5.0 Overview

This chapter discusses some of the most effective practices that existing ERCs have learned to use in conducting industrial collaboration and innovation programs. It addresses issues such as establishing a partnership with industry, building an industrial constituency, the benefits and difficulties of industrial interaction, building an "innovation ecosystem," and the role that the NSF plays. Case studies are used to illustrate some effective approaches. Abbreviations for ERCs that are referenced in these case studies are defined in Attachment 5-A. This chapter also defines the innovation ecosystem, along with the management and delivery of intellectual property from the perspective of ERC planners. It ends with a discussion of the role of the ILO within the ERC.

A central motive of the National Science Foundation (NSF) Engineering Research Centers (ERC) program is to form partnerships between academia, industry, and innovation-focused entities in systems-oriented research areas that are critical to the Nation's future economic strength. Each ERC collaborates with industry and other practitioner organizations from the early inception of its vision creation and subsequent strategic planning, and this collaboration extends to technology development and application. By thus expanding and accelerating technology translation, transfer, and eventual commercial use, this approach bridges the traditional innovation gap between the single university investigator and industrial adopters of academic research results. ERCs develop a group of members that includes firms of all sizes along the value chain of sectors important to the realization of the ERC's engineered systems vision.

By embracing industry and innovation throughout the entire cycle of technology creation, development, and implementation, the ERCs are distinctive among NSF research centers. Each second-generation (Gen-2, Class of 1994-2006) and Gen-3 (Class of 2008 and beyond) ERC is tasked to develop a membership program for industrial collaboration and technology transfer. In addition, each Gen-3 ERC is challenged to expand that program to include state and local government or university organizations devoted to stimulating entrepreneurship and innovation—the innovation facilitators. Both Gen-2 and Gen-3 ERCs are expected to stimulate technology transfer through member firms by means of information exchange, hiring of ERC graduates, member-funded sponsored research projects, and translational research with small firms when member firms fail to license new ERC-generated Intellectual Property (IP). Both Gen-2 and Gen-3 ERCs are charged with developing graduates who are better prepared for effective practice in industry and leadership in technological development. In addition, Gen-3 ERCs are charged with developing graduates who are more creative and innovative and better prepared for leading innovation in a global economy than their non-ERC counterparts are.

Thus, each ERC team envisions and plans transformational technology and education with its industrial/practitioner[1] partners from the outset. Each center's strategic plan, developed with industrial partners, helps identify areas for joint projects and experimental testbeds for validating research results in practical applications. NSF holds ERCs responsible for tracking their research results through commercial implementation.

ERCs are required to build large research programs with considerable financial support from industry. While some support may be in the form of contractual agreements with deliverables, in many centers an equivalent or greater sum consists of unrestricted industrial grants to the center. Special emphasis is often placed on attracting small and medium-sized companies to ERCs because of their more rapid acceptance of new technologies and rapid growth potential.

In 2012, ERCs reported corporate memberships ranging from 7 to 47 companies per center (averaging 23 per center). The distribution of membership among large, mid-size, and small companies depends somewhat on the industry involved, but most centers have members in all three size categories. Overall, small firms (<500 employees) and large firms (>1,000 employees) make up 43% and 48% of the members, respectively.

For established centers, industrial/practitioner member organizations provided 9.4% of the total ERC direct support in 2012 (5.4% unrestricted cash, 1% sponsored projects, and 3% in-kind contributions). Including support provided by organizations who were not members, this percentage rose to 11.7% of ERC direct support for 2012.

Equally impressive is the large number of technologies that have been invented by ERCs and implemented by their industrial partners. For example, as of fall 2012, a total of 676 patents had been awarded to 61 ERCs between 1985 and 2012; 1281 licenses had been issued to companies; and 146 companies had been formed as spin-offs of

ERC research, with a total of 1,032 employees. In addition, hundreds of discrete innovations had made their way into use in industry. The ERC Program invested over $1.0B in ERCs between 1985 and 2010, with a return on investment in the 10s of billions of dollars[2].

While all ERCs are expected to plan, create, validate, and transfer new technologies, some of these activities inevitably receive greater emphasis at different stages in a center's life cycle. New centers (years 1-3) necessarily focus on strategic planning with industrial partners, attracting new members to their efforts, and developing forums for interaction. Mid-term centers (years 4-7) must focus on demonstrating successful industrial collaboration and technology transfer results, promising more to come beyond the sixth-year review, and beginning to prepare for self-sufficiency. Mature centers (years 8-10) are putting new technologies into play while attracting new companies and finding new ways of teaming with industry without NSF support, including generating industrial endowments. Successful centers initiate long-term sustainability planning jointly with their industrial partners well before the end of ERC Program funding, ideally as early as year 4, with significant progress by year 6.

