalize partnerships with both external as well as internal NSF organizations: • Emphasize discovery research in IREE partnerships with ENG divisions.
ENG: “National Nanotechnology Initiative.”	(4) Build a culture of discovery and innovation in our Engineering Research Centers • Enhance NCN (5) Formalize Partnerships with both external as well as internal NSF organizations: • Enhance IREE funding in nanotechnology-related research through partnerships with ENG divisions.
ENG: “ENG is uniquely able to integrate research, education, and innovation…”	(5) Formalize partnerships with both external as well as internal NSF organizations: • Increase EEC emphasis on integration of research, education and innovation through Gen-3 ERC, IREE and NSEC programs.
ENG: “Preparing the Workforce of the 21st Century”	(1) Enhance the K–12 pipeline: • Strengthen RET

	(2) Promote the success of the undergraduate learning experiences: • Strengthen EEP, REU, NUE, BBSI • Strengthen IREE partnerships with ENG divisions.

American Competitiveness Initiative **(ACI)**

Education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy. For the United States. to maintain its global economic leadership, we must ensure a continuous supply of highly trained mathematicians, scientists, engineers, technicians, and scientific support staff as well as a scientifically, technically, and numerically literate population. Recognizing the critical importance of science and technology to America's long-term competitiveness and building on previous efforts, in February 2006 President Bush introduced the *American Competitiveness Initiative (ACI)*, an aggressive, long-term approach to keeping America strong and secure by ensuring that the United States continues to lead the world in science and technology.

ACI	**2007 EEC Plan**
Overall Theme of ACI An overall theme of ACI is that the environment for innovation within the United States must be strengthened so that the American economy remains the most flexible, advanced and productive in the world. ACI describes education as key to this: "Education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy." ACI's proposed initiatives will help the nation's science, technology, engineering and mathematics workforce prepare for the 21st century, improve the quality of math and science education in U.S. schools, and prepare our citizens to compete more effectively in the global marketplace.	(1) Enhance the K–12 pipeline • Research Experiences for Teachers (RET) sites program (2) Promote the Success of the Undergraduate Engineering Learning Experience • Research Experiences for Undergraduates (REU) Sites Program • Nanotechnology Undergraduate Education (NUE) Program • NIBIB-NSF Bioengineering and Bioinformatics Summer Institutes (BBSI) Program • Engineering Education Program (EEP) (4) Build a Culture of Discovery and Innovation in our Engineering Centers: • Generation Three (Gen-3) Engineering Research Centers (ERC) Program (5) Formalize Partnerships with both External as well as Internal NSF Organizations: • International Research and Education in Engineering (IREE) supplements
Goals of the American Competitiveness Initiative (ACI)	(1) Enhance the K-12 Pipeline (2) Promote the Success of the Undergraduate

- **300** grants for schools to implement research-based math curricula and interventions; - **10,000** more scientists, students, post-doctoral fellows, and technicians provided opportunities to contribute to the innovation enterprise; - **100,000** highly qualified math and science teachers by 2015; - **700,000** advanced placement tests passed by low-income students; and - **800,000** workers getting the skills they need for the jobs of the 21st century.	Engineering Learning Experience (3) Improve the Pathway into Graduate Programs for US and Permanent Residents (4) Build a Culture of Discovery and Innovation in our Engineering Centers (5) Formalize partnerships with both external as well as internal NSF organizations: • Develop partnership with FIRST Robotics to enhance NSF's role in the K-12 pipeline into engineering schools • Foster a working relationship between engineering schools and school principals/superintendents to include ordinary "Supply-Chain" relationships in the K-12 pipeline • Help organize an Engineering Undergraduate Associate Deans Council to catalyze and implement engineering education research and innovation

Rising Above the Gathering Storm

In 2006, the National Academies was charged by Senator Lamar Alexander and Senator Jeff Bingaman of the Committee on Energy and Natural Resources to respond to the following questions:

> *What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of those actions?*

Ten weeks later, in October 2006, the National Academies Committee on Prospering in the Global Economy of the 21st Century released its findings to this charge under the title *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* This document defines the policy implementations that are necessary if America is to play any role in the face of rapidly changing market forces which are moving jobs to countries with less costly, often better educated, and more highly motivated work forces. Other factors that impact this jobs exodus are the fact that there has been a steady erosion of the U.S. scientific and technological building blocks that spanned our economic leadership and the presence of more friendly tax policies for businesses in other countries. The committee's biggest concern is that these factors will contribute to an abrupt loss of U.S. scientific leadership which, at a time when many other nations are gathering strength, can have dire economic consequences for the U.S.

To mitigate the negative consequences of these trends, the committee found that there are two major challenges that must be met:

- Creating high-quality jobs for Americans.
- Responding to the nation's need for clean, affordable, and reliable energy.

To meet these challenges, the committee defined four key recommendations which are summarized in the first column of the table below. The next six columns link the Recommendations with the EEC Objectives defined in the introduction.

***Rising Above* Recommendations**	**EEC Objectives**
Increase America's talent pool by vastly improving K-12 mathematics and science education	(1) Enhance the K-12 pipeline
Sustain and strengthen the nation's commitment to long-term basic research	(2) Promote the Success of the Undergraduate Learning Experiences (3) Improve the Pathway into Graduate Programs for US Students and Permanent Residents
Develop, recruit, and retain top students, scientists, and engineers from both the U.S. and abroad	(2) Promote the Success of the Undergraduate Learning Experiences (3) Improve the Pathway into Graduate Programs for US Students and Permanent Residents (4) Build a Culture of Discovery and Innovation in our Engineering Centers
Ensure that the United States is the premier place in the world for innovation	(4) Build a Culture of Discovery and Innovation in our Engineering Centers

It is noted that the first three recommendations set forth by the Committee on Prospering in the Global Economy of the 21st Century have been integral parts of the Engineering Research Center's Program structure for years. In addition, the 2007 release of the ERC's Gen-3 solicitation has added a new element aimed at enhancing the rate of innovation of the ERC technologies. Consequently, the fourth recommendation from the Rising Storm is now an integral part of the EEC objectives as well.

Educating the Engineer of 2020

This monograph was published through the efforts of the National Academy of Engineering in 2005. The monograph includes 10 recommendations. Five of these 10, shown below as (a) – (e), are directly related with EEC Division Objectives (1) – (5) as follows:

2020 Engineer Recommendation	**EEC Objective**
(a) "Colleges and Universities should endorse research in engineering education as a valued and rewarded activity for engineering faculty and should develop new standards for faculty qualifications."	(2) Promote the Success of the Undergraduate Learning Experiences
(b) "Institutions should encourage domestic students to obtain MS and/or PhD degrees."	(3) Improve the Pathway into Graduate Programs for U.S. Students and Permanent Residents
(c) "The engineering education establishment should participate in efforts…… to improve math, science and engineering education at the K-12 level."	(1) Enhance the K-12 pipeline.
(d) "The National Science Foundation should collect data on program approach and student for engineering departments outcomes /schools so that prospective freshman can better understand the "marketplace" of available engineering baccalaureate programs."	(5) Formalize Partnerships with both external as well as internal NSF organizations.
(e) "Institutions should take advantage of the flexibility inherent in EC 2000 accreditation criteria of ABET in developing curricula, and students should be introduced to the "essence" of engineering early in their undergraduate careers."	(4) Build a Culture of Discovery and Innovation in our Engineering Centers