ENGINEERING EDUCATION AND CENTERS

Directorate for Engineering

National Science Foundation

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Executive Summary

The Engineering Education and Centers (EEC) Division provides support in two main areas, research centers and programs based on partnerships between government, academe, and industry, and research and support for engineering education and human resource development aimed at developing the nations engineering workforce. EEC has three characteristics that make it unique among the divisions in the Engineering Directorate. First, EEC serves no particular disciplines or research communities but instead supports multidisciplinary research teams that address the frontier that exists at the boundaries between disciplines. This research is also unique in its emphasis on the development engineered systems that exist at these multidisciplinary research frontiers. Second, while all divisions of the directorate are implicitly involved in the development of engineering faculty and students, EEC has explicit responsibility for advancing engineering education, at all levels. How young people come to engineering, and advance through undergraduate and graduate study, is a principle responsibility of EEC programs. Finally, because of its long history involvement with research centers, EEC personnel have developed expertise in the management of large programs.

EEC's strategic plan addresses the two areas principle areas of its programs, Centers, and Engineering Education and Human Resource Development, as well as its operational processes. In Centers, the plan calls for an examination of the basic underlying assumptions upon which the centers were developed. When both the I/UCRC and ERC programs were developed, it was felt that there was a national need to improve the competitiveness of U.S. industry in response to perceived threats from foreign competition. Additionally, it was felt there was a need to have universities pursue interdisciplinary research, and that the disciplinary structure of a university posed a barrier to this type of work. The solution revolved around NSF serving as a catalyst for bringing universities and industry together, while also providing an incentive for universities to establish large, multidisciplinary activities on their campuses. After 20 years of success, the programs' assumptions need to be revisited in light of today's global environment, and a program defined that addresses the new competitive challenges that are emerging from the large political, technical, and economic changes that are emerging. This review will be done both internally and externally.

In Engineering Education and Human Resources, the division has played a leading role in the directorate's Engineering Workforce Study and has used the results of that work to guide its future plans. The development of a strong engineering workforce is a major element in this nation's ability to continue as a world leader in technological innovation, a major source of the nation's economic well-being. The plan addresses the engineering workforce at all levels, attracting talented students to engineering particularly women and minorities, graduating globally competitive and innovative undergraduate and graduate engineers, and diversifying the engineering faculty. This will be done strategically by first investing in existing programs that have been shown to be effective in developing students for engineering, serving as a catalyst to develop a community of scholars devoted to understanding how students learn engineering, and developing programs that attract and retain women and minority faculty in engineering.

In the division operations area, we will examine our internal processes and deploy the available tools that will maximize our effectiveness in reviewing and processing proposals. We will also ensure that all staff will take advantage of available professional development activities.

Introduction

The Engineering Education and Centers (EEC) Division (http://www.eng.nsf.gov/eec/) was formed in 1992 by the merger of the pre-existing Engineering Infrastructure and Engineering Centers Divisions. EEC programs enable faculty and teachers to continuously transform the engineering education and research enterprise to fulfill changing economic, social and technological needs, in partnership with government and the private sector. This adaptation is required to ensure the availability of an abundant, diverse and highly capable technical workforce. It is achieved through the exposure of students at all levels to engineering innovation involving design and discovery through research, and through the introduction of new learning theories and emerging scientific disciplines into engineering curricula. In our research centers, grade school students and teachers and doctoral candidates experience the generation of fundamental knowledge, new invention and commercial products. The stream of advanced technologies emanating from EEC centers is carried into industry by new generations of graduating engineers who have learned the skills needed to be effective leaders in technology innovation in collaboration with the help of faculty and partners from industry.

Overall, the EEC division leads the Engineering Directorate in

Multidisciplinary engineering research

Transforming programs for the future of engineering education and the development of a technically agile and productive workforce

Enabling engineering research center programs and inventive engineering research infrastructure, and

Development of innovative, productive and globally competitive partnerships with industry.

Engineering Education and Centers Division (EEC) programs are the focal point for integrating across the other discipline-based divisions while complementing the research and education portfolios of the other divisions of ENG. Its programs benefit from a scope encompassing all of engineering and a scale that both facilitates the incorporation of new scientific disciplines into engineering and requires rigorous monitoring and evaluation systems.

EEC has highly developed management and oversight systems and a full-time evaluation officer, responsible for supporting contracts to study the effectiveness of EEC and other ENG programs.

OVERVIEW OF EEC PROGRAMS

The Engineering Education and Centers Division has two major program elements, the Centers programs and the Engineering Education and Human Resource programs. The Centers have as a central theme the partnership of NSF with industry and academe, the Engineering Research Centers, the Industry/University Cooperative Research Centers, and the Partnerships for Innovation. Their relationship to research and innovation are depicted in Figure 1, and each is discussed in more detail in the following sections. The Engineering Education and Human Resource programs have as their focus the development of new engineering curricula and materials, and the recruitment, development and retention of engineering talent.

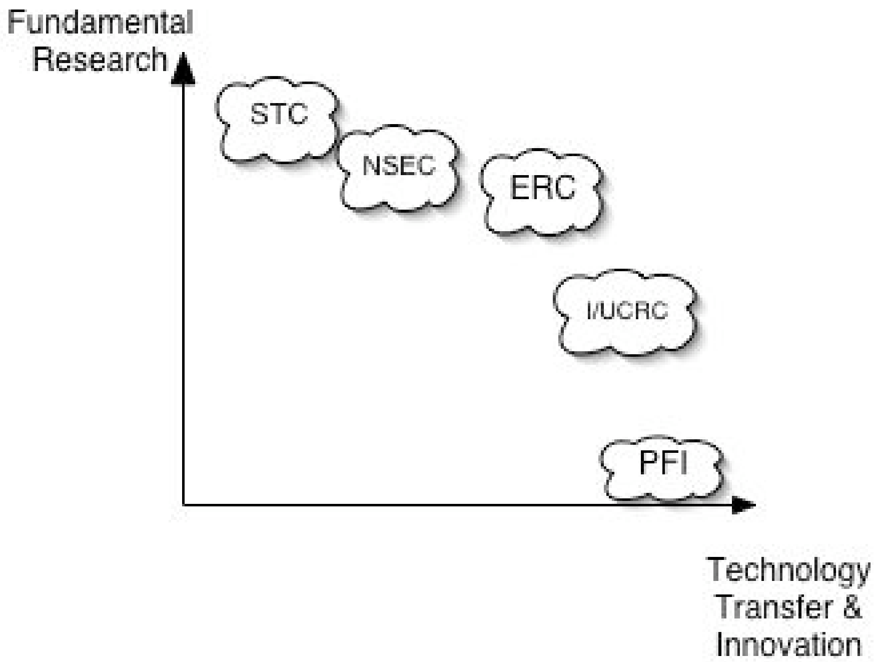


Figure 1: Conceptual map of Centers relative to their activities in fundamental research and technology transfer and innovation.

