5.2 Building an Industrial Constituency

5.2.1 R&D and Commercialization Strategies to Serve Industry

In fundamental research, a full understanding of the impacts and ramifications of the work is impossible at the outset. Industry, on the other hand, requires some projected future payoff to justify research funding. Bridging this dichotomy is at the core of the ERC mission. Of course, not all ERC research will result directly in a commercially viable discovery or technology; however, the likelihood of this result is increased by the periodic involvement of industry at critical points in the research planning and review process. This review process is akin to the product development model, which industry has used for many years. Applying this model to university-based research necessarily involves scaling back such things as market reviews and surveys posing hurdles that a new idea must clear. What is useful about the model is the scheduled interaction among various stakeholder groups at critical points in the development (research) process.

5.2.1.1 Developing and Maintaining an Industry-Relevant Research Agenda

Developing the research agenda is a fundamental aspect of ERC management and oversight. However, the perspective of industry has traditionally not been prevalent in this process in university research. It is essential that the ERCâ€™s research management team recognize the importance of industrial input, consider the opinions of industry representatives in their decisions, and encourage the research faculty and staff to do likewise.

Most ERCs have established mechanisms for including industrial input in formulating new research and overseeing ongoing work. Most often, this opportunity occurs during an annual or semi-annual meeting of the entire industrial members group or some subgroup thereof. Depending on the diversity of interests among this group, research focus meetings can be held during plenary sessions of the meeting or in industry-specific breakout sessions with only those representatives interested in a particular topic in attendance. For projects sponsored by a single member or a consortium of members, only contributors to the project under consideration need attend.

The diversity of interests among members can make a group meeting of them and ERC researchers a challenge in agenda-setting. Keeping these meetings focused on the goal of developing a consensus in the research direction is vital. Time should be set aside for constructive criticism of past work and decisions, if appropriate; but it is the role of the ERC research management team to keep the meetings on track and focused on setting realistic goals that are likely to produce tangible benefits to industry.

At times, some ERC members may want to explore research directions that do not map perfectly onto the ERCâ€™s core research goals. It is the ERCâ€™s responsibility to meet this need by collaborating with these companies under other mechanisms, such as sponsored contract research or fellowship research. ERC industry members should be made aware of the various collaborative opportunities and should have a clear understanding of the difference in IP policies under the various options, especially as it pertains to multiple ERC partner institutions. This is discussed further in Section 5.3.2.9.

5.2.1.2 Balancing the Needs of University Researchers and Industry

Throughout the research, development, and commercialization process, it is important to balance the needs of industry and the university. Whereas a universityâ€™s central missions are teaching and generating knowledge though research and publication, industry is concerned with maximizing financial value. The potential for conflict between the two must be acknowledged and dealt with in a balanced manner. Questions about the nature of confidential information, the length of time a discovery must remain confidential, and how results can eventually be published are usually specifically addressed in the research contract and confidentiality agreement as discussed in Section 5.3.2.9. The terms of these documents are usually negotiated among the ERC, industry legal staff, and the university technology transfer office.

5.2.1.3 The Changing Roles of Academic and Industry Researchers in Commercialization

For ERC-generated IP, the ERC offers the option to license to the member firms. If a member firm exercises the option, then the technology may move directly to the firm or the firm may sponsor a translational research project, involving ERC researchers in the process but under IP arrangements specific to the project. In this case, the roles of the ERC project director or Principal Investigator and the industrial sponsor will likely reverse. The ERC researcher at this point moves from directing the project into the advisory role, which had been occupied by the industry representative, and vice versa. In some cases responsibility for scaling up the technology may move to someone in industry who had not been connected to its laboratory development. In either case, the ERC researcher should seek to remain available and involved. In cases in which the ERC researcher has a financial interest in the commercial success of the technology (such as inventorship of the IP), the incentive for involvement is obvious. The importance of input from the researcher in maximizing the chances of success of the technology (regardless of IP ownership) should not be overlooked, however.

For IP that member firms do not license, the ERC may offer the license to a large firms with resources sufficient to explore further development of the technology; or, to a small firm (member firm or not). Because small firms do not have funds available to advance the technology, the firm may seek support from the ERC Programâ€™s Translational Research Fund under the annual Small Business/ERC Collaborative Opportunity (SECO) solicitation. In that case, the small firm submits the proposal with a subaward to the ERC. IP generated from sponsored project support and translational research project support under SECO does not revert to the IAB or the university.

5.2.2 Attracting Corporate Members

The need to attract new industrial members continues long beyond the start-up phase, as all centers experience turnover in membership due to shifts in corporate strategies and fiscal constraints. Many centers have formal criteria, often developed with the Industrial Advisory Board, for identifying those companies that can belong to the center. These criteria deal with issues such as foreign firms and Multinational Corporations (MNCs), whether consulting firms may belong, and whether company size or location limits membership. It is noteworthy that, while some centers have a geographically concentrated membership, no center limits membership based on location, and some engage their members at long distance. This section addresses successful strategies for recruiting appropriate members.

5.2.2.1 Strategic Plan for Recruitment

The ERCâ€™s Industrial Liaison Officer (ILO) or Innovation Director manages this activity. Centers vary significantly in the formality of their strategic plan for recruiting member companies. Proactive approaches to industry member recruitment are highly recommended. As of 2013, the ERC Program Office requires ERCs to strategically plan to include the appropriate firms along the value chain most relevant to the ERCâ€™s engineered systems vision. In that way, the research is informed by the appropriate firms involved in the technologies underlying the system, as well as the system itself. In addition, these firms also find benefit in interacting across the ERCâ€™s value chain in the IAB. See Figure 5-1 for an example from CBiRC.

