Chapter 2: Center Leadership and Strategic Direction

(rev. March 2014)

2.10 Life After NSF

2.1 Introduction and Approach

2.1.1 Directing an ERC: Basic Principles

Directing an ERC requires considerable technical and managerial leadership talent. First, the Director is responsible for the vision and center-level strategic planning that determines the direction of each center and inspires loyalty to its objectives. Second, he/she is responsible for taking the lead in organizing and structuring the center, which includes selecting the executive and administrative management team; organizing the principle research thrust areas; structuring the center's educational, outreach, and industrial liaison efforts; and deciding on what to delegate and to whom. Delegation and staffing during the life cycle of an ERC is an issue of fundamental importance to the success of the center; and the center's structure will directly influence the center's success in research, education, and industrial participation.

In addition, there is clearly no single absolute and "correct" way to direct an ERC. There are, however, a series of choices that must be made as the process is undertaken, and each choice necessarily leads to a set of consequences. The cumulative experience of the people who have directed ERCs for varying lengths of time in the center's life cycle has shown that every committee that is set up, and every administrative structure that is developed, will affect the center in ways that can be anticipated, at least in general terms. There are certainly many research centers in American universities, but the objectives, key features, and funding pattern of the ERC Program through the cooperative agreement with NSF make these centers unique in several important ways. The directorship of an individual ERC is, therefore, a unique responsibility in the academic framework of the universities within which these centers are placed.

All the ERCs owe a debt of gratitude to the pioneering Directors of the early "classes" of ERCs, who paved the way for the Directors of the later classes to refine the ERC concept. Building on the experience of these first-generation ERC Directors, a second generation of Directors expanded upon the ERC concept to position their centers for success in the 21st century. The third generation of ERCs (Gen-3), beginning with proposals in 2008, have additional responsibilities to address decreased student interest in science and engineering and an increasingly global economy. Thus, in addition to the goals of preceding ERCs, Gen-3 ERCs were commissioned to educate students to be more creative, adaptable, and entrepreneurial, as well as to understand the value of teamwork and their place in a globally competitive workforce. Gen-3 ERCs are also expected to reduce the time from discovery to innovation through adoption of an "innovation ecosystem." Additionally, Gen-3 ERCs have expanded educational and outreach missions to show impact over the life of the ERC on place-based activities at targeted K-12 schools that serve underrepresented and economically disadvantaged youth, to encourage interest and careers in the STEM fields.

Just as there is no absolute and "correct" way to direct an ERC, there is no "model" of the ideal ERC Director. There are, however, a range of characteristics that are likely success factors and any given individual will be stronger in some of these than in others. In addition, the "ideal" profile will vary across different fields, universities, and industry bases.
The Director normally would be a tenured professor with a PhD degree in a relevant field of engineering or science and some management experience. He/she would have achieved widespread recognition in his or her field for scholarly and intellectual attainments. If a Director comes to the university from industry to lead the ERC, it could

be problematical if he/she expects to use a more "directive" style of management at the university than the academic culture normally accepts.

In terms of leadership ability, five very important traits can be identified: 1) the ability to articulate a vision for the ERC that is shared with industry and the faculty and that is flexible enough to evolve over time with the developments of the ERC and the field; 2) a clear perception of the current status of the field and a vision of future advancements and a strategy to achieve them; 3) the ability to think at the systems level and integrate research from different fields to achieve a systems-level goal; 4) the ability to recognize intellectual needs and identify needed talents, both internal and external to the university faculty, and to form and sustain a cross-disciplinary team over time; and 5) the ability to lead without coercion. A Director will probably be someone who prefers to deal with the big picture, rather than with details, and who knows how to hire and delegate the detailed tasks. It is also quite useful if the individual is a skilled “salesman” in representing the center's needs and capabilities to potential sponsors in industry and government, as well as within the university. Again, the ability to articulate the vision of the ERC and energize people to share in the vision for the ERC and its development is critical.

To that end, interpersonal skills that involve team building are valuable. Management in an academic environment is often a delicate operation, so it is strongly advisable that the Director be diplomatic, tactful, and empathetic as well as perceptive, alert, and determined. Given the enormous demands of the job and the personal self-sacrifices it entails, the ability to make a total commitment to the center is vital.