The total current investment by EEC represented by active awards is about $829M as of December 2004. Table 1 provides a summary of different categories of EEC investments. As expected, our largest investment is in Engineering Research Centers, which account for almost $720M in current awards. Education investments, which include our investments in both engineering education research and reform, and in our human resource development activities such as Research Experiences for Teachers and Research Experiences for Undergraduates, account for about $86M. Awards in other categories,, such as the Partnerships for Innovation program, account for about $23M.

of the current active

Table 1. EEC Investments by Topic, Active awards as of December 2004.

Code	**Count**		**Expected Total $**	% by $
education research	124	$	33,464,780	4%
emerging technology	13	$	16,360,047	2%
engineered systems	25	$	378,622,281	46%
engineering curriculum development	26	$	11,330,552	1%
engineering education	20	$	6,481,725	1%
industry-university research centers	152	$	38,737,576	5%
nanotechnology undergrad ed.	31	$	3,303,913	0%
other	8	$	2,477,541	0%
research centers	18	$	286,101,981	35%
research experiences for teachers	30	$	9,682,936	1%
research experiences for undergraduates	99	$	21,901,735	3%
technology innovation	54	$	20,605,294	2%
Totals	600	$	829,070,361	100%

Summary

Centers:	208	$	719,821,885
Education:	330	$	86,165,641
not Centers or Education	62	$	23,082,835
	600	$	829,070,361

Engineering Research Centers Program

Over the past two decades, the Engineering Research Center Program has become a benchmark for how federal support can create, and foster partnerships between universities, industry, and government that lead to new technologies, engineering processes, and innovative products and services, while also creating a new generation of graduates with skills to be highly effective in academia or industry. The research performed in the ERCs focuses on next generation advances in complex engineered systems important for the nation's future.

The ERC mission has three main elements that must be addressed by each ERC

Cross-disciplinary and systems oriented research

Education and outreach

Industrial collaboration and technology transfer

To be successful, ERCs must develop a vision for the research and develop a strategic research plan that addresses the vision. The research must promote interdisciplinary approaches involving engineering, science, and other disciplines, and be able to cover the continuum from basic discovery to proof-of-concept. The plan must address the long-term involvement of industry partners in both the research and the educational activities, both undergraduate and graduate student involvement, as well as outreach to the K-12 level, and specific goals for diversity must be developed.

The total annual funding for each Center ranges from $3.1 to $19.4 million. NSF's contribution ranges from $2.0 to $2.9 million per year, averaging $2.5 million per year. The major technological areas upon which current ERCs focus are,

Bioengineering
Manufacturing and Processing
Earthquake Engineering
Microelectronic Systems and Information Technology.

In addition, ERC Program Funds have been used to support the engineering based Nanoscale Science and Engineering Centers (NSEC) and the engineering based Nanoscale Interdisciplinary Research Teams (NIRT).

An important feature of the ERC program is the leveraging of NSF funds through the partnership if government, industry, and university, to create a much larger base of research funding than the program could achieve on its own. Figure 2 shows the support from all sources for the 19 ERCs (does not include the EERCs) for FY 2004. The total value of support is $108.8 million, an additional **$48.5 million** in research funds available as a result of NSF's $60.3 million investment.

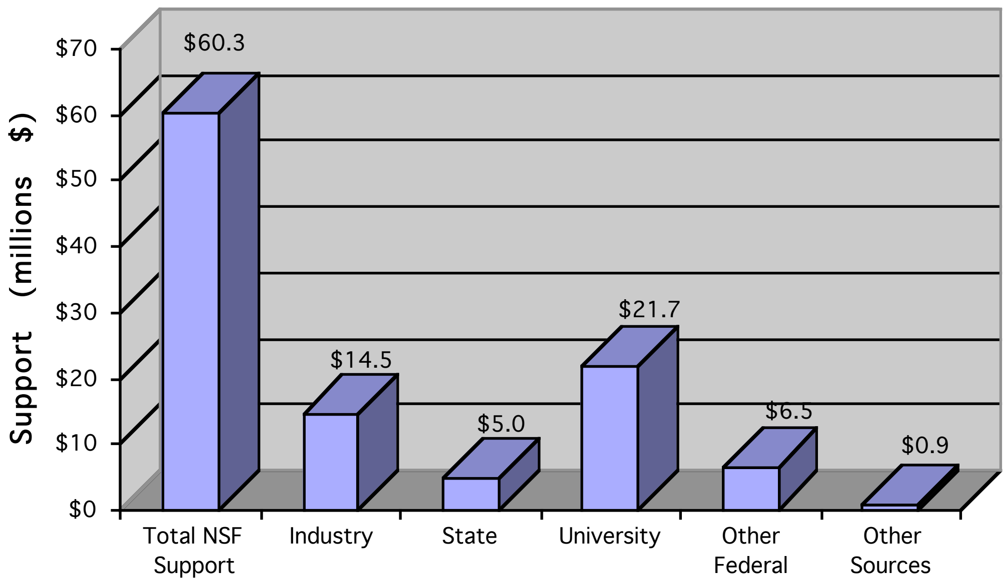


Figure 2: Support from all sources at 19 ERC, FY 2004.

There has been considerable interaction between EEC and the other divisions of ENG, as well as other directorates within the Foundation, in the management and oversight of the various centers. EEC relies on the program directors within all the divisions to assist in proposal evaluation and in Center oversight and management. Because of the requirements for each Center to develop a strong strategic plan, education and outreach activities, there is the need for lead program directors to provide considerable management oversight. This has resulted in most of the Centers having and EEC program director as the lead, However, in those areas where EEC PDs do not have the requisite technical background to evaluate the Center, EEC has recruiting lead program directors from the other divisions or from other directorates, as appropriate. In addition to the lead PD, there is typically a liaison PD from an ENG division or other NSF directorate who provide additional technical support. A table indicating the lead and supporting program directors, and the liaison and EEC management program directors for those Centers that will be continuing through FY 05 is provided in the Appendices.

Industry/University Cooperative Research Centers

The I/UCRC program is also a partnership between universities and industry, with NSF support serving as a cooperative leveraging mechanism. The features of the I/UCRC program are; high-quality, industrially relevant fundamental research, strong industrial support of and collaboration in research and education, and direct transfer of university-developed ideas, research results, and technology to U.S. industry to improve its competitive posture in world markets. Additionally, the I/UCRC program provides a high-quality, interdisciplinary education that has resulted in several thousand M.S. and Ph.D. graduates.