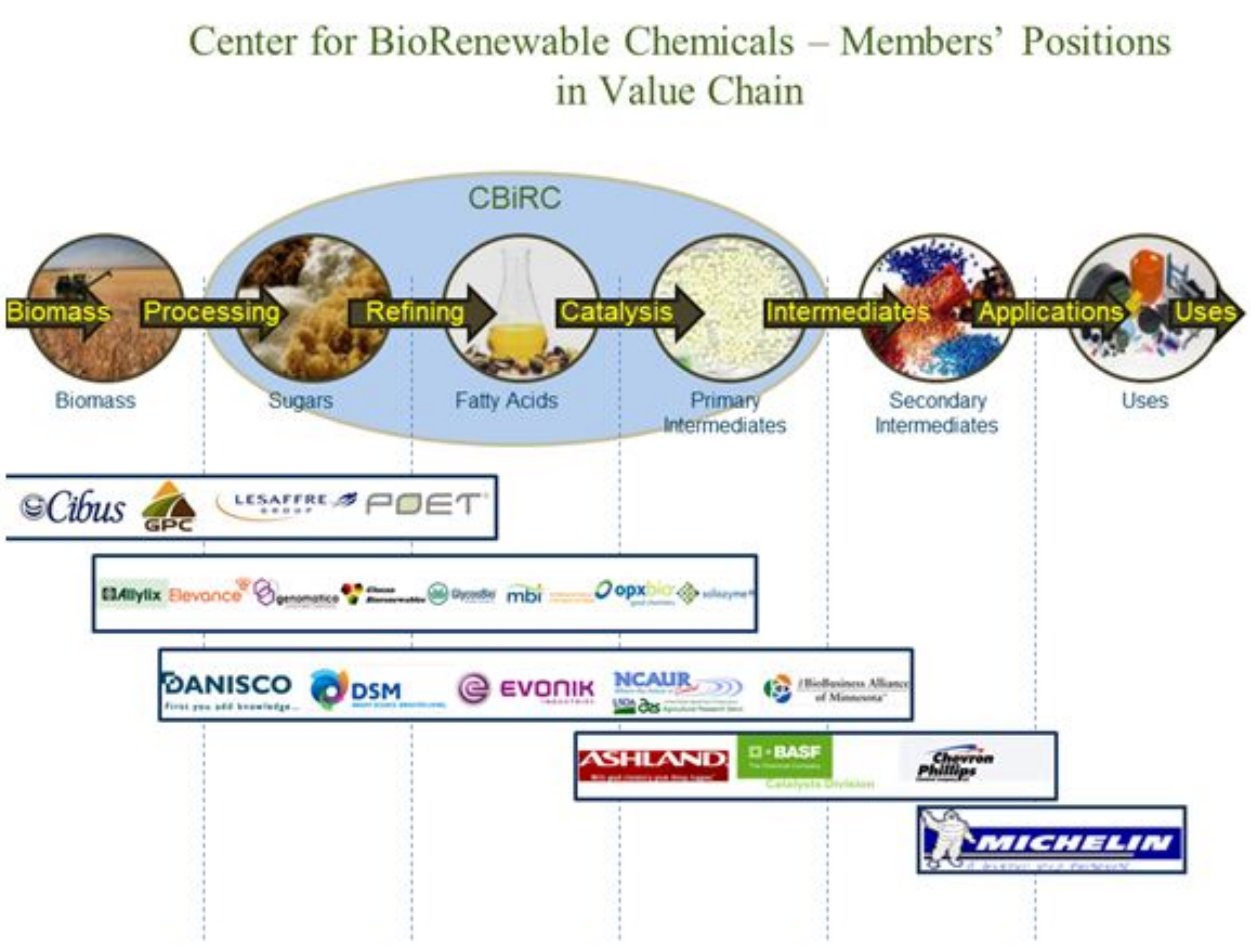

Figure 5-1â€"CBiRC Value Chain

Most ERCs focus on identified industry groups (sometimes with IAB input) and establish membership goals, do market research to further identify appropriate company prospects, and tailor recruitment strategies for each prospect.

5.2.2.2 Marketing the Center

An important component of the strategic plan for industrial interaction is a clearly defined marketing strategy for recruiting industrial sponsors. A well-developed marketing strategy typically includes an analysis of the industry sectors affected by the centerâ€™s research, the value chain, and the value drivers that industrial sponsors will find attractive in a research and technology transfer relationship. The marketing plan includes financial and technology commercialization goals, specific actions and timelines needed to reach those goals, and a budget for the Industrial Membership Program. This plan includes strategies not only for recruiting new members, but also for retaining existing ones through customer service activities such as communications of center research activities and results, faculty interactions with sponsor companies, interactions with students to gain know-how and recruit, and regular visits to sponsorsâ€™ sites.

Many ILOs have experience working in industry, but they also need to understand the academic culture and university/industry collaborations in research. The ILO position must be a full-time staff position reporting to the Director of the ERC. Selecting an ILO who is a staff member in the university technology transfer office, who might work part-time for the ERC, is not an effective strategy as the ILOs must first of all work for and promote the ERC.

Most ILOs report to the Center Director and work directly with faculty, industrial researchers, and often with students. If the Director has high industry exposure, then the industrial awareness of the ERC is heightened. Visibility of the ERC is further enhanced when the Director travels extensively and gives presentations at technology meetings attended by academic and industrial scientists and engineers. The visibility and reputation of the center rises to an even higher level if the key faculty also play a role in marketing the ERC when they are on

the road giving presentations.

Advertising and â€œcold callsâ€• to potential sponsors usually are not productive. Centers should instead target specific companies based on their involvement in the particular industry, their interactions with other sponsors, and their degree of involvement in technology development. The use of current industrial partners to identify leads is particularly effective in identifying potential new members. As in many business endeavors, perseverance is rewarded in recruiting members. Strong and continuous follow-up with several people in the organization, often involving visits to the center and to the company, is usually required after the initial contact. For a new ERC without a significant track record, it is a good idea to market the centerâ€™s program and vision. This approach can be particularly effective with companies that have been involved with other ERCs.

It is the high quality of research (and graduates) that is always most valuable to companies. An NSF study of industry member benefits provides insight into the value points and is presented in Section 5.2.4.1.

Every center uses its Director, staff, faculty members, and sometimes students in its marketing efforts, proactively or reactively. ERCs may also use consultants to contact potential sponsors to identify and explore areas of mutual interest. In any case, the ILO is primarily responsible for this marketing effort to industry and is challenged to call on all available personnel and resources, as discussed below.

Carefully identifying the companies that can benefit from the research in the centerâ€”that is, finding the right partnersâ€”is important in successful marketing. Presenting information about the centerâ€™s respected faculty members must be accompanied by clearly defining the value of center participation from the companyâ€™s perspectiveâ€”what is known as the â€œValue Proposition.â€• This is particularly difficult in industries with a poor track record for R&D funding. Marketing techniques include literature, newsletters and brochures (hard or softcopy); visits to industry by directors and faculty; visits to the center by industry representatives; booths and exhibits at trade association meetings; participation at technical society conferences; publication of technical papers; participation in industry research consortia; a center website; informational videotapes; letters to potential industrial sponsors identified through contacts; and topical workshops.

Centers disagree on the value of various printed materials in marketing, but most believe that personal contact at professional and trade meetings or other â€œnaturalâ€• venues and visits are very effective. Particularly valuable are visits to companies by teams comprised of center faculty, the Director, and the ILO. These visits not only introduce the center to a broad audience of company personnel; but also help the ERC understand the companyâ€™s products, business climate, and issues so that the value of ERC membership can be specifically defined. In arranging such a meeting, the ILO should gather in-depth information on the company, brief the Director and faculty, and set objectives for the meeting in advance. The Internet is a highly productive source of low-cost leads. Contacts come from companies referring to the center's website, social media such as LinkedIn, and search tools for industry specific needs that meet ERC foci.

Consider that it may also be in the best interests of existing industry members to join in the recruitment process to broaden the support base and intellectual breadth and depth of the industrial membership, and by extension the ERC. It is important to arm member "recruiters" with information about the center and its industry partner program. Additionally, the center's recruitment of industry support might align with and add to university or school development program goals. If so, leveraging the assistance of institutional development officers may help in identifying prospective members. For example, when Peter Keeling developed the Value Chain for the CBiRC ERC, it was clear to the IAB that there was an opportunity to diversify the membership by developing a recruiting campaign targeting various member companies across the whole value chain.

Finally, successfully commercialized technologies are valuable tools in marketing the ERC to prospective members. To the extent that technological advances cross industry lines, a new process or idea may enhance the appeal of ERC membership to previously underrepresented industries. The ongoing process of market analysis for new membership should constantly evaluate the appeal of new technologies to potential sponsors.

CASE STUDY: The Mid-Infrared Technologies for Health and Environment (MIRTHE) strengthened its industry outreach and marketing efforts through the addition of the â€œMedia Affiliateâ€• membership category. They currently have Media Affiliates that provide marketing and exposure for MIRTHE on an in-kind basis (e.g., free advertising or publishing articles on MIRTHE technologies and applications, subject to normal editorial criteria for publications). The Media Affiliates, in turn, benefit from a window into emerging technologies and new product applications. For example, one of MIRTHEâ€™s 2009 high school student summer interns wrote an essay about

her experience that was published in the Education section of Photonics Spectra Magazine. Other examples stem from the deployment of sensor systems into environmental testbeds, particularly in China and Ghana, which has provided excellent media content.

5.2.3 Engaging with Industry Members

Key to a centerâ€™s impact through relevant research and potential student hires is the depth of commitment and active participation of industrial researchers in center programs. Exploration by centers of the best ways to achieve a sense of "seamless community" with their partners attests to the creativity and flexibility of center personnel. This section summarizes centersâ€™ experiences in engaging with industry members.

Maintenance of the company membership base and recruiting of new members is a continuing challenge, especially in times of economic stress in industry. Resource limitation is a problem at universities as well, with faculty time being a prime example. In some centers, no industrial recruiting is done by faculty because they are overloaded. In the absence of strong university rewards for successful recruiting of center members, faculty members generally choose to spend their time in other pursuits.

Other issues perceived as barriers to getting and keeping companies active in centers are:

- Increasing costs of research at universities;
- The problems of generic vs. proprietary research;
- Publication requirements of universities;
- The mismatch between short-term research issues important to some firms and the requirement that Ph.D. students focus their research on longer-term, higher-risk areas;
- Dealing with the imbalance among sponsors' views of desirable long-term research directions; and
- Ineffective communication with upper-level management in sponsoring companies.

