EXECUTIVE SUMMARY

The Engineering Education and Centers (EEC) Division has traditionally provided support to the engineering community in three main areas: Research Centers, Engineering Education and Human Resources Development—the second category aimed at developing the nation's engineering workforce.

EEC also has two characteristics that make it unique among divisions in the Engineering Directorate. First, EEC serves no particular disciplines or research communities, but rather supports all disciplines through funding of research teams that address the frontiers between disciplines. This research is also unique because it emphasizes development of engineered systems that exist at these multidisciplinary research frontiers. Second, while all divisions of the Directorate for Engineering (ENG) are implicitly involved in the development of engineering faculty and students, EEC has explicit responsibility for advancing engineering education at all levels. Providing diverse pathways for young people to study engineering and to advance through undergraduate and graduate study, and ensuring their preparation for effective practice, is a principal responsibility of EEC programs.

As will become clear in this document, the EEC Division Plan directly connects with two of the basic objectives of the *American Competitiveness Initiative.* These are:

- Invest in "a system of education through the secondary level that equips each new generation of Americans with the educational foundation for future study and inquiry in technical subjects and that inspires and sustains their interests;" and
- Invest in "institutions of higher education that provide American students access to world-class education and research opportunities in mathematics, science, engineering and technology."

Objectives

EEC's 2007 Division Plan focuses on six basic objectives. The first four objectives outline some challenging, but inspirational goals. Looking ahead a dozen years to 2020, these goals challenge both EEC and the engineering community to commit to the following:

(1) Enhance the K–12 pipeline

Goal: 10 percent of all students matriculating at four-year colleges will study engineering.

(2) Promote the success of the undergraduate engineering learning experience

Goal: Three of four students who begin the study of engineering will complete at least a B.S. in engineering.

(3) Improve the pathway into graduate programs for U.S. and permanent residents

Goal: 5,000 Engineering Ph.D.s granted annually to U.S. and permanent residents.

(4) Build a culture of discovery and innovation in our Engineering Research Centers

> Goal: 1,000 students working in the Engineering Research Centers (ERCs) will graduate annually with ERC-related research and development experience.

These goals are challenging. Their attainment is quite clearly beyond the domain of a single division of NSF, or even the whole of NSF. But NSF can and must promote interest and support among American universities for these goals and help to catalyze the educational objectives of the nation.

An interesting parallel is that far less than 1 percent of the capital value of U.S. stocks are traded on the New York Stock Exchange each day, but these trades set the prices (and expectations) of the world's capital markets around the world. Similarly, NSF is viewed as a trend-setter and policy-maker in U.S. engineering research and education. What other federal agency besides NSF could realistically be seen as the leader in establishing national priorities in engineering research and education? A major role of EEC is to advocate for the future needs of the engineering workforce and its effective preparation. The engineering community needs a clear destination.

To help accomplish these goals, priorities for EEC funding are to respond to the following four questions, derived from our first four objectives:

(1) How can we increase students' interest in the study of engineering? Currently, less than 7 percent of entering university freshmen pursue engineering programs.
(2) How do students best learn engineering ideas, principles and practices and what are the impediments to adopting and supporting educational innovations in engineering schools? Furthermore, how do we increase the focus on developing creative and innovative engineers?
(3) What changes are needed in both undergraduate engineering curricula and the graduate pathways to attract more U.S. citizens and permanent residents into advanced engineering, especially Ph.D. programs?
(4) How do we involve and develop the ERC programs to provide opportunities to a larger set of institutionally diverse schools, particularly those not in the upper tier, to benefit from the systems-focused, cross-disciplinary nature of an ERC?

The first priority area—expanding the pipeline from K–12 into our engineering schools—has been and will continue to be of primary interest to EEC.

The second priority area addresses how change and innovation can best be implemented in engineering schools. Are engineering schools organized effectively to reward and promote the careers of the engineering faculty who are in regular contact with nearly 400,000 U.S. engineering students? This priority has been highlighted in the October 2006 *Journal of Engineering Education* with the article "Special Report: The Research

Agenda for the New Discipline of Engineering Education" (see "Engineering Learning Systems;" v.95, no. 4).

The third priority area addresses the national concern that every year, fewer and fewer U.S. citizens and permanent residents are pursuing and completing engineering Ph.D.s. In 2004, only 43 percent of our engineering Ph.D.s were awarded to U.S. citizens and permanent residents, compared to 50 percent 20 years ago. What kind of programs, innovations and pathways are needed to make advanced study a more desirable and rewarding career step?

The fourth priority area is focused on expanding the proven impact of the ERC concept into a broader range of engineering schools. ERCs provide students and faculty with the experience of being part of the overall process of discovery, development and building of products and systems—an integrating activity not usually visible in or part of a typical engineering program. Most engineering programs do not have the capability and resources to include an overall engineering system within their curricula.

Many of these EEC objectives are, of course, addressed quite successfully by EEC programs already underway. The Research Experiences for Undergraduates (REU) program is directly aimed at students with interest and potential for graduate schools, and has had considerable success. A recent study by SRI International showed that REU engineering students increased their likelihood of pursuing Ph.D.s from 25 percent before an REU experience to 48 percent after.

Our Research Experiences for Teachers (RET) Program reaches out to 500 high school teachers annually, a sizeable number but far short of the estimated one-quarter million math and science educators in middle and high schools nationwide.

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The remainder of this Division Plan is divided into several sections. The following three sections present EEC's future plans (both continuing efforts as well as new initiatives) in the three broad areas of education, human resources development, and ERCs. Finally, four appendices make this plan as self-contained as possible. These appendices include background on ERC programs, a brief summary of past EEC planning documents, and a selected set of assessments of past EEC programs.