The I/UCRC program with the heavy participation of industry, and in some cases state and federal agencies, is able to leverage by as much as 10 to 15 times the relatively modest NSF investment. There are currently more than 50 Centers, for which NSF's total contribution is about $6M, with funding from other sources totaling more than $70M. The areas currently being addressed by the I/UCRCs are,

Advanced Electronics
Advanced Manufacturing
Advanced Materials
Biotechnology
Civil Infrastructure Systems
Information and Communications
Energy and Environment
Fabrication and Processing Technology
Health and Safety
Quality, Reliability, & Maintenance
System Design and Simulation

As with the ERC program, the I/UCRC partnerships of government, industry and university also leverages the NSF investment into a much more robust funding base than could be achieved by just NSF's investment. Figure 3 shows the various sources and amounts for the more than 50 centers. NSF's total investment of $8.7 millions ($5.0 EEC, $3.7 other NSF), results in a total of **$66.9 million** in additional research support.

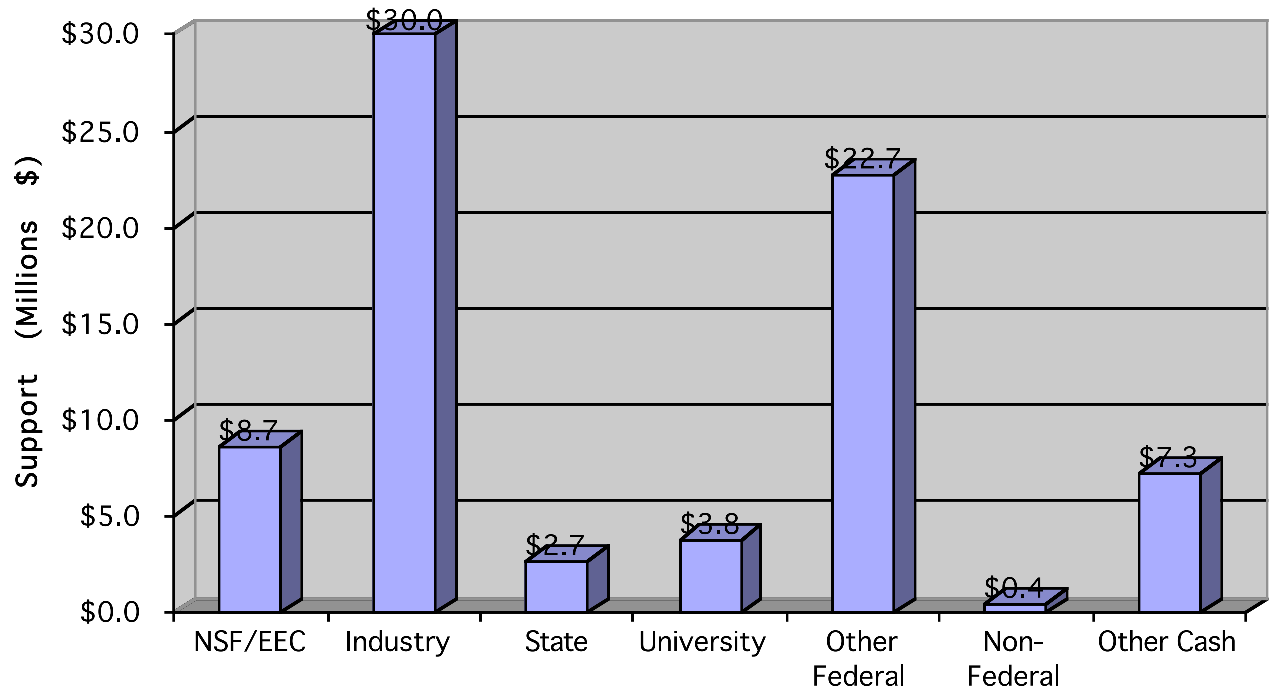


Figure 3: Support from all sources for I/UCRCs, 2002-2003

Partnerships for Innovation

Partnerships for Innovation (PFI) program promotes innovation by bringing together colleges and universities, state and local governments, private sector firms, and nonprofit organizations. These organizations form partnerships that support innovation in their communities by developing the people, tools, and infrastructure needed to connect new scientific discoveries to practical uses.

The goals of the PFI program are to:

Stimulate the transformation of knowledge created by the national research and education enterprise into innovations that create new wealth, build strong local, regional, and national economies, and improve the national well-being;

Broaden the participation of all types of academic institutions and all citizens in NSF activities to more fully meet the broad workforce needs of the national innovation enterprise; and

Catalyze or enhance enabling infrastructure necessary to foster and sustain innovation in the long-term.

Engineering Education

There are two solicitations currently active in engineering education, Engineering Education Program, and Grants for Department Level Reform of Undergraduate Engineering Education Reform. The Engineering Education Program is aimed at increasing the quantity and quality of U.S. citizens earning BS degrees in engineering. The program seeks new cutting edge ideas that will attract and retain students not typically attracted to engineering. This is a wide-open competition searching for creative solutions.

The *Department Level Reform* program is directed at departmental or larger units looking to transform their programs, or develop new curriculums, that will meet the needs of the nation for a vibrant engineering workforce. There are two levels of funding available, a one year planning grant for $100,000, and implementation grants for up to $1M each. A unique feature of the solicitation this year is the emphasis on service learning as an important means to enhance student-learning outcomes. Industry partners have offered their in-kind support for proposals which include a significant service learning component.

In addition to these solicitations, education is also a central part of the ERCs with every ERC having a senior member of the administrative staff serving as the Education Coordinator or Director of Education. Each ERC must develop a strategic plan for education programs which need to include design of an outreach strategy, undergraduate research participation, guidelines for graduate education, courses and curricula derived from the research results, and recruitment and retention plans for underrepresented populations in engineering.

In addition to these two programs, the Division also participates in the following education related programs,

Nanotechnology Undergraduate Education

Centers for Learning and Teaching

Math and Science Partnership

Model Institutes for Excellence

Interagency Education Research Initiative

National Science, Technology, Engineering, and Mathematics Digital Library.

Human Resource Development

The two major programs in Human Resource Development are *Research Experiences for Undergraduates (REU)* and *Research Experiences for Teachers (RET)*. EEC oversees the REU site solicitation for the Engineering

Directorate, which provide research experiences at a site in a single discipline, department, or interdisciplinary research experiences with a strong intellectual focus. A important element of REU sites is the involvement of students in research who might not otherwise have the opportunity, particularly for groups who are underrepresented in engineering.