Experience shows that the enthusiasm and appeal of a start-up center is very effective in attracting industry involvement; but as centers mature and sponsors become more demanding, industrial collaboration requires more work. On the other hand, age confers the advantages of experience and credibility. In the early stages, centers sometimes need to set modest membership fees, focus research on knowledge and technology development, and use industry as a partner in identifying problems. In later stages, in preparation for self-sufficiency, centers may begin to add sponsored projects funded by specific industry partners, where the research on these projects would include a focus on applications and firm-specific development based on the ERC knowledge generation and technology developments. Care should be taken to maintain a strong base level of support that enables discretionary funding of core projects and new and exploratory work. The ERC should be mindful not to turn the center into a "job shop" for industry or a collection of applied and often closely held sponsored projects as the time for self-sufficiency from NSF support comes into play.

The center's life cycle in the first few years is somewhat analogous to NSF being a venture capitalist, funding a build-up of infrastructure and providing substantial leverage to industrial support. But the venture capital analogy projects the wrong relationship between NSF and the ERCs because NSF is not looking for a direct monetary Return on Investment (ROI); rather NSF's expectation is that the Foundation's return on investment is in terms of high-quality research, impact on national economic development, etc. By year 6, the center has "gone public," establishing a certain amount of credibility with regard to its benefits to industry, and begins to face a new set of challenges. With the infrastructure in place, the center matures, and the issue of delivery becomes preeminent.

But industrial collaboration with ERCs extends beyond the development and transfer of technology. Industrial members are stakeholders in more than just strategic planning and collaborative research. They also have a vested interest in the ERC's educational activities because of the impact on their workforce development. Industrial members give practical experience to ERC faculty and students by hosting faculty sabbaticals, student internships, and on-site ERC seminars. Members also participate at the center in hands-on courses, seminars, and co-advising graduate students. The university and/or state and local government innovation partners in Gen-3 ERCs become more involved in stimulating entrepreneurship and promoting innovation.

Industrial involvement in the early stages of technology planning and development provides substantial payoffs when ERC students graduate. Many of the hiring companies have noted that ERC graduates, by virtue of their systems-oriented training, are more skilled at technological innovation and product/process development than their non-ERC counterparts. They also are capable of integrating knowledge across disciplines, working in teams, understanding industrial needs, and addressing problems from an engineering systems perspective. Industrial sponsors typically comment that ERC students "land on their feet running" and "do not require the usual 12 to 18 months to come up to speed." Many ERCs and their industrial members agree that students are the best and most lasting form of technology transfer. (See Section 5.2.4.1 for a more detailed discussion of the job performance of ERC graduates.)

The ERCs' relationships with companies and practitioner organizations are situation-specific to some degree. Each one is unique, depending on the nature of the research undertaking, the scope and type of the industries involved, the strategic direction of the center, and the personalities of the leadership team. Within this diversity there are common issues, which each center must resolve to create a functioning partnership with industry. The objective of an ERC should be to establish a very broad constituency of industry and government practitioner stakeholders. Emphasis on the dollar amounts of support should be balanced by a focus on the intellectual and economic potential of a collaborative effort.

Ultimately, the ERCs are testbeds for broader cultural change in university-industry collaborative research. They are pioneering new ways of bringing research results to market, breaking down many traditional barriers that have hindered cooperation between universities and industry. Every lesson they learn makes it easier for those who follow to work together productively, as the working partnership of university administrations and faculties with corporate researchers develops. This is perhaps even truer of the centers that have graduated from NSF support, since those centers operate without the NSF ERC award and therefore must justify their benefits to both their host universities and their industrial members.

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[1] Practitioner partners are organizations that will support the ERC's research as center members and will use the outcomes in the delivery of services; these include local government agencies, hospitals, etc. Industrial/practitioner partners will be referred to as industrial partners or industry members throughout the rest of this document.

[2] Engineering Research Centers: Innovations—ERC Generated Commercialized Products, Processes, and Startups, Courtland S. Lewis, February 2010. (http://www.erc-assoc.org/topics/policies_studies/ERC%20Innovations%202010-final.pdf)