Effective interaction with industrial sponsors is most often limited by the failure of either industry or the center to provide the resources (time and appropriate personnel) for interaction. Partnerships grow best with continuity in the people involved and a commitment to regular communication. It is important for upper management in sponsoring companies to understand that the greatest benefit from membership is the most costly in personnel time. Centers need to provide incentives to faculty members to continue developing partnerships with companies that will become members of the ERC as opposed to sponsoring research in the facultyâ€™s laboratories. Some centers report that the key is the reward of the intellectual challenges provided to the faculty member by the company partner; but for this to be effective, the faculty interests and those of the company researcher must be aligned and clear to both parties.

5.2.3.1 Effectively Engaging Industry Champions

It is important to develop one or more champions within each company. Usually these will be firmsâ€™ representatives to the IAB, but there may also be an additional strong supporter of the center within the company's top research management or general management. These people go to bat for the center when continued membership is an issue. They may be proactive in disseminating center products and information within the company; and they look for joint research opportunities. An enthusiastic and forceful championâ€”preferably in a senior executive position at the companyâ€”makes the difference between a strong corporate member and a *pro forma*, uncommitted one. If the industrial representative must step down due to transfer, promotion, or other cause, it is crucial to enlist his or her help in identifying a suitable replacement champion. Having two or more champions is of obvious benefit at such times.

Because ERC / industry member activities are both technical and managerial, many ERCs have industry member liaisons that come from both those groups within companies, and in many cases from different groups within

companies. This is an excellent practice, as ERCs are well served by engaging multiple internal champions within companies to best spread the impact of the ERC and establish redundancy in contacts should one champion leave the company. Engaging strong management as well as technical contacts in companies is a solid strategy to assure that company technical and business-oriented needs are being fulfilled.

In considering effectively engaging champions under the structure of an Industrial Advisory Board, several guidelines can be offered. First, it is important to remember that it is an advisory body. Final decisions must remain with the center management, and specifically the ERC Director. Of course, ERCs should always try to heed the advice given by this body, but extenuating circumstances, conflicting input from other company personnel and from NSF site visit teams, and other factors may have to be integrated into the final resolution. It is also important in the early years of a center to accustom the IAB to thinking longer range; the university structure is not equipped to put out today's fires. Another key point is that research results will be commercialized only if advances are relevant to industry needs. Thus, it is important to get the IAB involved in planning the research program to ensure that it will be relevant when completed.

5.2.3.2 Information Exchange with Companies

One challenge of ERCs is how to share information broadly within member companies when active participation often is limited to a few individuals within each company. This is a two-way problem, with faculty members needing to know more about the companyâ€™s interests and industrial representatives needing a fuller understanding of how they might benefit from the center. Most centers try to distribute written materials as widely as possible within member companiesâ€”a strategy that is substantially aided through electronic communications. Publications distributed by most centers include newsletters, technical reviews and annual reports, reprints of research articles, information on intellectual property, and summaries of meetings of advisory groups. Assessment of the effectiveness of these materials varies; each center must determine what works in its own industrial environment. Many are using extensive center websites and companiesâ€™ internal email systems to share information. Others are using electronic forums and video-conferencing as ways to broaden awareness.

All centers hold formal research review meetings and engage in discussions both during visits and informally, one-on-one. These sessions allow highly effective two-way personal interaction. Agendas for these meetings should include significant time for industrial participants to interact with the material and its presenters. The traditional academic one-hour presentationâ€”with an introduction, methods, results, summary, and conclusionsâ€”involves one-way communication that may be inappropriate for an industrial audience. One center uses 20-minute presentations with the conclusions up front, a brief description of methods and results, and a repeat of the conclusions at the end, followed by 20 minutes for discussion. Others use shorter, 10-minute presentations with 5-minute discussion periods. The point is to meet the audience halfway by making the sessions interesting from their perspectives and leaving time for listening and interacting. No matter what format is used in research review meetings, it's important to plan and manage the presentations to ensure that they are aimed at the industrial audiences' interests and needs. The industrial audience wants to know the industrial relevance and applications up front, while academic presentations typically start with a strong focus on the "science" and pay little attention to applications, except as an afterthought. It is important to keep cultural differences like this in mind whenever the ERC presents its results to industry, to clearly demonstrate the value that industry sponsors are getting for their investment in the ERC.

Research review meetings include all researchers (faculty, students, and industry); in some centers they are open to all interested companies and in others are for members only. A number of centers with closed meetings allow prospective members to attend one session as a marketing tool. Some centers mix a public meeting/dinner on one day with a closed member meeting on the second day, thus giving prospective members the opportunity to interact with current members without being part of the exclusive group. Some of the centers charge company representatives for attending meetings; others include the cost in membership fees. Some centers use hotel meeting facilities, while others hold the meetings at university sites. In any case, proximity to ERC facilities allows tours and laboratory visits to be included, either formally or informally.

Centersâ€™ meetings with Industrial Advisory Board members vary considerably, but are usually 1-2 days long. The Chair of the IAB organizes the meetings, serves as a chair for each meeting, and works with the members to set the agenda. It is important for the entire leadership team of the ERC (Director, Deputy Director, Thrust Leaders, ILO, and Administrative Manager) to participate in this meeting. Industry participants should be made to clearly understand that this is their best opportunity to guide the ERC and therefore they should not be inhibited in their

discussions for any reason. Distribution of the agenda and pre-meeting materials 1-2 months in advance facilitates the meeting. Including the last Board meeting minutes as part of the package is found to be extremely useful in conducting Board business.

For the IAB meeting that is contiguous with the ERCâ€™s NSF site visit, the IAB members need to attend the ILOâ€™s briefing of the site visit team (SVT) and then devote an hour to meet with the SVT in private to present their SWOT analysis of the center to the SVT and discuss their mutual findings. The ILO and Center Director are not present at this meeting because NSF and the IAB meet as joint funders of the ERC. In assessing its performance, each ERC is required to assess its strengths, weaknesses, opportunities, and threats in a specified, structured manner. This SWOT analysis is a vital tool for the center in its efforts toward continuous improvement. It is also among NSFâ€™s most important measures of the centersâ€™ performance. The purpose of the SWOT is to:

- Analyze the *strengths* and *weaknesses* of the ERCâ€™s vision, strategic plan, research, education, industrial collaboration, leadership and team, and management system;
- Identify any *opportunities* for the ERC to increase its impact; and
- Identify any serious *threats* to the ERCâ€™s ability to fulfill its vision; these include both internal and external threats.

Industry members summarize the results of the analysis in bulleted slide presentations, for the use of the NSF annual Site Visit Team and the ERC leadership. The ILO and IAB chair have to determine how best to develop the SWOT analysis so that it is ready for the annual site visit presentation. The IAB Chair, at least, also will discuss the results of the IAB SWOT with the ERCâ€™s leadership team.

This exercise provides an integrative forum for industry members to focus on center goals; builds more cohesive industry support; provides focused input to the ERC and to the NSF site visitors to help strengthen the ERC; and strengthens the investment partnership between NSF and industry by clarifying industryâ€™s priorities and concerns.

The second IAB meeting, about six months after the first, will include separate research reviews (â€œERC Research Daysâ€•), the agendas of which vary from center to center. Typically such a review is held during a 1Â½- to 2Â½-day meeting, which may include: a plenary session overview of activities; consecutive or simultaneous technical sessions covering major research areas; roundtable discussions (sometimes including an outside perspective, e.g., clinicians for biotechnology); poster sessions (at several centers this is combined with lunch or a buffet supper); and industry feedback sessions. Some centers use the â€œrawâ€• feedback from such whole-group sessions for guidance; others have representative technical advisory committees that meet in formal session to codify input. Experience suggests that these committee meetings are more effective with a clear agenda (ideally prepared with industry input), minutes, and action items, and seating around a table rather than classroom style. This type of meeting is necessary for the IAB to be able to provide input on the progress of ongoing projects and the plans for new projects.

Another typical formal center meeting type is a topical workshop, often with topics recommended by industrial participants. These are often one-day sessions led by an academic or industrial organizer (or team). Presentations or panel discussions are arranged with sufficient time for discussion. Such meetings are an effective way to explore possible new research directions for a center.