The Research Experiences for Teachers (RET) activity began in the Directorate for Engineering in December 2000 involving the pairing of individual teachers with NSF grant recipients through supplements. This has quickly expanded to include RET sites (5 to 15 teachers) at nine Engineering Research Centers (ERCs), (including the Washington D.C./Maryland/Virginia regional program involving up to 75 teachers, managed by the Johns Hopkins University CISST ERC, Carnegie Mellon University, AAAS, and the Smithsonian Institution), and 17 RET Site Programs awarded from FY 2002-FY 2004. As a direct result of this expansion process, the teacher's involvement has evolved to include a range of activities directed not only at maximizing the summer research experience, but also at the translation of this experience back into the classroom. The end goal has now been added to affect the performance and achievement of K – 12 students in science, math and engineering through the RET program.

This has meant that groups such as JHU/CMU and others that have developed programs span the simple distributed single investigator model to the site and regional models. Such efforts have begun to redefine the methodology of the RET program to meet the combined teacher /student goals and the need to build the higher education capacity to sponsor such programs without straining the capacity of the faculty / institution.

From the Engineering Directorate's perspective, the RET program would be most effective if engineering research and design curriculum could be used to infuse new pedagogical approaches to the teaching of math, science and engineering within the K – 12 learning community. The programmatic features of the RET must therefore be structured and aligned so that the research and design processes of the higher education partners be systematically blended to the professional development, curricular, and standards objectives of the school district.

Future RET programs therefore might include or at least address several important factors:

- The contextual linking of the summer research experience to specific curricular or problem based learning investigations for the K – 12 classroom;
- The development of a pedagogy that supports the infusion of the engineering domain into curriculum, after school programs, and teacher development activities;
- The establishment of a sustainable post summer program within a given school or district through such programmatic elements as teams of teachers from a given school working together both during the summer and the school year, the involvement of administrators and guidance counselors in the RET, the participation of the PIs and graduate students back in the teachers classroom / school, etc.;
- The application of standardized evaluation and assessment instruments that can be configured for the overall RET program that will facilitate comparisons between various funded projects;
- The development of a Best Practices Manual that could outline specific program elements common to all RET programs, an overview of current NSF programs and materials that could be integrated and translated into new proposals for an RET;
- The teaming of teachers not only with PIs, but also pre-service teachers, graduate students, REU students, and other teachers from the same school / district;

- The provision for training grants to undergraduates and graduate students who would like to work with the teachers during the summer and throughout the academic year;
- The provision for funding for teachers who have graduated from the RET program for funds to both execute programs back into the classrooms and also to organize events like summer camps from their students the next summer; and
- The provision of funds to adequately allow the institutional partners to have an infrastructure required to support the increased requirement of the teachers and the schools for support that stretches well beyond the summer program.

In conclusion, the larger and more extensive RET programs offer opportunities to engage multiple learning communities that can encompass a significant number of participants to create the critical mass within the school districts and higher education to affect meaningful change. However, new RET programs must be able to leverage knowledge and content gained from not only previous RET sites, but also other NSF programs such as Teacher Enhancement, Math and Science Partnerships etc. in such a manner to build capacity to support hundreds of teachers nationally without straining the resources of any one partner.

BUDGET

A summary of the yearly EEC budget is provided in Table 1.

Table 1. EEC Total Budget and Percentage Changes, 2001-2004

	2001	2002	2003	2004	2005 (Plan)	2006 (Req)
Total Budget	109.48	116.47	132.72	134.029	127.057	129.2
Percent Change		6.00%	12.24%	0.98%	-5.49%	1.66%

The average percentage change between the 2001 budget and the 2006 requested budget is 3.08%,

The details of the EEC budgets between 2001 and 2004 are provided in the Appendix.

EVALUATION OF EEC PROGRAMS

The Engineering Research Centers Program began in 1985 and set up a system for post-award assessment and evaluation at that time. Each center provides an annual report on progress and plans, which are assessed by an outside team of experts through the site visit format. These reviews are guided by a uniform set of review criteria that sets a standard for excellent and poor performance for differing stages of development of an ERC. Each center develops a database of indicators to report on progress, impact, and financial management. These data are included in the annual reports and are submitted to an electronic database, where they are available to NSF and the ERCs. Dr. Linda Parker, an evaluation specialist assigned to EEC, periodically carries out program-wide evaluations to determine whether the ERC Program as a whole is effective in achieving its goals. These have included studies of the impact of the ERCs on their member firms, the effectiveness of ERC graduates in industry, the impact of ERCs on their home universities, the variation in industrial involvement in revolutionary and next-generation ERCs. The program uses the outcome of these studies to improve program and center-level execution. For example, one study found that many ERC students did not get enough exposure to working on systems, a key feature of an ERC. That indicator plus concerns at the program level about how effectively ERCs focused on systems led to a change in the strategic planning constructs for ERCs. Studies of student involvement in ERCs led to the requirement that all

ERCs form Student Leadership Councils (SLC). The SLCs are responsible for organizing an ERC's students to be sure that the ERC provides the research and educational experience envisioned by the program goals. The students carry out a SWOT analysis that feeds into the deliberations of the annual review site visit teams and the ERC's management team. The ERC Program's evaluation studies have served as models for other center programs as well. The ERC database has also served as a model for other NSF center programs. Dr. Parker manages data base efforts for the Nanoscale Science and Engineering Centers, the Partnership for Innovation Program, among others.

The Industry/University Cooperative Research Centers (I/UCRC) Program was initiated in the 1970s. Each I/UCRC has an in-house evaluator charged with providing input to the Director and the industrial partners on how to strengthen performance. There is a database of indicators of outcome and impact that is available on-line for program-level reporting and assessments. The I/UCRC Program has carried out numerous evaluations of program effectiveness through an evaluation specialist at North Carolina State University.

Dr. Parker has also carried out several evaluations of the education programs of EEC. An evaluation of the Engineering Education Coalitions Program produced results that were used in developing new engineering education programs as the Coalitions programs. The other studies included assessments of the course materials produced by the Combined Research and Curriculum Development Program led us to better understand the appropriate timing of assessment of curricular materials. There is an extensive evaluation of the Research Experiences for Teachers program underway that will feed into program improvements.

COV RECOMMENDATIONS

In March 2004, a Committee of Visitors (CoV) conducted a thorough review of EEC programs and operations. Their report was forwarded to the Engineering Directorate Advisory Committee and accepted. The CoV found that the ERC program was an excellent performer in all categories of their assessment, and suggested that we develop a vision for the next generation of ERC programs that might diversify the center portfolio by size, areas of innovation, and demographics of researchers and students supported. They felt that the I/UCRC program could use more funding and should try to address support for the underlying fundamental research within the centers

The Engineering Education and Human Resource development programs were also considered to be achieving their goals, but that the engineering education program needed a strategic vision. Additionally, they were looking for evidence that these programs were having a positive impact in promoting diversity, multiculturalism, multidisciplinary, and multi-institutional teams. They also suggested that we consider how our efforts might better support the integration of research and teaching within funded institutions.