The prospective Director must have gathered together a group of colleagues and junior faculty in relevant fields who are willing to form the core of the ERC faculty team. It is also very important to have an industrial support base (or at least strong contacts) established through consulting, participation in a previous center, industry employment, etc. It is useful if the individual has good relations with the university and departmental administrators, although these relationships can be built after the center is established. Also valuable are other federal, state, and private support bases (e.g., foundations) beyond NSF.

The Director should understand the opportunity the ERC provides to change the educational/research culture of the engineering efforts of the university and the potential to impact the university beyond engineering. H/she should be interested in integrating the results of the ERC’s systems perspective into the curriculum in new and innovative ways.
Finally, in terms of attitudes and personal orientation, an ERC Director should be a team-oriented coalition-builder who welcomes change, since technological and "cultural" change are what the ERCs are all about. The person's attitude toward the encouragement of women and underrepresented minorities to pursue engineering education and research must be genuinely positive. He/she should be oriented toward focused basic research that integrates science and engineering with long-term benefits for industry, because this is the fundamental rationale for the ERC Program. Finally, the Director should be oriented always toward achieving a center in which the integrated whole is greater than the sum of its individual parts.

In directing an ERC, a statement made by Professor Greg Carman, Director of the Center for Translational Applications of Multiferroic Systems (TANMS), based at UCLA, might be helpful advice to remember: *"I have always believed that life is more about the individual than the organization. If an organization is good, everyone contributes to the organization but no one is indispensable. Also the world does not fall apart if a member of the organization leaves; it is simply a natural occurrence that should represent an opportunity to make the organization stronger. In my world, the key is to make sure people enjoy what they are doing and to give them opportunities for*

growth. Furthermore, make sure that your employees have all the opportunities available to them and if there is a better position for them outside the organization, support them in getting this position—i.e., do not try to impede individual growth for the sake of the organization. I think this philosophy comes from managing students where they are not permanent employees but just staying long enough to learn a skill set and grow into more productive researchers outside. That is, if you want the best people you have to be prepared that some jobs in your organization are simply stepping-stones to where the individual will eventually be in their career."

Because the success of an ERC must be measured in terms of the extent to which it has fulfilled the mandate set for these centers by NSF at their inception, it is useful to review their stated purposes. The primary goal of ERCs is to conduct innovative, cutting edge research to enhance the global competitiveness of American industry. Very direct and effective integration with industry is implicit in the charter of the ERCs; and the centers are to have a systems focus and to emphasize cross-disciplinary research and education. Consequently, an important change is envisioned in the education of young engineers—ERCs are to act as catalysts for the transformation of fundamental academic research in engineering into innovative technologies that industry can bring to commercial realization. That is, they will be centers that establish world leadership in emerging and important areas of research, in industrial relevance, and in cross-disciplinary education.

This chapter was prepared by a team of current and former ERC Directors (see Appendix A to this chapter). It is hoped that the suggestions made herein, although by no means absolute prescriptions, will provide new or prospective Center Directors with a greater sense of confidence in their decisions.

2.1.2 Chapter Organization and Objective

In an attempt to avoid duplication with other chapters of the ERC Best Practices Manual, this Center Leadership and Strategic Direction chapter will address the conception of an ERC, the daunting task of building and directing an ERC, and the set of decisions and actions that a new Director and Deputy Director must take, roughly in the sequence that they must make them. In doing so, it touches on subjects that are covered in much more detail in other chapters, such as Research Management (Chapter 3), Education Programs (Chapter 4); Industrial Collaboration and Innovation (Chapter 5), and Administrative Management (Chapter 6),

Early in the life of an ERC the Director must establish the ERCs vision and strategic direction, decide to what extent s/he will delegate responsibility for specific aspects of the center's operations, and must then hire or assign employees or faculty members to fulfill these functions. The initial management team and management structure is, by necessity, defined in the proposal and refined in the full proposal. Because not even the most heavily endowed universities can have all the high-caliber faculty in the right areas that are necessary to execute the strategic plan of a good ERC, faculty recruitment is the most potent weapon that the Director has in hand to shape the center. One of the Director's main contributions to the center will, therefore, often be in the area of faculty recruitment and replacement, both externally and on campus. This contribution will extend throughout the life of the center and will depend heavily on the relationships that s/he has built with contributing departments and with the university administration.