Informal interaction with IAB members between meetings is common. Visits by companies to the center or by center faculty to companies are often informal interactions facilitated by center staff and/or faculty. The purpose of the visit determines which faculty members, students, and administrators are included. Tours of center laboratories may be appropriate for prospective members or new visitors from member companies. It is helpful for all participants to know the purpose, the participants, and the agenda. Briefing materials for a visit should be digestible during a one-hour plane trip. It is often the responsibility of the Industrial Liaison Officer to determine and track follow-up action items from the session.

Finally, it's critical to note that one of the most important roles played by the Industrial Liaison Officer in communicating between the ERC and industrial sponsors is that of ombudsman or the "voice of the customer" in the ERC. The ILO typically has more direct experience in industry and with everyday industry contacts than anyone else in the Center and he or she must be seen as an impartial advocate for the interests of the industrial

membersâ€”in essence, their internal advocate. Undertaking this role makes the ILO an invaluable resource to members and serves the purpose of the ERC in fostering closer industrial collaborations.

5.2.3.3 Industrial Input into Strategic Planning

Strategic planning for the center's research, education, diversity, and industrial collaboration and technology transfer programs is a vital segment of the activities of all ERCs. Their charter with NSF requires that ERCs periodically identify goals in each area of operation, establish paths to their objectives within an identified time, outline how resources will be organized to achieve objectives, make assumptions about the state-of-the-art and future expectations, and evaluate their progress toward their goals.

Most centers rely heavily on their sponsors and industrial advisory groups for input into their strategic planning. There are several vehicles for doing this, some formal and others informal. Some advisory boards and technical advisory groups hold special strategic planning sessions; some consortia engage in road-mapping activities. Several centers survey members to gather initial information for planning discussions, including recommendations for and evaluation of new projects. One-on-one interviews are also employed.

CASE STUDY: CCEFP introduced the Technology Readiness Level (TRL) system to its industry members as a tool for program and project management. The TRL system was originally developed and refined by the US Department of Defense (DoD) and NASA to define the maturity of a technology. It is widely used in both agencies. TRL numbers range from 1 to 9. A project rated TRL 1 is the least mature (it could be just an idea or a sketch on a napkin) and TRL 9 represents full commercialization. Projects above roughly TRL 4 are moving from pre-competitive to competitive, so when Center research projects reach this level they are â€œgraduatedâ€• (i.e., Center funding is stopped). The technology resulting from the research can then be transferred to industry directly or matured through a directed / sponsored project partnership between industry and the PI. The use of the standardized TRL terminology has provided a common language that makes communications about the maturity of a project much easier. The use of TRL assessments for project review, selection, and tracking provides a clear means to show progress of a project toward commercialization and a projectâ€™s maturity relative to other Center projects. It also helps explain the so-called â€œValley of Deathâ€• that exists between the pre-competitive research done at an ERC (generally progressing up to TRL 4) and the level of technology readiness at which industry is typically interested in using significant internal resources to commercialize a product or technology (typically TRL 6 and above). The TRL structure utilized by CCEFP (adapted from the DoD TRL) is shown in Figure 5-2.

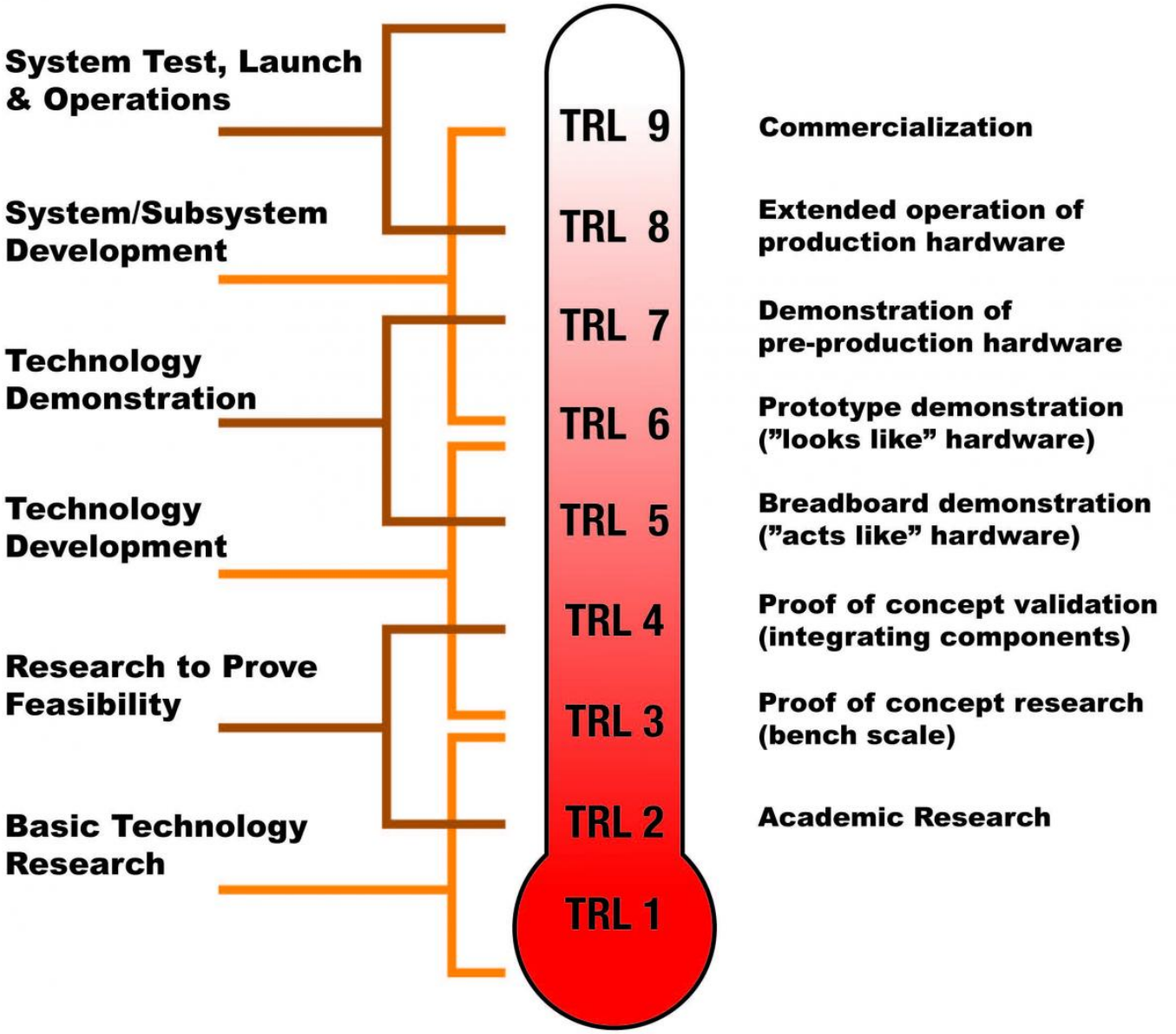

Figure 5-2. CCEFP Technology Readiness Levels

5.2.3.4 Mechanisms to Enhance Interactions

Of all the approaches used to expand and deepen industry involvement in centers, nearly all centers agree that the most effective are personnel exchanges and joint research activities, both of which foster one-on-one interaction. Successful collaboration must benefit both the collaborating individuals and the cooperating organizations sufficiently that obstacles (and there are many) will be overcome. One center Industrial Liaison Officer uses the â€œhealth club analogyâ€• with industrialistsâ€”the more you participate, the more you benefit.

Most centers attempt to broaden their interaction with member companies and provide a variety of ways in which companies can interact. Frequently used mechanisms that have been found to be effective include:

- Student internships at company sites
- Student mentoring by industry
- Industry participation on thesis committees
- Faculty sabbaticals in industry
- Extended visits to the ERC by industrial researchers

- Technical review meetings (review and topical)
- Industrial Advisory Board meetings
- Visits (of varying lengths) by industry to the center and by the center to industry
- Collaborative research projects
- Contract research projects
- Consortium meetings
- IP licensing
- Hosting center tours for members and their clients/prospects
- Tours of member facilities by visiting colleagues
- Short courses.