Strategic Plan

VISION

An engineering workforce that enables the Nation's future prosperity, health and security, and is the most productive and creative in the global environment.

The Nation's future wealth and security depends upon a strong engineering workforce. Our university system must produce engineering graduates that are prepared to enter a workplace that is more globally competitive and collaborative, more technically interdependent and multi-disciplinary and changes more rapidly than at any time in our history. The future success of the Nations engineering capability will depend on investments NSF can make in helping university systems adapt to these new challenges.

MISSION

The Division of Engineering Education and Centers (EEC) promotes and facilitates university frontier research and transforming curricula through innovative programs focused on multi-disciplinary research, leads the transformation of engineering education, integrates research and education, enhances the quality and quantity of the engineering workforce, promotes new engineering research infrastructure with breadth of investigation spanning discovery through innovation.

STRATEGIC PLAN FOR CENTERS

Goal: Advance the US into new emerging technology areas and maintain international leadership of the US in all technology areas where it has leadership in the research, development and implementation of engineered systems through the partnership of academe, industry non-profit funding agencies, and government.

Research and educational partnerships between universities and industry in the Engineering Research Center (ERC), Industry/ University Cooperative Research Centers (I/UCRC), and Partnerships for Innovation (PFI) Programs improve the quality of the educational enterprise and strengthen the competitiveness of industry and the Nation. These partnerships provide a technology-focused, industry-informed, interdisciplinary environment in which students are educated by, through, and in conjunction with, active participation in the performance of cutting-edge engineering research and technology innovation. The ERC and I/UCRC program each have long history of success that has been based on a clear vision for the Centers, established procedures for managing the center research, and strong oversight by EEC and ENG staff.

With this goal, we intend to ensure that the Centers programs remain as the world leading program in how a partnership of government, academe, and industry can work together to create new technologies, innovations, and a creative workforce.

> **Strategy*: Examine Assumptions underlying the ERC and I/UCRC programs, trends for the future, and define guidelines for configuration of center program of the future.***

We feel that the current constructs for both the ERC and I/UCRC are in need of review and possible reform to position them to be as productive in the next 20 years as they have been in the last 20 to 30 years respectively. Both programs were started when the US was being challenged by Europe and Japan to strengthen the competitive position of US industry through research and a more innovative workforce. They both have succeeded in that goal but the economy has changed in the last 20 years to place the US in a position of competing with a broad base of new and innovative economies (China, Singapore, and India) in addition to continuing competition from European and other Asian Nations. The challenge now is to strengthen the innovative base of the US economy and broaden the education of engineers to include experience in technological innovation and business development. This will require that we explore ways to engage centers in research that is truly transformational or disruptive to current product lines, engage more small, innovative firms in our centers, and provide educational experiences for engineers that focus on innovation and business development.

In addition, looking back at our center programs we see that the social engineering inherent in an ERC has grown significantly in the last 10 years with expectations that now are more befitting for department or engineering schools than a center. We also find that the expectation that ERCs focus on truly transforming or disruptive technologies may be incompatible with the requirement for systems-driven strategic plans where technological goals are within sight enough to plan for realization in 10 years. We believe we need a planning stage before transitioning into the full ERC model for research and innovation. In addition, evaluations indicate that the ERC students who are exposed to the full spectrum of the engineering experience (fundamentals to technological innovation) are more productive in industry. This successful model should be migrated to engineering curricula across the country, not just to the departments associated with ongoing ERCs. The I/UCRCs have proven highly effective over the last 30 years in generating research solutions to near-term industrial needs and also in educating engineers who are very productive in an industrial setting. However, it has become more evident over the last 10 years that NSF support for fundamental research underpinning industry's longer-term needs is not sufficient in these centers. The centers are not able to support the longer-term needs of industry for technological advancement.

The intent here is take a "step-back" and assess these assumptions, and either validate or update as appropriate to ensure that the program continues to have a positive effect on the ability of the nation to continue as a leader in engineering innovation.

The following actions are proposed to implement this strategy.

> **Action:** Investigate a new organization of the centers program that allows for the full range of innovation to occur, from exploratory, high-risk research with the potential for creating new industries, to fundamental research meant to demonstrate proof-of-concept, through to applied research to address more near-term industry needs.
>
> **Action:** Investigate the impact of moving the responsibility for undergraduate and graduate educational initiatives from the centers program to the Engineering Education Program.
>
> **Action**: Develop a Blue Ribbon Panel to review and assess the proposed changes and the underlying assumptions of the ERC current model. Examine the proposed changes in the Centers program, and evaluate them relative to the future environment for engineering innovation.
>
> **Action**: Develop a report by an external contractors (e.g. a WTEC study or other means) on how "center-like" programs are run and operated world-wide and on what technology areas they focus .
>
> **Action**: Develop a vision for centers that will be as effective in the next 15 to 20 years as in the last 20 years. Analyze the positive and negative impacts on universities and NSF of the emerging trend toward multi-university centers.
>
> **Action**: Develop a transition plan to incorporate suggested changes

STRATEGIC PLAN FOR PARTNERSHIPS FOR INNOVATION

> ***Strategy: Build the program on the original foundation of individual grants by supporting groups, centers, and networks to stimulate and sustain innovation in localities and regions throughout the nation. NSF will leverage these efforts by coordinating its activities with complementary efforts of other federal and state agencies..***

In the original strategic plan for PFI, the funding was to increase to $20 million by the third year and $50-100 million by the end of year five. The budget has not increased over the original $10 million, so these activities could not be pursued. However, there have been discussions with the SBIR Program to have a joint PFI/SBIR program solicitation to have proposals jointly reviewed and the winners would receive $700 K from PFI for the academic partner and the small business partners would receive $300 K from SBIR with demonstration of continued collaboration. There was never $3 million extra in the PFI budget to fund this activity. There have been discussions with NIH to have a joint solicitation in the biomedical area with joint funding. NIH would fund any clinical studies and NSF would fund the NSF-like activities. This would require an extra $3 million in the PFI budget. There have been discussions with the Kauffman Foundation to have a joint solicitation to fund 3-6 national innovation networks that would promote innovation/entrepreneurship and do research on the topic to develop effective methodologies for various technology and geographic sectors. Again, an additional $3 million would be needed in the PFI budget. EPSCoR, SBIR and PFI are currently discussing a joint effort. There has always been excellent co-funding of PFI grants with the EPSCoR Program.