2.11 Summary Observations

2.2 Vision and Center-Level Strategic Planning

2.2.1 Creating the Vision

How are the themes and vision for a prospective new ERC developed? It begins with a challenging and timely problem of great societal importance for which no single institution or discipline can overcome the technical, social, and economic barriers to achieve workable solutions. Every investigation or research agenda is based on a "genealogy," or cumulative body of knowledge or thought, upon which the researchers base their current understanding of a field and from which they draw a vision of how the current state of knowledge might be advanced.

Based on the historical developments in the field, each center creates a vision of what can be accomplished within 5- and 10-year horizons. Such a research vision should be based on realistic resources and the need for bringing various aspects of a particular field together to create the needed critical mass of interdisciplinary effort. The vision must be unique, or it will not strike a responsive chord in the NSF site review team that makes the initial recommendation for approval. The uniqueness of the vision will have educational ramifications both for the ERC and for achieving breakthroughs of sufficient intellectual weight to alter basic concepts in the field in which it originated, which will lead to educating a new type of graduate. However, the vision must also be industrially related and of sufficient practical importance to favorably affect the competitiveness of this country, if it is to gain the imprimatur of the ERC Program.

Since the main mission of the ERC Program is to make a positive impact on the U.S.' competitiveness in the global marketplace, it is important to understand and articulate the potential commercial impact of an ERC, if it is to be successful in achieving its goals. One way to make a case for the significance of the impact is to start with an extensive market analysis showing the size (current or potential) of the industry affected. If successful, will it impact systems integration and new ways of doing business? Will it help address the social dimensions of change? Will it create a major new industry? Is there an existing major industry in which the ERC expects to stimulate technical advancement and growth? Will the role of this ERC be central in the future of that industry? These are all elements of the center's vision.

Here the research thrust area[1]* leaders, center associate directors, and key industrial representatives usually have input into the development of the vision and achieve consensus regarding it. Although the broadest possible "buy-in" to the vision is considered essential, it is difficult to involve more than this group of key individuals in these discussions. In many cases an incoming Director will have formed very strong working relations with a few key individuals. These persons believe passionately in the vision on which the center is based, and in the objectives of the ERC Program. This group must forsake the security of the successful, well?funded Principal Investigator (PI) format of traditional research grants.

A consensus vision statement is now prepared that is shared with center faculty, students, the university hierarchy, and industrial representatives. Each vision statement should identify the overall goals of the center, not only in research but also in education and industrial interaction. Among the most challenging tasks is to build a sense of “community” among ERC researchers, who are spread among different campuses and different universities.

As the originator and/or custodian of the vision of the ERC, the Director must be prepared to articulate this vision, in verbal and written form, to a wide variety of audiences ranging in sophistication from local agencies to an NSF site review team. The Director is responsible for "tracking" the vision of the ERC and working with the Deputy Director in its evolution and execution to guarantee that the center is always at the cutting edge in research and at the forefront in the articulation of the perceptions that form the vision. The Director ultimately will be held responsible if the ERC is ever eclipsed or surpassed in any major component of the vision on which it is based. Consequently, a Director must maintain continuously a clear perception of the linkages between the vision of the center and its research, education, and industrial activities and progress within them.

Since it is essential that all participants in an ERC buy in to the vision once it is articulated, it is useful to examine the sub-elements of the vision in the form of the strategic plan and thrust area research plans at regular intervals so that the faculty, students, and industrial members of an ERC community have the opportunity to become engaged

with the vision and subscribe to it. In ERCs that are narrowly based on specific, fast?changing technologies, it may actually be imperative that the basic vision of the center be examined periodically, in cooperation with industry, and altered to suit the advancing state?of?the?art. However, most ERCs are based on much broader visions, and here the role of the Director is pivotal. Strategic plans are just that—strategies. The thrust areas of the ERC can assume a life of their own and begin to consume their leaders' scientific and engineering passions, but thrust areas are only more valuable than the sum of the efforts of individual PIs if they contribute to achieving the center's vision. It is the task of each Director to ensure that the vision is clearly seen and well served by the center through integrated research and education. In fact, it is a requirement of the ERC Program that the integrated whole of the center be greater than the sum of its individual parts.

2.2.2 Pursuing the Vision: The Strategic Plan

The ERC now must develop a broad strategy for achieving its vision. How can a cross-disciplinary center take advantage of the opportunity envisioned? This is its mission. Is it realistic? Does the ERC have the necessary intellectual horsepower to achieve success in this area?

