Chapter 1: Introduction

1.1 About this Manual

1.1.1 Purpose and Intended Audience

This document is intended as a "how-to" manual for those involved in, or contemplating involvement in, the operation of a National Science Foundation-sponsored Engineering Research Center (ERC). Its purpose is to distill the existing knowledge and experience base regarding ERC start-up, operation, and management into a resource tool for use by directors and other managers of prospective, new, and established ERCs.1

The Best Practices Manual is also unusual in having been conceived and written largely by those who do the jobs and have the experience-current ERC managers-employing not only their own experience but also the responses to extensive questionnaires sent to others in those positions across the ERCs. (As such, it should be noted, the manual is a publication of the collective body of ERCs themselves, and not of the National Science Foundation.) It was envisioned as a "living document" that would have immediate utility and direct relevance to users' needs and concerns. The manual is structured in a way that makes it accessible and easy to read, as well as easy to update periodically. It is available for viewing or download on a dedicated website at http://www.erc-assoc.org.

The authors wish to emphasize that this manual is not a "cookbook" or template for structuring and operating an ERC. As a resource tool, it is rich in ideas and experiences; but every ERC is different and exists in a different environment. Each of the existing ERCs reflects that uniqueness, and NSF expects that every prospective and new ERC also will be unique

1.1.2 Organizational Structure

The manual is organized by chapter according to management roles. A decimal numeric heading system has been used, with a separate Table of Contents for each chapter, to facilitate reader access to specific topics.

- Chapter 2 addresses the role of the ERC Director and other executives in providing leadership and strategic direction.
- Chapter 3 addresses the management, both long-term and day-to-day, of the center's research programs.
- Chapter 4 deals with the multifaceted education programs of an ERC.
- Chapter 5 describes the activities involved in industrial collaboration and technology transfer, focusing on the role of the Industrial Liaison Specialist.
- Chapter 6 describes the many vital tasks involved in the day-to-day administrative management of the center, including financial, personnel, and facilities management. The focus here is on the functions of the center Administrative Director.
- Chapter 7 deals with the efforts of the ERCs to increase the gender, racial, and thnic diversity of the center leadership, faculty, and students, and to establish a thriving culture of inclusion, in the interest of fairness as well as to gain the greatest possible breadth of input from the widest possible pool of engineering talent.
- Chapter 8 focuses on the Student Leadership Councils (SLC) that each ERC has, in which the students play an active role in the programs and even the strategic planning of the center.
- Chapter 9 addresses the special challenges of operating multi-institutional centers such as ERC, with a variety of academic partners.

The approach taken in each chapter is similar, in that there is, first, an overview of the functional area and its relation to the overall center operations. Key issues and concerns are then identified and addressed across the specific functions within each section. Where appropriate, an effort has been made to differentiate these issues in terms of the different phases in the life cycle of an ERC: start-up (Years 1-3), mid-term (Years 4-7), and maturity

(Years 8-10). There is a strong reliance on actual events and case studies of successes and failures to derive "lessons learned" and "tips" for the practitioner. Attachments to some chapters amplify material dealt with in the text of the chapter.

In addition to the organizational similarities, the reader will also notice some differences in structure and style from chapter to chapter. These differences reflect the fact that different groups of ERC personnel wrote the chapters. Although the assembled document was edited throughout, the stylistic and organizational individualities of the chapters were in many cases retained as being reflective of, and pertinent to, the specific content and functions being addressed.

1.2 About the ERC Program

The ERC Program began in 1985 when the Nation was facing a strong emergence of highly competitive foreign firms fueled by government investment. There was a clear need to form partnerships that would strengthen the contribution of academic engineering to industrial competitiveness. The goal then was to address these challenges by developing 25 Engineering Research Centers, each of which (a) focused on a long-term vision important for industrial competitiveness, (b) integrated the traditional disciplines to address systems-level engineering research, and (c) formed university/industry partnerships in research and education.

A companion goal was to use the ERC concept as a catalyst to stimulate a broad-based change in the culture of academic engineering by integrating academic and industrial views, promoting the integration of research and education, involving undergraduates in research, and broadening the diversity of engineering graduates. The mechanism of centers was chosen as the means to accomplish those goals because centers can bring disciplines together. ERCs provide an integrated environment for academe and industry to focus on next-generation advances in complex engineered systems important for the Nation's future. Activity within ERCs lies at the interface between the discovery-driven culture of science and the innovation-driven culture of engineering, creating a synergy between science, engineering, and industrial practice. ERCs provide the intellectual foundation for industry to collaborate with faculty and students on resolving generic, long-range challenges to produce the knowledge base needed for steady advances in technology and their speedy transition to the marketplace.