Given the following budget levels, the PFI Program could do the following:

$10 million	Maintain the program as it currently operates
$15 million	Start Regional PFI Networks with grant sizes up to $1 million each
$15-20 million	Partner with the Kauffman Foundation and SBIR
$20-25 million	Additional Partnership with NIH

STRATEGIC PLAN FOR ENGINEERING EDUCATION

Goal: 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 in industry, academe, and society.

Sustaining a vibrant engineering workforce will allow us to maintain our leadership position as a world leader in engineering innovation but doing so depends on our ability to attract talented students from all demographic groups and provide them with the knowledge, skills, and experiences that will prepare them for the coming century. As we enter the 21st century, new challenges are developing for engineering graduates and there is a need for the curriculum, both undergraduate and graduate, to keep pace. EEC's Engineering Education and Human Resources research portfolio has been organized around two central strategies,

Development of fundamental research into how students learn engineering education

Attracting talented students, especially women and underrepresented minorities, to all levels engineering education

Strategy: Develop an understanding of how students learn engineering to better inform how engineering curriculums can better meet the growing demands for new knowledge and skills

Through the 80s and 90s, there was a major push by NSF through the Engineering Coalitions Program to reform engineering education, modernize it, and institutionalize the changes. This program met with moderate success and a number of things were learned from the program. Probably the most significant changes occurred in two areas, first,there was a widespread reform of the first-year experience in engineering programs to increase retention, and second, the establishment of engineering education research as an area of scholarly pursuit for engineering faculty (examples include the VaNTH ERC, NAE Center for the Advancement of Scholarship in Engineering Education, and ASEE's Journal of Engineering Education). It is this second outcome that this strategy will concentrate on, and support the establishment of a community of scholars working to develop a fundamental understanding of how students learn engineering. For undergraduate education, the pressure to include new technologies (nanotechnology, biotechnology, complex systems) as well as new skills (leadership, global and social awareness) into the existing four year curriculum has led to resistance and confusion about how to fit this new material into the existing four-year engineering curriculum. Fundamental research is needed to define the fundamental knowledge and skills that an engineer should posses, how they can best learn these skills, and how the engineering curriculum can be structured to make efficient and effect use of university and faculty resources.

Action: Through high-level workshops, bring the best scholars on engineering education together to define a research agenda for engineering education focused on how students learn.

Action: Develop a new solicitation to support the research agenda developed above.

Action: As the research matures, work with other federal agencies, and ABET to define a new engineering curriculum that is based on the research results achieved above.

Strategy: Attract and retain talented students to all levels of engineering education, particularly women and underrepresented minorities. and achieve a diverse engineering faculty and workforce whose demographics more closely mirror that of the general public.

The NSB publication, Science and Engineering Indicators 2004, indicates that at current retirement rates, the S&E workforce will experience rapid growth in total retirements over the next two decades, and without changes in degree production, retirement rates, or immigration, the S&E workforce will grow at a slower rate. Recent trends in engineering enrollment also indicate that there has been a steady decline in engineering enrollments since the mid-80s that has recently increased, but the percentage of engineering degrees produced when measured against the total bachelor degrees has steadily declined. There has also been a change in the U.S. demographics which has seen the percentage of non-Hispanics whites, a traditional source of engineering students, steadily decline (74% in 1984, projected 54% in 2020), while at the same time there has been a rapid growth in non-white population groups, who have historically been traditionally underrepresented in engineering. From the SEI 2004 report,

> *"Even as larger proportions of U.S. citizens avail themselves of higher education, the nation has lost the advantage it held for several decades as the country offering by far the most widespread access to higher education. Starting in the late 1970s and accelerating in the 1990s, other countries built up their post-secondary education systems, and a number of them now provide a first-level college degree to at least one-third of their college-age cohort. There is evidence that many countries are trying to increase production of degrees in NS&E.*

They appear to be succeeding in that goal well beyond what the United States has been able to achieve over the past 25 years."

Overlaid on this is clear evidence that interest in engineering education is declining among white males, and among women, while staying relatively flat in all other groups. With the addition of stricter immigration laws, the influx of foreign students into our programs, particularly graduate programs, has diminished and is not being replaced by natural-born students. All this leads to the conclusion that to maintain a vibrant and creative engineering workforce, we will need to attract more students from those groups that have traditionally been underrepresented in engineering. The actions associated with this strategy will focus on attracting a more talented and diverse student body to engineering education, actions aimed at increasing retention of underrepresented groups in engineering, increasing participation and retention in graduate study by all groups, and diversifying the engineering faculty.

- ***Actions aimed at attracting student to undergraduate engineering***

Action: Expand the Research Experiences for Teachers program.

Action: Establish an Advanced Placement course in Engineering

- ***Actions aimed at increasing retention in engineering education of underrepresented groups***

Action: Examine engineering education culture and pedagogy as a means for increasing diversity

Action: Expand support for REU program. Investigate partnerships with other agencies (e.g. currently DoD supports REU sites with us).

Action: Partner with other agencies in specific areas of their interest to create interest in new areas of engineering (e.g. the BBSI program which focuses on Bioengineering and Bioinformatics)

- ***Actions aimed at increasing participation and retention of all groups in graduate study***

Action: Develop opportunities for networking and mentoring for graduate students

Action: Using the experience gained in the ERC Education programs, investigate the development of a curriculum in graduate study that will focus on knowledge and skills that all engineering Ph.Ds should possess

Action: Investigate the requirement that all ENG grants that support graduate study demonstrate effective mentoring and advisement of graduate students for careers in engineering or academe

- ***Actions aimed at diversifying the engineering faculty***

Action: Develop support networks for women and minority faculty, leveraging CAREER awardees

Action: Examine new entry paths for women and minorities into engineering professorate, either from other disciplines or from industry

STRATEGIC PLAN FOR ORGANIZATIONAL EXCELLENCE

Goal: To become the top division at NSF in the development, processing, and mentoring of engineering programs

Strategy: Make full use of all available tools to increase division effectiveness

Action: Examine and develop a plan for electronic processing of all division proposals

Action: Examine and develop a plan for work distribution that defines primary and secondary responsibilities for all programs

Strategy: Develop EEC staff to their full potential.