One way to answer these questions is to form a "blue ribbon" panel of objective outside experts to evaluate the plans and personnel of a proposed ERC. If the answers are encouraging, then the next step is to develop a strategic research plan to achieve the vision and mission. In this chapter we will focus on the overall strategic plan for a new center. Chapter 3, "Research Management," describes the process for development and updating of the strategic research plan.

In contrast to the process of originating the center's vision, the process of strategic planning is more democratic. In some centers the initial planning is done by an executive committee consisting of the Directorate (including associate directors, if any), thrust leaders and/or senior faculty, and key staff such as the education and outreach directors. A smaller group allows faster convergence on the initial plan. But in most centers the process involves, either at the outset or subsequently, discussion and input from all faculty members and research staff. (At one center the plan is posted electronically for criticism by all center participants; commentary is circulated via e-mail until all issues are resolved.) Usually the plan is reviewed and discussed at least annually by the Industrial Advisory Board (or equivalent). It can be tricky to avoid the natural tendency of industry to direct the details of the plan toward areas of short-term interest; the Director must be vigilant to filter out such influences and absorb them in the higher aims of the plan.

However, as with all proposals, once the center looks like it will be funded the faculty will ask “what’s my role and funding?” This is especially challenging for ERCs, because typically a small, dedicated core of faculty may have actually written much of the proposal and the research thrusts and themes are usually written around teams, not individuals. Thus, the individual roles of faculty and students may not be well defined. For this reason, a center-wide retreat very early in the life of ERC is important—perhaps even prior to the actual funding start date—to develop a coherent vision and remind all participants about the various components of a viable ERC.

The first kick-off meeting would be the starting point for the review of the strategic plan for the ERC. Later on, it will also provide a benchmark for assessing the progress of the center and the value added to the field by its activities. No strategic plan is static, and prior to each annual report the plan should re-visited and refined. Often some topics that seemed important at the proposal stage will seem less critical as new ones emerge and the ERC team begins to pursue its research and outreach agenda. It is unwise to conduct a wholesale revision of the strategic plan. Rather, it’s more like mid-course adaptations to experiences and “boots on the ground” realities, and responding to initiatives that may evolve from close collaboration with IAB members.

The Director, with key leaders of the ERC, may engage in “thought pieces” in influential feature articles or editorials about the domain in which they work. This will help articulate where the field is going and, by implication, how the strategic activities of the ERC map onto this comprehensive view.

[1]A cluster of research projects managed as an integrated group to achieve one component of the center's overall strategic plan.

2.3 Structuring the Center for Success

Delegation and staffing during the life cycle of an ERC is an issue of fundamental importance. The related questions of how much to delegate, what management and operations functions to delegate, and how best to accomplish this distribution of responsibilities should be addressed in the planning stages of the ERC and on into the initial stages of funding and implementation of the ERC proposal. The center's structure will directly influence the center success on research, education, and industrial participation.

2.3.1 Deciding How Much to Delegate

When an ERC is funded by NSF it is probable that there will have been a personal prime-moving force who has initiated the application and gathered the research team. It is equally probable that the initiator will have a large and well-funded research group, or it is unlikely that the application would have been successful. But it is apparent that the duties of the Director of an ERC are sufficiently challenging that they are very difficult to combine with those of a successful and busy PI or research group leader unless the person concerned is adept at delegation. For this reason the first, and one of the most important, choices that a founding Director will make will be the extent to which s/he delegates responsibilities within the center as it begins its progress towards its first date with destiny at mid-Year3. If the Director delegates too little, s/he risks eventual "burn-out" and the loss of his/her own research program and even the center itself. If s/he delegates too much, s/he is likely to lose control of the center and jeopardize its ultimate success. The founding Director should assess the importance of all the potential roles within the center and decide which to delegate and which to retain. Three major factors that influence the Director's choice are: 1) the peculiar strengths of his/her center team, 2) the overall interests of the center and, finally, 3) the meshing of his/her own research interests with the welfare of the center. In any case, the Director's research must fit integrally within the scope of the center's research or it may be seen as a conflict of interest and a threat to the cohesiveness of the center. Such conflicts are viewed as serious by NSF, and must be resolved quickly.