CASE STUDY: The MIRTHE education program reflects strong industry connectivity. Every August there is a weeklong Summer Workshop that is held on a core partner university campus, on a rotating basis, and culminates in an industry/student networking dinner on the last day. During the workshop, students are the lead organizers for a "students-only" afternoon that provides opportunities for MIRTHE students to present research to the IAB and SAB. The Student Leadership Council (SLC) facilitates student meetings with the MIRTHE program evaluators and has significant input on the choice of career workshop speakers. Also, the SLC advises the faculty on how to choose the best student papers and posters and its members are often tapped to chair student-related sessions.

5.2.3.5 Industry / University Collaborative Research Teams

ERCs have found that close, personal liaison and one-to-one collaborations between faculty and students with industrial sponsors at the project level are very effective methods of technology transfer. Most centers have established cooperative projects where center personnel and industry partners have specific responsibilities and meet regularly to review progress and determine directions. In some cases industrial researchers provide leadership on project teams.

Faculty members join ERCs because of their interests in industrial problems and in systems-oriented, interdisciplinary research. Centers encourage this inclination by encouraging research done cooperatively with industry.

In some centers, research collaborations have extended to groups of companies, consortia, and other universities. Successful research collaboration between faculty and industrial researchers then becomes part of the culture of a center. Graduate students trained in this environment assume that it is a normal and effective way to pursue industry-relevant research. They take that orientation with them as they go into careers in academe and industry.

CASE STUDY: At the Rutgers University-based C-SOPS, industry mentors are integrated at the project level. Industry mentors are invited to co-mentor students and postdocs on all projects, and matches are facilitated by C-SOPS. Companies designate specific personnel to serve as mentors, with the number of mentors determined by the level of participationâ€"Level 1 sponsors have several mentors; Level 2 sponsors are limited to two project mentors. Each project has multiple industrial mentors, with one serving as a lead mentor. Roles are clearly defined, including communication and progress standards. Mentors provide formal assessment of specific project progress at IAB meetings to focus on results and deliverables. Mentoring allows for input at the industry â€œgrassrootsâ€• level within a company, while maintaining upper-level strategic involvement at the IAB level. Mentoring with the testbeds may play a critical role as these are closer to commercialization, and industry involvement may play a translational research-to-development role. There are distinct pluses, downsides, and challenges to this model. Pluses: The industry mentor has a vested interest in solving a process or manufacturing problem and technology partners are engaged, since the project is focused on their future product. This distributed model of industry engagement makes it more valuable to companies, as interactions are not limited to one person within the company (both high-level strategic and â€œgrassrootsâ€• engineering support). Companies often have meetings to bring together all of their mentors participating in projects. The value of the overall engagement can be communicated to upper management, thus making participation in C-SOPS more tangible to upper management. Downsides: Creation and management of the mentor activities is very time-consuming. Discipline may lag at

critical periods if teams have scheduling challenges. There tends to be more one-way communication from the center to industry, and this may not be as interactive as desired, since most of the team meetings are done via teleconferences due to restriction of industry travel. In some cases, certain industry personalities may dominate. Challenges: The IP protection process is challenging with outside mentors closely involved in projects. On the flip side, the industry mentors may be too close to what they are doing within their company, and may remove themselves from projects to protect the companyâ€™s interests or intellectual property.

5.2.3.6 Tracking Interactions with Industry and Innovation Partners

As in any customer-oriented enterprise, it is important to develop systems for tracking interactions with companies and assessing the effectiveness of the industrial collaboration and innovation programs. ERCs and NSF regard this capability as vital to any centerâ€™s success. A customized database or commercially available contact tracking software package is a necessary tool. Most centers find it useful to maintain a contact log, to augment memory and to provide reminders on follow-up action items. In planning such a system, it is important to consider who will use or access it, how it will be backed up, and what features are important. At minimum, a center needs a complete company mailing list and a procedure for keeping it current. Security issues may arise if companies require that the list be used for center activities only (a reasonable request). In designing the system, one might also plan for the impromptu reports that will be needed, such as lists of currently active member companies or current fiscal information. NSF's database and reporting requirements call for accurate data on company membership, support, and other forms of involvement, which must be validated by the university's office of sponsored research.

CASE STUDY: SynBERC has created an in-house electronic (web-based) project proposal submittal and review tool that captures all relevant information in a very concise and complete way. There is a separate, excellent review and scoring process to go along with this â€œProject Centerâ€• and it gives a good overview of the SAB and IAB view of the overall proposed project portfolio to guide the Leadership Team in funding decisions. Other ERCs have adopted similar systems based on the SynBERC model.

5.2.3.7 Balancing Long- and Short-Term Research

Despite industry's perennial need for short-term problem-solving, several centers reported few problems in matching long-term university research with industryâ€™s need for longer-term R&D. The continued participation of companies in centers, based on corporate assessment of the value of the investment, provides centers with a clear measure of the relevance of their longer time-horizon research efforts.

Centers that work with small companies or have contract work in their operation tend to have more short-term research in their portfolio. Examples of some of the balancing strategies used are involving undergraduate and/or postdoctoral research associates on short-term research projects, separation of general center research (long term) and contract research (short term), and obtaining additional direct funding of short-term projects.

**CASE STUDY: The RMB program management system helps the ERC to assess the balance of basic and applied research efforts, putting each project into a progress- or milestone-driven process. This helps RMB to assess each project from quarterly reports for progress and deliverables, keep track of student advancement, determine when projects may begin to intersect or align, and it provides a mechanism for determination of go/no-go decision points. Not only does the project management system drive research progress, but it also provides an â€œefficiency frameworkâ€• for faculty to operate within, creates parity and transparency in funding decisions, and supports an educational environment for student development relevant to industry. This also is a system that allows industry to offer input at critical research decision points, and can point a project towards a market opportunity not previously imagined.*

5.2.3.8 Industry Support for Consortia vs. Directed Research

At times, industry tends to move away from supporting academic consortia in favor of directed sponsored research. A commonly heard company argument is that with tight industry research budgets, companies must focus scarce

resources on:

- a list of favored universities for each company (usually top-down driven), and
- specific researchers who are well known in their field and are doing work that is specifically targeted toward the companyâ€™s interests (usually industry researcher / bottom-up driven).

With that said, industry seems to understand the significant benefits of leveraging the NSF investment in key fields of development, as evidenced by the large number of companies supporting ERCs. An ongoing challenge for the ILO is keeping industry engaged in longer-term research wherein specific benefits to the company are not clearly demonstrable. This is the same issue that ILOs have faced since the inception of the ERC program and is inherent in a program that balances basic research with industrial collaboration.

ERCs may see more opportunities to partner with industry in innovation-focused research proposals jointly submitted to federal funding agencies. The ILO and Associate Director for Research or Thrust Leaders should survey leading agencies for such opportunities, as funding for innovation and translational research is a growing opportunity.

5.2.3.9 Measuring Program Effectiveness

Metrics used to assess the effectiveness of the industrial collaboration and innovation programs vary among the different centers, but NSF does have some common expectations, as discussed here and required by NSF in the ERC's annual report. Other metrics will be useful in reporting to the center's Industrial Advisory Board. Still others may be used only internally for program management and improvement. All centers should keep track of the impacts of their work on companiesâ€”what was adopted, how it was used, the impact on the company and on the industry, and other indicators. Data quantifying the impact are especially powerful. In all cases, success "nuggets" describing the impact on industry are useful in explaining the center's accomplishments and should be preserved to expand on the numerical listings. In addition to the centerâ€™s own use, this information is used by NSF for a variety of purposes. Metrics used in ERCs can include:

- number of joint research projects with industry;
- number and names of students hired by member companies;
- number and titles of publications;
- number of patents/licenses;
- company funding figures and in-kind corporate contributions;
- number of companies attending center meetings;
- number and industrial collaborators on projects; and
- number of faculty visits to companies.

Some centers have found it useful to individualize the data by company to support center industrial representatives in their justification of membership renewal, if requested.