Action: Investigate how program staff functions will change as new systems come on and develop new responsibilities accordingly

Action: Ensure that the staff takes full advantage of professional development opportunities

Appendices

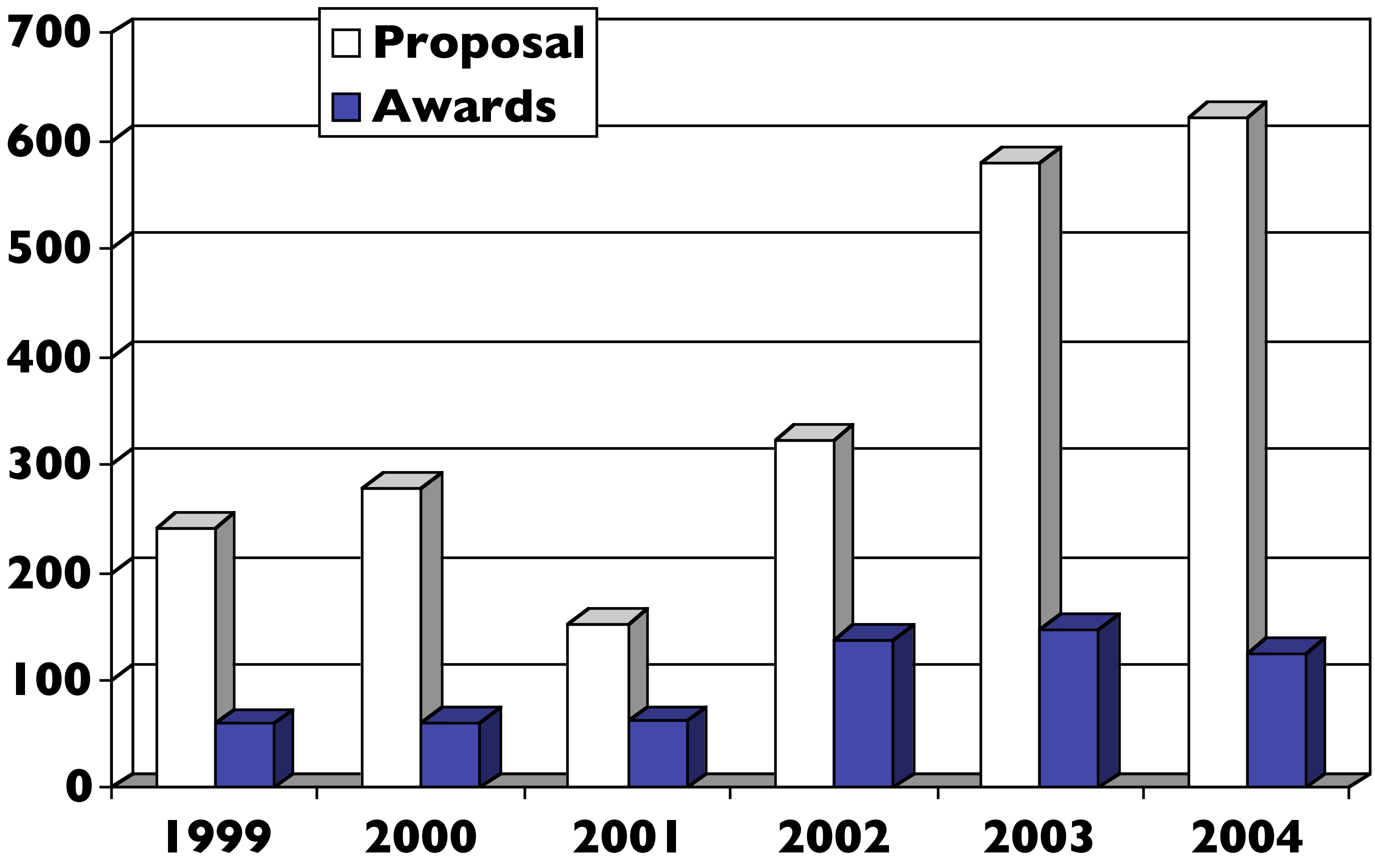
EEC Budgets 2001 - 2004

	2001	2002	2003	2004
	EEC	**EEC**	**EEC**	**EEC**
A. NSF Level				
Nano Solicitation	2,750,000	12,367,712	14,376,196	15,180,000
Nano Education	0	0	950,000	1,500,000
NNUN/NNIN	0	0	0	
BE	0	0	0	
ITR	0	490,000	500,000	500,000
Math Priority Area	0	0	151,667	150,000
HSD	0	0	0	0
CAREER	0	0	0	0
IERI	2,000,000	2,000,000	1,990,000	1,990,000
Science & Technology Center (STC)	0	0	0	0
IGERT	2,980,000	3,860,000	5,220,000	7,750,000
GRF	2,790,000	3,450,000	4,120,000	6,900,000
GK-12	700,000	1,480,000	2,540,000	3,220,000
ADVANCE	0	0	0	0
Subtotal	11,220,000	23,647,712	29,847,863	37,190,000

B.ENG Special Emphasis				
Sensors and Sensor Networks	0	0	0	0
ME Sol.	0	0	0	0
QSB	0	0	0	0
Biophotonics	0	0	0	0
Optech	0	0	0	0
Optical Comms & Networks	0	0	0	0
Organic Electronics, Photonics	0	0	0	0
TSE	0	0	0	0
NTE	0	0	0	0
Phytoremediation	0	0	0	0
Undergrad BME Design	0	0	0	0
SSP (ECS)	0	0	0	0
EPNES (ECS)	0	0	0	0
NSF - Sandia	0	0	0	0
HUD - PATH	0	0	0	0
U.S. - Japan	0	0	0	0
ENG Transport Industries	0	0	0	0
Scalable Enterprise Systems	0	0	0	0
ICIS	0	0	0	0
NISEE	0	0	0	0
EERI	0	0	0	0
CLEANER	0	0	0	0
HNHRA	0	0	0	0
POWER	0	0	0	0
Plasma	0	0	0	0
Mixed Signal	0	0	0	0
PTAP	0	0	0	0

Spin Electronics	0	0	0	0
IOC	0	0	0	0
GOALI	0	0	0	0
Envir. Conscious Manufacturing	0	0	0	0
Scalable Enterprise Systems	0	0	0	0
PREMISE	0	0	0	0
Eng Research Centers	59,459,930	53,802,288	62,593,804	62,780,000
Earthquake ERC's	5,990,000	5,990,000	6,000,000	5,990,000
I/UCRC	5,180,000	5,380,000	5,790,000	6,000,000
S/I/UCRC	900,000	450,000	370,000	300,000
Engineering Education Coalitions	10,370,000	5,400,000	1,600,000	0
BEE	0	2,950,000	1,600,000	0
Department-Level Reform	0	3,000,000	3,940,000	3,690,000
Center for Learning & Teaching	0	880,000	980,000	1,070,000
BBSI	0	0	200,000	100,000
CRCD	2,590,000	1,030,000	1,950,000	680,000
CRCNS				0
NEES Research (NEESR)				0
OAD Special Studies	0	0	0	
Subtotal	84,489,930	78,882,288	85,023,804	80,610,000
C. Supplements/SGERS, etc.				
REU Supplements	0	0	0	
REU Sites	5,990,000	6,740,000	6,910,000	7,000,000
RET Supplements	0	0	0	
RET Sites	0	1,040,000	2,510,000	2,500,000
SGER	0	0	0	
SBIR Phase I	0	0	0	
SBIR Phase II	0	0	0	
STTR	0	0	0	
Subtotal	5,990,000	7,780,000	9,420,000	9,500,000
D. General Tax	882,073	910,000	970,000	772,321
E.Stipends Tax	0	0	0	1,593,825
Subtotal A-E	102,582,003	111,220,000	125,261,667	129,666,146
F. Unsolicited	6,897,997	5,250,000	7,458,333	4,363,188
Total Budget	**109,480,000**	**116,470,000**	**132,720,000**	**134,029,334**