If the Director chooses to retain control of administrative and routine personnel matters, s/he will drown in details as the center grows to encompass about 100 people. If the Director retains direct, personal control of financial matters, s/he can use this control to steer the center in detail, but s/he will be held responsible for every fiduciary ripple and s/he will encounter resentment when support is withheld or withdrawn. Experience teaches that, given the efficiency of sole autocratic command, a researcher can control and steer a research group of about 40 with some help from experienced staff and postdoctoral fellows. Therefore it is critical that the Director rely on and distribute responsibilities amongst her/his leadership team, beginning with the Deputy Director and Administrative Director. One approach is to have all of the administrative staff report through another designated individual (Deputy Director, Executive Director, or Administrative Director).

Sometimes just as important as the degree to which the Director delegates responsibility within the center are the mechanism(s) of delegation. This delegation should be done very carefully because its consequences for the smooth operation of the center are likely to be quite significant. Everyone involved in an ERC must realize that the whole exercise is driven by the center's vision and strategic plan. The administrative function is only an "engine" (albeit an essential one) to facilitate the realization of the vision and, as such, it will always be secondary to the program activities of the center.

There is general agreement among ERC Directors that the following responsibilities should not be delegated.

- Major resource allocation and budget decisions, including fiscal oversight
- Major realignment of center administrative and research structure
- Final decision on hiring (and termination of) faculty and key staff
- Final selection of companies to recruit as members
- Formal contacts with NSF to address major issues
- Policy interactions with department heads, college deans, and university top administrators
- Negotiations with lead university administrators for commitments of resources
- Integration of the ERC's annual report to NSF
- Responsibility for the integrity of the ERC's reporting systems.

2.3.2 Staffing the Center

2.3.2.1 The Executive Team

An important early decision must be the type of supervision and reporting to utilize for management of the center. There is clearly a limit, which is dependent on the personality and policies of the Center Director, to the number of center employees who can take detailed direction from this one source. The ERC Director can be aided in the complex center leadership role by selecting a Deputy Director who is capable of sharing the leadership and management responsibilities in the ERC. Some centers also have the Deputy Director share in overseeing many of the operational aspects of the center, such as directing specific research areas, accessing new facilities, allocating resources, negotiating with university administrative personnel, spearheading industrial interaction and technology transfer, and supervising administrative activities. It is also common for the Deputy Director to assist the Director in organizing and preparing the center's NSF annual report and site visit.

In most centers, the Director and Deputy Director(s) are assisted by an Administrative Director who is in charge of many of the day-to-date operation tasks (Section 2.3.2.3 and Chapter 6), an Industrial Liaison Officer responsible for the implementation of the industrial program (Section 2.3.2.5 and Chapter 5), and an Education Coordinator or Education Director who leads in the implementation of the education and outreach efforts (Section 2.3.2.4 and Chapter 4). In addition, some centers have Associate Directors who oversee specific areas of research (Section 2.3.2.2 and Chapter 3).

2.3.2.2 Research Management

Chapter 3 deals specifically and in detail with research management in an ERC. However, management of this activity is central to the overall management and direction of an ERC and impinges on the success of every other area of center activity. The discussion here addresses research management in this broad context.

An ERC is an excellent power base because it represents a large amount of research money, and it will attract those who are interested in wielding financial power. The Director of an ERC must make a choice as to whether s/he will become the sole power broker, the leader of a small and select coterie of power brokers, or the arbiter of power who balances the process for the good of the center. A lesson learned from the management of research centers is that even the most promising center, founded on the most talented team of researchers, needs a constant flux of new people and new ideas to keep its edge. All centers try to stay ahead of the curve by recruiting excellent graduate students and postdocs, but very few give newly recruited faculty members senior positions with real access to center resources (especially if they are from outside the university). For this reason, the Director of an ERC may resolve to build an effective faculty intake mechanism into the center, select the new team members with great care, and choose research management structures that allow the newcomers to share power and resources on an equal footing with all other participants. The intent here is to ensure that the ERC survives beyond the 10-year time horizon by accommodating growth and preventing stagnation.