As discussed in Section 5.2.3.2, industrial members perform an annual SWOT analysis. Additionally, each centerâ€™s students perform a second, parallel SWOT analysis. Members of the ERCâ€™s Student Leadership Council gather and synthesize input from participating students (as both participants in and customers of the ERC). Students use the same criteria and techniques as those of the industry membersâ€™ SWOT analyses. Like their industrial counterparts, they communicate the analysis to the NSF site review team and the ERCâ€™s leadership for the purpose of continuous improvement

CASE STUDY: CBiRCâ€™s SLC has an especially strong SWOT (strengths, weaknesses, opportunities, threats) analysis protocol that exposes, from student perspectives. critical issues relating to how well the ERC is achieving its goals. The annual analysis, which partners students, ERC leadership, and the NSF to strengthen the enterprise, is designed to mitigate the influence of individual (one-off) opinions that might not be shared by the larger student group. The analysis has five main steps: (i) brainstorming to generate question topics (e.g., the ERC's collaboration with industry is a strength?); (ii) analyze results to create key questions for survey; (iii) survey students (e.g., strongly agree/agree, no opinion, disagree/strongly disagree); (iv) analyze results (quantitatively and qualitatively to assess all student responses); and (v) present findings to the ERC and NSF. An example of how findings can be

presented is as follows: student responses indicated that "lack of scientific knowledge being shared by industrial partners" was a CBiRC weakness in 2011 (44% strongly agreed/agreed, 27% had no opinion, and 29% disagreed/strongly disagreed). Action items can be derived from stated weaknesses (e.g., ways to strengthen opportunities for internships). Additionally, results from prior years can be compared to current-year results to assess progress (e.g., have communication and collaboration with industry increased?). In summary, this type of SWOT analysis can be very informative in communicating to ERC leadership and the NSF regarding the overall health of the ERC.

A final note on technology utilization metrics: Licenses are an easily measured record of success. Perhaps a more significant cumulative impact, however, is gained from the little ideas and bits of information that spark an inspiration for someone, and when they take it back to their company it becomes an non-measurable (but important) piece of some large system. One way to measure this is through testimony by working engineers within the company who have benefited from the interaction. Thus, perhaps another metric should be, "Has the center established an effective forum for intellectual exchange within its technology focus area?"

5.2.3.10 Start-up and Small Company Challenges and Opportunities

Identifying mutually beneficial relationships with start-up firms and small companies has specific challenges for most centers. These companiesâ€™ small R&D staffs and immediate product concerns often hinder them from participating proactively in center research projects and activities. When approached, their initial reaction often is that they may need immediate consulting assistance or they want to hire students, but may not benefit from full membership in a center when considering the membership fee and time commitment. Nevertheless, in high-risk research areas such firms may represent an important mode of technology commercialization. Most centers have developed special ways of working with small companies to make joining possible (such as reduced-rate memberships or short-term project teams of undergraduate students with faculty and industry researchers). Marketing the center to such firms can emphasize benefits such as access to prospective product buyers from large companies at meetings; a window on the future directions of the technology; access to prospective employees; and any special programs developed. Teaming with small firms on proposals to other agencies also is an effective way to establish a partnershipâ€”especially with a government agency focus on innovation in solicitations.

Care must be taken to manage conflicts of interest for any spin-off firms that involve the ERCâ€™s faculty, executive managers, or ILOs. The ERC must develop a conflict of interest (COI) management plan with the university COI officers.

The ERC must be diligent that small and large company engagement is perceived as equitable. One concern is that larger companies may be reluctant to contribute a substantially larger cash or cash / in-kind investment with an ERCâ€™s perceived focus on smaller company-focused innovation and technology commercialization programs. Additionally, some ILOs have voiced concern that the focus and time spent on engaging small companies can tend to decrease the ERCâ€™s overall industrial membership fees, as small companies typically pay less than large-company fees for equivalent benefits, especially access to IP. Clarity as to the expected mix of large and small company focus for each ERC should be carefully considered, as each centerâ€™s potential industrial support base is unique and sometimes quite dissimilar from other centers (e.g., biotech/emerging medical technology vs. electronics-focused centers). Above all, the industry and innovation partners need to perceive as equitable the industrial partnership and fee structure and the opportunity to leverage ERC technology outputs to the benefit of the partner.

Longer-term engagement of small companies, especially in difficult economic times, can be less stable than for large companies, as trimming of whatâ€™s sometimes perceived of as â€œnon-essential activitiesâ€• spending is usually the first step in retaining capital for core functions. This can lead to higher small-company turnover and therefore more time spent in recruiting new companies. These concerns can be valid in that the ILOâ€™s time is typically stretched, especially with the added innovation duties of the Gen-3 centers, and ILOsâ€™ need to prioritize their recruitment attention and time.

Most states have innovation programs to support the development and commercialization of technology by small companies. They may provide business incubators, help in applying for Small Business Innovation Research

(SBIR) or Small Business Technology Transfer (STTR) grants, matching funds for federal grants, or even direct equity investments through venture or seed capital funds. A useful source of information is the State Science and Technology Institute (www.ssti.org), a nonprofit research and education organization that tracks such state programs and monitors the state-federal relationship in science and technology.

5.2.4 Benefits and Challenges of Interacting with ERCs

Studies of ERC industrial sponsorsâ€™ satisfaction with and benefit from the ERC programs were completed in 2004[1] and 2012[2] and the results provide a clear view of the benefits and challenges of industry interacting the ERCs that is instructive to ILOâ€™s and other center leadership. This section will highlight the major findings of those studies, but the reader is directed to the referenced reports for further detail.

5.2.4.1 Benefits to Industry of Engaging with ERCs

Overall, both studies found that ERC industry members were generally very satisfied with the ERC programs. The 2012 study found that almost 90% of the members felt that their expectations of the ERC had been met or exceeded and in both studies, approximately 75% of industry respondents felt that the benefits received matched or exceeded the financial commitment that they had made to the center. While the entire ERC package (research, education, outreach, industrial collaboration, innovation) is designed to support industry, a more granular look reveals the specific benefits that industry values.

The 2012 study confirmed that industry members recognize the strengths of the ERC IAB model for a number of reasons. Industry felt that the ERC systems-level approach and industrial consortium model kept a focus on cross-disciplinary research in complex fields that addresses important problems in industry and gives industry input into how best to direct the NSF funding. Additionally, industry valued the ERCâ€™s ability to work on pre-competitive research that brings together scientists and engineers (from sometimes competing companies) with academic researchers to advance technology. Ultimately, the study showed that industry valued their participation to improve the chances that the technology will transition to industry and be scaled up. In addition, they valued development of the talented young ERC researchers/students in preparation to joining industry.

A company makes a decision to join and maintain membership in an ERC based on its expectation of benefits. It is important for the ILO and center leadership to understand industryâ€™s specific expectations in order to highlight these benefits as part of the centerâ€™s marketing efforts. The 2012 study queried industry sponsors as to the single most important factor influencing the companyâ€™s decision to join the IAB, as well as the three most important factors. The cumulative responses to both questions were very consistent and so only the survey results regarding the three most important factors in joining the ERC are given here, but the reader is again directed to the report for further detail. Industry members identified their three most important factors influencing the companyâ€™s decision to join the IAB as:[3]

- Follow developments in a field related to my companyâ€™s business (61%)
- Support advances in a technology space important to my company (53%)
- Gain access to specific expertise resident in the ERC (37%)
- Establish relationships with ERC faculty (33%)
- Network with other IAB members (28%)
- Evaluate students as potential employees (26%)
- Leverage company resources through collaborative research (23%)
- Access ERC developed intellectual property (19%)
- Seek partnerships with other IAB members (11%)
- Gain access to ERC facilities / equipment (9%)
- All other responses (5%)

The 2004 study showed similar findings of industry benefits as the 2012 study. In the 2004 study, industry members were asked to estimate the relative importance of specific reasons for their firm joining the ERC. That study indicated that the most important reason for joining the ERC was access to new ideas and know-how (rated

by 78 percent of respondents as very or extremely important), followed by access to faculty and to ERC technology, and then by prior connections or relationships with individuals at the ERC.

Of significance in the 2004 study, 40% of industry members reported that they had hired center students or graduates. Among those industry members who received benefits, the value of hiring students or graduates was rated more highly than any other benefit studied. On every one of a wide range of performance criteria shown in Figure 5-3, a large majority of ERC students or graduates hired were rated somewhat or much better than comparable non-ERC hires.