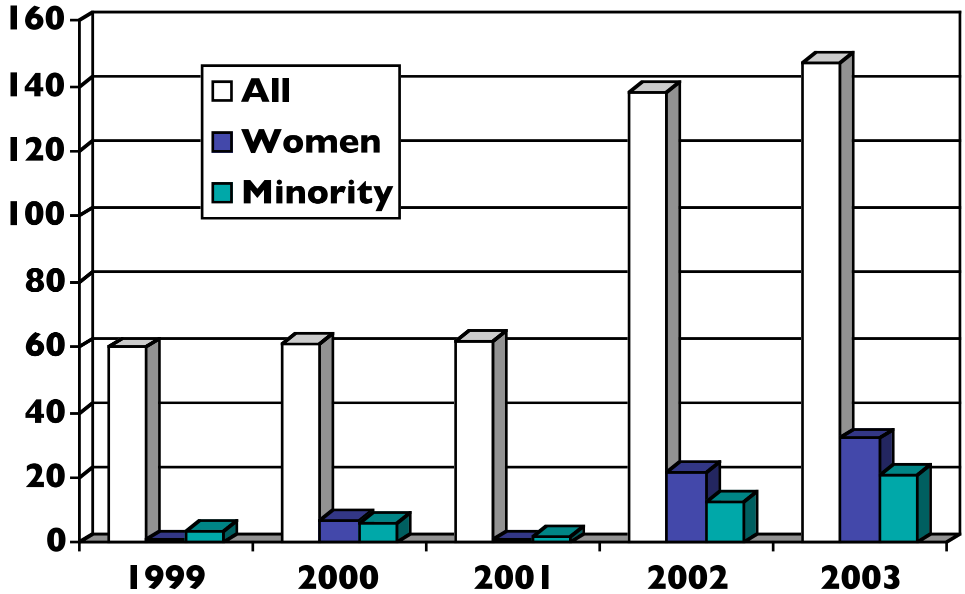
EEC Proposal and Award Activity 1999 - 2004



Award Size

FY	Number of Comp Awards	Annual Median Current $	Annual Median Constant $	Annual Mean Current $	Mean Duration	Active Median $	Active Constant $
2004	120	$100,000	$100,000	$144,154	2.55	$100,000	$100,000
2003	142	$100,000	$100,000	$137,405	2.18	$100,000	$100,000
2002	138	$100,000	$100,000	$133,310	2.40	$99,948	$99,948
2001	63	$72,400	$72,400	$90,774	3.52	$79,139	$79,139
2000	57	$98,717	$100,691	$151,490	2.93	$78,333	$79,900
1999	60	$86,010	$89,020	$102,693	3.55	$74,500	$77,108

Awards to Women and Minorities



ENG Participation in ERCs

The following table shows the lead and supporting program directors assigned to each ERC that will be continuing through FY05. Also shown is the liaison program directors and liaison EEC management.

INSTITUTION	TOPIC	LEAD & Supporting ERC PDs	Liaison PDs & EEC Mgt
Arizona	Environmentally Benign Semiconductor Mfg	Hurt, John	None
Clemson	Fibers & Films	Bruce Kramer	Glen Schraeder (CTS)
Colorado Statei	Extreme UV ERC	Bartoli, Fil (ECS)	Denise Caldwell, Physics,
Georgia Tech/Emory	Tissue Engineering	Rastegar, Sohi (EEC)	1 PD
Johns Hopkins, MIT, CMU	Surgical Systems	Khosla, Rajinder (ECS)	1PD, Gary Gabriele (EEC)
Kansas	Environmentally Beneficial Catalysis	Glen Shraeder (CTS)	Tap Mukherjee (Expert)
Northeastern	Sensing & Imaging Systems	Rastegar, Sohi (EEC/BES)	1 PD
Purdue	Nanosimulation Network	Preston, Lynn (EEC)	George Lea (CISE), Rajinder Khosla, (ECS)
UMass	Collaborative Adaptive Sensing of Atmospheric	Nelson, Steve (ATM),	Vital Rao (ECS), George Lea (CISE), Vilas Mujumdar (EEC), Gary Gabriele (EEC)
USC - IMSC	Multimedia Systems	Kramer, Bruce (EEC)	TBD (CISE), Gary Gabriele (EEC)
USC - BMES	Biomimetic Microelectronic Systems	Rastegar, Sohi (EEC/BES)	Lynn Preston (EEC), Soo-Siang Lim (EEC/BIO)
Vanderbilt	Bioengineering Educational Technology ERC	Pauschke, Joy (CMS)	1PD, Gary Gabriele (EEC)
VPI. et al	Power Electronic Systems	Preston, Lynn (EEC)	Usha Varshney, ECS
Washington	Engineered Biomaterials	Rastegar, Sohi (EEC),	1 PD
Michigan RmS	Reconfigurable Machining Systems	Kramer, Bruce (EEC)	Jian Cao (DMII)
Michigan WIMS	Wireless MEMS	Kramer, Bruce (EEC)	Preston (EEC) & Rastegar(EEC/BES)
NSEC Berkeley	Integrated nanomechanical Systems	Khosla, Rajinder (ECS)	1 PD
NSEC Cornell	Nanaoscale Systems in Info Technology	Bruce Karamer	1 PD
NSEC Northeastern	Center for High Rate Manufacturing	Durham, Delcie (DMII)	1 PD, Gary Gabriele (EEC)
NSEC Northwestern	Integrated Nanopatterning and Detection Technologies	Sohi Rastegar	1 PD

NSEC Ohio State	Center for Nanoengineering of Smart Biomedical Devices	Kramer, Bruce (EEC)	1 PD
NSEC Rice	Nanoscience in Biological and Environmental ENG	Rastegar, Sohi (EEC)	1 PD
EERC - SUNY Buffalo	MCEER EERC	Vilas Mujumdar (EEC)	Pauschke, Joy (CMS)
EERC - U of Illinois Urbana-C	Mid-America EERC	Vilas Mujumdar (EEC)	Lynn Preston(EEC)
EERC - UC Berkeley	PEER EERC	Mujumdar, Vilas (EEC)	1 PD