Rather than making all research management decisions personally, an ERC Director may find it more useful to maintain the vitality of the center by making sure that all ideas that serve the vision have an equal chance of implementation. It is certainly not the intent of the ERC Program to provide 10 years of high-level funding to a Director and an unchanging group of researchers, however capable and even brilliant they may be. Thus, a new Director must decide whether s/he will retain complete personal control over research management, set up a closed system of research management involving a select group of insiders, or augment the closed system with strategic planning and revitalization mechanisms that involve the whole center. Perhaps there is no choice to be made by a new Director, in the initial stages of the organization of an ERC, that will affect the center more than this pivotal decision. It is, however, advisable that the important decisions on strategic planning and research goals are made with the support and agreement of the Deputy Director and the key research faculty.

Research in an ERC is inspired and directed by the center's vision, as articulated by the Director and Deputy Director and supported by its members. The practical vehicle for the realization of this vision is the strategic plan, and the mechanism for its execution is the structure of thrust areas and testbeds found in all ERCs. As was described in Section 2.2, the Directors of most ERCs maintain firm control of the center-level strategic planning process; most decisions in research management are made by these Directors with the advice of a small inner circle of senior center researchers who comprise an executive committee. In some cases, periodic retreats or cyber sessions for the input of ideas have been employed as a means of involving more center members, and these have been proven effective in facilitating the development of a "center" perspective. But generally the responsibility for the planning and management of research remains centralized.

The complex research tasks and the associated reporting requirements of the ERC Program review process virtually demand that each center must appoint a leader for each research thrust area and that someone, usually

the Director--often with the aid of the Deputy Director--must combine these reports with those of the education and technology transfer programs to produce the annual report. These thrust area leaders also provide a necessary management interface between the Director and the rest of the center's executive team and the faculty researchers, with responsibility for the detailed planning of research within each thrust. It is important to begin with the right number of research thrust areas. The "right" number may differ from center to center and field to field, and may also change across time. However, in general the fewer the research thrust areas, the easier it is to manage the research program.

Several centers cite difficulties in terminating existing projects. Most report that they depend ultimately on the Director to make these hard decisions, but such ERCs have closed research management structures that may require that the research committee vote against one of its own members. A number of centers often take input from the Industry Advisory Board (IAB) on the relevance/quality of projects heavily into account in deciding whether to continue them. Site visit recommendations are another source of input**.** It is easier to terminate unsuccessful lines of research if there is a detailed strategic plan with milestones; this makes it apparent when a project is going nowhere and/or no longer fits within the strategic plan. Open channels of communication, with emphasis on the ERC research as a team effort, help to soften the blow. Nonetheless, it is important at the outset of an ERC for the leadership team to articulate both the requirements for retaining financial support during the life of the ERC as well as the process to terminate, such that all involved perceive the process as fair. Many ERCs also provide support to the graduate student(s) involved for at least one semester after termination and try to accommodate them within other ongoing projects.

2.3.2.3 Administrative Management

Because an ERC with NSF funding and average industrial, state, and university support constitutes a roughly $10 million/year enterprise, a centralized and proficient administrative structure is mandatory for effective organizational and financial responsibility. Therefore, an important leadership role in the center is the Administrative Manager or Director (AD), who is responsible for general management of the day-to-day operations. The selection of a capable AD is one of the most important administrative decisions a center must make. This position is discussed in more detail in Chapter 6.

The Director and the AD typically work very closely together; the smaller the administrative staff, the more this tends to be the case. The position of AD requires a strong generalist, and selection of the right person is critical. These individuals play a key role in the overall success of the centers. It is essential that the AD understands fully the vision of the center, its ideals, and its intended impact, and that s/he be treated as an equal partner in bringing them to fruition. The AD accepts the responsibility of implementing the center's vision in a manner acceptable to the university's and NSF's bureaucracy. Therefore, mutual respect must be present between the Director and AD, with the Director articulating the concepts and ensuring buy-in and the AD providing a reality check on what is possible and identifying ways to implement the concepts. (Again, see Chapter 6 for a full discussion of this function.)

It must be noted, however, that the Director is ultimately responsible for any administrative lapses that may occur; consequently, it is important to maintain supervisory oversight and control of office management functions. One potential problem is that major budgetary/accounting problems may arise in a center from a variety of causes. Therefore, it is advisable for the AD to have significant expertise in budget management/monitoring and databases. If this is not the case, an additional person with this critical expertise must be added to the team and must also work close with the Center Director, at the expense of adding administrative costs.