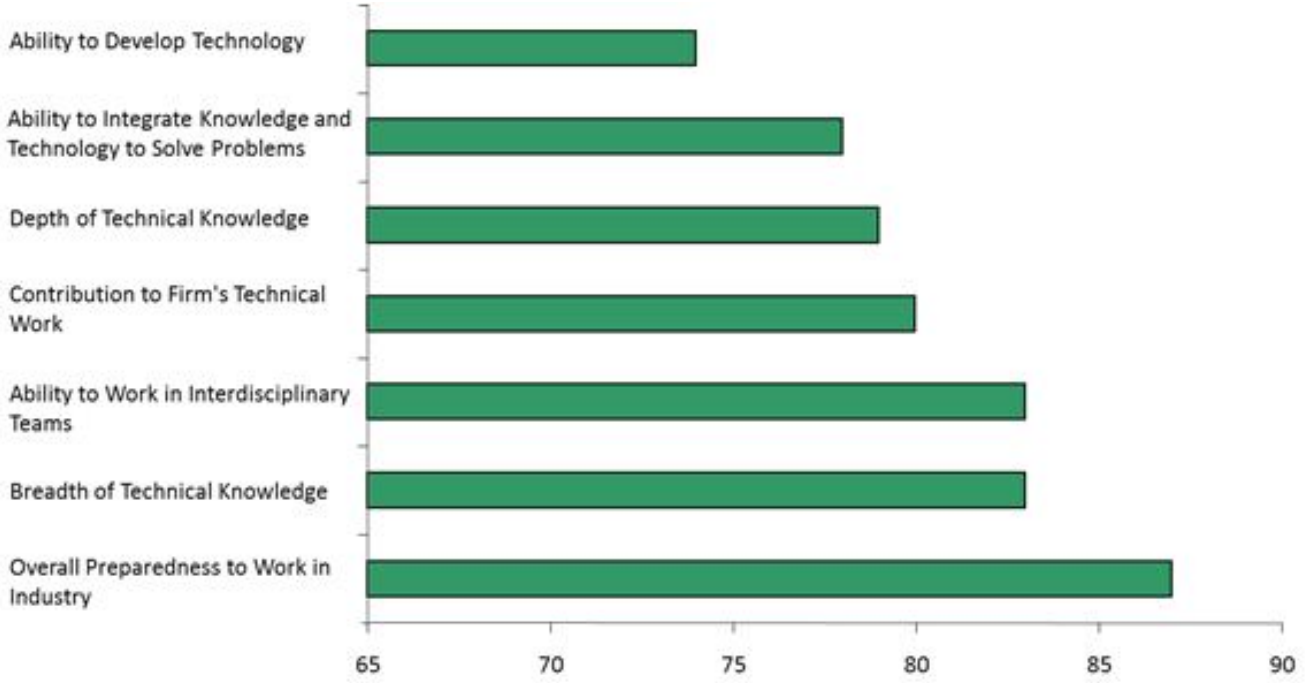

Figure 5-3â€"Percentage of industrial supervisors rating the former ERC students / graduates hired by their firms as â€œBetter Thanâ€• or Much Better Thanâ€• equivalent hires without ERC experience.

The message to ILOs is to encourage industry members who hire ERC graduates to get the message out to the other companies regarding the value of these students, and for the ILO to carry this message to new companies they are recruiting.

Industry members in the 2004 study were also asked to identify and rate factors that might contribute to the benefits their companies gained from ERC participation. The top factors that were rated as very or extremely important by the highest proportion of representatives (between 48% and 53%) were:

- The continuous existence of a strong ERC â€œchampionâ€• in the company unit (53%);
- Responsiveness of ERC faculty/researchers to our needs (51%);
- Management support of the ERC within our company (49%);
- The closeness between the ERCâ€™s specific technical focus and ours (48%); and
- The ERCâ€™s efforts to communicate and stay in contact with sponsors (48%).

ILOâ€™s should take note each of that these top factors can be heavily influenced by the ERCâ€™s leadership, with the ILO as the point of contact, putting in place a sound industrial member retention strategy.

When considering the barriers to companies receiving benefits from their ERC membership, industry members overall felt that the ERC consortium model was effective in that none of the barriers presented extreme difficulties for most members. â€œOther company mattersâ€• (45% of respondents) and â€œdifference conceptions of timeâ€• (38% of respondents) were the most significant barriers identified.

When one considers the time and effort typically spent on discussion of IP clauses of the Industry Membership Agreement when recruiting a company, itâ€™s interesting to note that access to ERC-developed intellectual

property ranked relatively low compared to the value that companies put on more general benefits such as following development and supporting advancements in the companyâ€™s field, according to both the 2004 and 2012 studies. The 2004 study showed that 90% of industry representatives reported gaining access to ideas and know-how, 60% reported improving or developing new products and processes, while only 15% licensed center-produced technology or software. Additionally in the 2004 study, the ability to license inventions or software developed by the ERC ranked as one of the least important reasons given to join the ERC (along with access to equipment, facilities, and/or testbeds and the ability to leverage the firmâ€™s research investment with money from other ERC sponsors).

General experience (time in the trenches) can provide guidance to new ERC industry members as much as studies. In order for industry to gain maximum benefit from their partnership with the ERC, the following best practices guidance for industry from Gen-II ERCs is provided:[4]

- Early and long-term engagement enables members to reap the most rewards; do not sit on the sidelines as an affiliate. This has been proven through Gen-II and now Gen-III ERCs. The level of active industry member participation over years of membership is directly related to benefits accrued.
- Active participation in strategic planning, providing guidance on research and education through the IAB, brings relevance. As shown in the referenced studies, both industry and the ERC gain significant benefits in high level, long-term partnerships to guide the centerâ€™s strategic plan.
- Bring students to your firm for ERC-relevant internships. ERC students are different in terms of their skill sets and experiences; and these differences can be leveraged by companies that actively engage with these students early in their academic careers.
- Become a champion for a thrust or a testbed. Nothing engages and impacts like active engagement and championing of a specific project. Get in the trenches.
- Provide sponsored project in addition to membership support for the most payback to the firm. Companies who benefit most understand that the value of the research and education goes beyond core research. Companies can tailor results to their benefit through support of directed research that builds on the ERC core research base.

5.2.4.2 Benefits to the Center of Industrial Involvement

Interaction with the leading companies in the industry increases the center's credibility and prominence in the field and can be very instrumental in attracting other companies to become members. This advantage is even stronger when existing members are willing to network actively with the center and prospective member companies.

For ERCs involved in emerging technology areas, the critical mass represented by the industrial members actually nucleates and creates new industries as companies, by incorporating the technologies, give them higher visibility. The center thus grows along with the industry and becomes centrally associated with it.

As the ERC-Industry partnership adds value to industry members, so it also adds significant value to the ERC. The 2012 study highlighted the breadth of benefits that center directors and ILOs felt were gained from the IAB. ERC Membership Advantages for the ERC as reported by the center leadership included:

- The ability to pursue small development projects to help vet and advance some premature technologies towards commercialization;
- Support for industrial outreach efforts;
- The ability to expand educational outreach and support for special ERC projects (e.g., testbed expansion);
- The ability to increase the number of students and postdocs that are funded; and
- The ability to hold workshops on specific topics of interest to industry.

The 2012 study polled center leadership as to the single most important area where additional guidance from the IAB is needed, as well as the three most important areas. As with the benefits to industry results, the responses to these queries were similar, so only the three most important areas where additional guidance from the IAB would aid the ERC are reported here. Those areas were (with the percent of respondents):

- Technology road mapping / strategic research direction (54%);

- Sustainability planning (46%) (note: 33% of the ERCs polled were older than six years);
- Understanding how to position technology in the marketplace (31%);
- Technology assessment (23%);
- Support for internships (23%);
- Referrals for partnerships (23%);
- Market assessment (15%);
- Enhancing technical capabilities (staff, equipment, etc.) (15%);
- Student preparation for research in an industrial setting (15%);
- Understanding ERCâ€™s value proposition to industry (15%);
- Understanding the competitive environment (8%);
- Entrepreneurship training (8%);
- Support for seminars and workshops (8%); and
- Developing center messaging (8%)

Studying these benefits through the referenced report is instructive to ILOs in confirming that industry serves a key role for the ERCs in high level, longer-term functions (e.g., technology road mapping, sustainability planning) as well as shorter-term functions (e.g., technology assessments, internship support). ILOs should keep this in mind as they best engage their industry members to forward the ERC mission and programs.