ERCs also integrate engineering education and research and expose students to industrial views in order to build competence in engineering practice and to produce engineering graduates with the depth and breadth of education needed for success in technological innovation and leadership throughout their careers. The interface between research and education in an ERC is seamless at both the undergraduate and graduate levels, producing curriculum innovations derived from the systems focus of the ERC's strategic goals. ERCs can be a platform from which spring interdisciplinary, systems-oriented graduate degrees and options preparing students for careers in both industry and academe. Thus, graduates associated with ERCs enjoy the capacity to contribute to the Nation's global future through a rich spectrum of career paths at the cutting edge of technical progress and innovation. ERCs also emphasize outreach in research and education that allows faculty, college-level undergraduate and graduate students, and pre-college students and their teachers to be involved in the ERC.

ERCs are established by NSF as a result of peer-reviewed competitions generated by program announcements. They are supported by funds from NSF, industrial partners, the host academic institutions, and in some cases the home states and other governmental funding agencies. While NSF provides significant funds for each center, an ERC must identify and obtain substantial support from the other sources. This novel approach to funding a major research program is illustrated in Figure 1-1.

Figure 1-1: Primary Supporters of an ERC

NSF	INDUSTRY	UNIVERSITY
Catalyst/Integrator	Active Participant	Long-Term Commitment

• Base Funding • Management Guidance • Evaluation • Catalyst for Partnerships	• Advisor on Research, Education, and Testbeds • Funding Support • Collaborative Research Projects	• Research Facilities and Resources • Culture Change • Recognition for Tenure and Promotion • Nurturing of Students

In FY 2016, total annual funding provided directly to each ERC by NSF ranged from $2.48 to $11.09 million (for centers in their phase-down period prior to graduation from NSF support) to $3.25 to $8.38 million per year for ongoing centers. Roughly 60 percent of an ERC's annual budget comes from NSF and another 8% from industry; the remainder comes from other Federal agencies (22%), the host university (8%), and state and local and other sources (3%).
Currently (FY20), NSF supports 14 ERCs pursuing specific research foci in four broad areas, as listed below. (As of October 2019, 34 ERCs are self-sustaining after the conclusion of NSF support.)

For further details, see NSF's ERC Program homepage at https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13526&org=EEC&from=home.

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Competition for new ERCs is now held periodically, usually every two years. ERCs receive NSF funding for up to 10 years, dependent upon renewal reviews conducted in the third and sixth years. At the end of their life-cycle as NSF-supported Engineering Research Centers, NSF expects ERCs to become self-sustaining with support from their members, universities, state governments, and other federal government agencies. Teams may emerge from parts of self-sufficient ERCs and enter competition for support as new ERCs. These ERCs recompete on an equal footing with all other applicants.

It is evident that the range of technology areas covered by the ERCs is quite broad. These centers are having a significant impact on U.S. industry through the transfer of knowledge and technology as well as through their graduates. More than 275 U.S. companies were members of one or more ERCs in FY 2018, of which about 46% were small businesses. Other ERC-supporting industrial organizations brought the total up to nearly 600. As of 2018, a total of 851 patents had been awarded to ERCs, 1,363 software licenses had been issued to companies, and 223 companies had been formed as spinoffs of ERC research, employing 1,414 people. Also as of 2018, the cumulative totals for degrees granted to ERC students were: 4,962 PhD, 4,238 MS, and 4,414 BS degrees. In recent years, roughly 1.5 percent of all engineering doctoral degrees granted annually in the United States are awarded to ERC students. Over the past 35 years, the ERC interdisciplinary, industry-oriented systems approach to engineering has spread rapidly throughout industry and academe. The ERCs continue to evolve and to fulfill NSF's expectation that they serve as change agents for academic engineering programs and the engineering community at large.

The participants in the ERC Program who have authored this manual hope that it will serve as a further vehicle for disseminating the ERC approach to engineering research and education, which we believe is highly beneficial and healthy for both academe and industry, throughout the American engineering enterprise.

NOTES

[1] Relevance of the manual to other research center programs (not only within NSF but also those of other federal or state agencies) was a secondary consideration. However, many of the principles presented herein are applicable to any government-sponsored university research center, especially one with industry involvement-not only in the United States but also abroad.

[2]An ERC jointly supported under a Memorandum of Understanding between NSF and the Semiconductor Research Corporation.

[3]The Earthquake Engineering Research Centers (EERCs) were established under a special program in 1997 to further knowledge and technology for earthquake hazard mitigation.