The 2012 study also informs on the avenues for the most helpful guidance from IAB members. While input from industry members should and does come in many forms, center leadership felt that the maximum value of industry member input is provided (on a scale of 1-6, with 1 being the most useful):

- in private conversations (2.15);
- during IAB meetings (3.0);
- through conversations between IAB members and the ILO (3.54);
- during one on one discussions with the ERC management team (3.85);
- from the IAB SWOT (4.15); and
- during one-on-one discussions with project teams (4.31).

5.2.4.3 Benefits of the ERC to the University

It is important to recognize that the universities are perhaps the greatest beneficiary of the NSF ERC Program. Todayâ€™s academic environment is being swept by change in both the quantity and quality of industrial interactions. The ERC provides a challenging yet well-honed paradigm for achieving these goals. Most U.S. universities are becoming more effective in learning how to work efficiently with industry, and the ERCs have led the way. An ERC stands to benefit greatly, as its host university and affiliated institutions continue to regard the ERC system as a trailblazing effort. Some of the chief benefits to the university are:

- If it can successfully conduct one consortium, it can grow to adopt new ones.
- The skills and coordination required to manage a consortium become fundamentally integrated with the various departments involved in university administrationâ€”especially in coordinating R&D contracts, IP management, and commercial licensing.
- An R&D consortium, built over many years, is an â€œinstant marketingâ€• system comprising a set of well-informed partners (as opposed to a series of one-at-a-time and one-to-one handoffs)â€”the consortium partners will tend to â€œpull on the rope,â€• rather than pushing on it, as most universities do today.
- A well-managed group of targeted R&D consortia can be used to steer the university in new directions and to capitalize on underutilized assets, especially for faculty needing and seeking new research directions.
- For both new faculty and highly successful senior researchers, the consortium model developed along the lines of the ERC system can lead to greater scientific and technological accomplishment overall, as the scientific enterprise in such a highly coordinated, multidisciplinary system is an enormous drawing card to the best engineering researchers[5]

5.2.5 Driving Toward Self Sufficiency

NSF supports the ERC program to provide international leadership in engineering research, education, outreach, and innovation that goes well beyond the NSF ERC funding cycle of 10 years. It is the Foundationâ€™s intent that the NSF funding be catalytic and result in growth in center programs to the point that other entities (e.g., industry, universities, and other federal programs) will sustain the centers to serve future generations. As such, the ERC team, under the leadership of the Director and ILO, need to plan for self-sufficiency from the early years of the centerâ€™s life.

A clearly defined value proposition can be a key to success in retaining members in the drive to self sufficiency. How each ERC chooses to articulate its specific value proposition, it must show how the center can provide substantial benefits to stakeholders, especially industry, beyond the NSF funding cycle. Industry needs to understand that the ERC can continue to provide financial impact; knowledge; technology; talent; and relationships.

A 2010 NSF-commissioned study of graduated ERCs[6] found that 83% of the then-35 graduated ERCs are self-sustaining. Several major factors contributed to this high rate of ERC self-sufficiency post the NSF funding cycle and a review of major findings with regard to successful transition of ERCs to self-sufficiency is instructive:

- Broad involvement of faculty, staff, industrial partners, and university administration in transition planning is critical. Self-sufficiency, which includes replacing substantial NSF support (financial and otherwise), is not a trivial challenge and all stakeholders need to be engaged and brought into the process from an early stage. Effective implementation of a realistic transition strategy that builds on and enhances the centerâ€™s strengths is key. While the Centerâ€™s attention will be focused on forming and growing programs in the early years, a realistic self-sufficiency plan should be crafted, with input from all stakeholders, prior to the sixth year review.
- Institutional factors such as the degree of university commitment, the extent to which the center is prized, and whether or not the centerâ€™s policies support cross-disciplinary research and education, are critical. The ERC should be a leader on campus in terms of establishing a systems-level approach to research and development, fostering research and education collaborations with industry, and building strong innovation programs. These should serve as templates for other programs to establish the â€œERC cultureâ€• across the partnering universities.
- At the end of the NSF funding cycle, the education, outreach, and industrial collaboration programs are typically under the most stress, since the research program can to a degree rely on more traditional funding sources for a university. In order to maintain a true ERC culture, these programs, especially education, must be sufficiently valued by faculty and students such that they will be maintained. This usually requires a core group of faculty dedicated to these functions.

Maintaining the active participation of industry post NSF funding is difficult and requires a redoubling of efforts by the center leadership. Retaining the ILO is critical. Companies that have ERC graduates as valued employees will feel a greater allegiance to the center and will have a greater self-interest in its continuation. It is key to use the early and growth years of the ERC to foster industry champions who believe strongly in continuation beyond the NSF funding cycle. A history of having involved industrial members closely in the centerâ€™s strategic planning of research, in joint research projects, and successful transfer of technologies that have been valuable to companies in product/process commercialization are crucial factors in convincing industry to remain in the center following graduation. Around Year 5, it is important to begin discussing with the IAB the eventual cutoff of NSF funds and to involve them in the centerâ€™s self-sufficiency planning as valued partners in the continuing life of the center.

CASE STUDY: IPrime was formed in 2000 from successful industrial collaborations begun under the Center for Interfacial Engineering (CIE), which operated at the University of Minnesota with NSF funding from 1988 to 1999. IPrime is now self-supporting based on substantial annual membership fees from m,ore than 40 diverse, large and small industrial partners. IPrime focuses on collaborative two-way knowledge transfer and provides important benefits to its members by offering a â€œone-stop-shopâ€• entry point for industrial connections to the university research infrastructure (numerous faculty plus several technology departments and research program areas, some still supported by NSF-funded Materials Research Science and Engineering Center activities). IPrimeâ€™s Director reports that the groundwork for successful transition from ERC status to self-supporting operation must be

established long before an ERC is ready to "graduate." In his view, key elements of that early groundwork include: (a) broad coverage of technologies of interest to industry; (b) an Industrial Fellows program, which consists of scientists from industry who are resident on campus for a time to work on a research project of mutual interest with a faculty member and perhaps graduate students; (c) ability to solicit and act expeditiously on industrial input; (d) Technical Advisory Committees, through which companies can influence the general direction of university research programs and also suggest research that they would like to see but do not have the time or resources to pursue; (e) mutual faculty and industrial interest in continuing interactions, including expressed faculty interest in applied science as well as basic science; (f) senior faculty modeling of successful interactions with industry in order to train younger faculty; and (g) staff that embraces the industry-oriented customer focus, that makes it easy for industry to do business with the ERC (e.g., approaches that minimize legal wrangling), and that understands R&D management issues. IPrime's experience demonstrates that graduated ERCs can retain a strong industrial partner base if the necessary factors are in place beforehand. The end result, demonstrating tangible benefits for both university and industrial organizations, is a "win-win" for both sides -- complementing industry as well as the enduring elements of the former ERC. [For more information, see: www.iprime.umn.edu.]

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[1] The Impact on Industry of Interactions with Engineering Research Centersâ€”Repeat Study; SRI International: Arlington VA, December 2004.

[2] IAB Involvement in ERCs: Assessing and Strengthening the Role; Peter Seoane; presented at the NSF ERC Annual Meeting: Washington, DC, November 2012.

[3] Percentages shown are those companies identifying that benefit as one of their top three.

[4] Best Practices for Industry Members of an Engineering Research Center; 2012 ERC Startup Briefings Presentation; Lynn Preston, Leader of the ERC Program: NSF, November 2012.

[5] See, for example, Impact of ERCs on Institutional and Cultural Change in Participating Institutions, SRI International: Arlington VA, June 2001.

[6] Post-Graduation Status of National Science Foundation Engineering Research Centers, Report of a Survey of Graduated ERCs; SciTech Communications LLC: Melbourne FL, January 2010.