The decision to hire specialists for other functions will affect the center in various ways. If an assertive accountant is hired, the finances of the center will be well managed; but at an extreme, account management may not be as flexible as the Director needs. If the industrial interface is handled by administrative staff on a part-time basis, the Director will be the *de facto* salesman for the center. If, on the other hand (as in most centers), an aggressive Industrial Liaison Officer is hired, the industrial interface will burgeon and there will likely be a strong technical connection with industry through the PIs. If the details and the policy of interdisciplinary education in the center are managed by a part-time faculty member as Education Director, students will tend to be trained in their home departments and assembled in the center for occasional seminars and NSF site visits. But if experienced specialists are brought in to be responsible for University Education and Precollege Education (as currently required), these vital areas of the center's activities will be competently planned and carried out, engaging students at all levels integrally within the center, Therefore, care needs to be taken when hiring specialists to ensure that they are capable of and willing to work in a collaborative open environment and can avoid Ãƒƒƒ‚Ãƒ‚¢Ãƒƒ‚¢€Ãƒ…¡Ãƒ‚¬Ãƒƒ‚…Ãƒ‚¢€Ãƒ…“turf" wars.

The administrative infrastructures of centers thus range from a few people gathered tightly around the Director to small armies of specialists working for the benefit of the center, and each choice that is made will affect the kind of center that will emerge at the critical third- and sixth-year review milestones. The choices made in setting up the infrastructure of the center are matters of policy, and not of financial expediency, because at least two of the key responsibilities (technology transfer and education) may become largely self-funding. The administrative structure of the center must be set up thoughtfully by the Director, who must ensure that all major policy matters remain firmly under the control of center leadership and are complementary to the primary objectives of the center.

2.3.2.4 Education and Outreach Programs

One of the three pillars of the ERC Program, education is an element with which most centers feel that they have had great success. This success may reflect the national need for education of interdisciplinary team-oriented PhDs more than it does the effective policies and programs implemented by individual ERC Directors, but in any case it is a very fertile area that may come to dominate the future of individual ERCs and figure even larger in the priorities of the ERC Program itself. In the past decade, the National Academies of Science and Engineering and NSF joined with other professional groups to rethink engineering education at all levels.[1]

Education at all levels is a lot like gardening, in that it is labor intensive and requires great patience and commitment. Hence, it is an area of responsibility which an ERC Director must delegate to one or more full-time professional Education Directors. This responsibility is shared in a wide variety of ways across different centers. There is often one Director responsible for University Education and one for Precollege Outreach; in other cases there is an overall Education Director (often a faculty member) assisted by one or more Education Coordinators. In an area such as education, in which the ERC can facilitate but not dictate, the Center Director must work with the Education Director in setting up the college program structures. The Education Outreach Director is usually responsible for leading programs that include outreach to undergraduates from other universities and community colleges, as well as outreach to secondary school teachers and K-12 students. At the precollege level, many center faculty and students become involved in local science fairs, both as mentors or judges, and in community events such as science museums.

An experienced Education Director should know the center's students well enough to flag cases in which the student is confused and/or troubled by conflicting demands of the center and of his/her home department, or by any of the myriad problems that beset the engineering acolyte today. Because a mature ERC may involve 40-60 undergraduate and 60-80 graduate students, the Education Director cannot involve himself in either their individual or collective supervision. For this reason it is advisable to appoint an education committee of faculty, whose chairperson works closely with the Education Director to liaise with the students. In this way each student knows that the center provides a professional and a faculty member that they can contact with any problems.

All contemporary ERCs develop mechanisms for evaluating and assessing their education programs. Several have professional staff dedicated to this effort, which is a specialized discipline in itself. For more details, see Chapter 4, Education Programs.

The ERC Program strongly emphasizes education and is proud of the accomplishments of the ERCs in education at all levels. Although sustaining education programs after graduation can be a challenge, as the ERC moves to self-sufficiency after 10 years individual ERCs may find a very successful interdisciplinary education program that is relevant to industry to be an asset in their continuity.

2.3.2.5 Industrial Liaison/Technology Transfer

Industrial associates in a number of ERCs contribute to the finances of an ERC in a myriad of ways. Membership in an ERC at various levels requires a fee ranging from $1,000 to over $100,000 per year. NSF values these industry contributions and often uses the amount of cash fees collected from industry by a center as a “thermometer” of the health of its industrial program. NSF also requires a significant portion of these industry fees to be unrestricted funds (as opposed to directed funds for a particular thrust or project). However, these funds are still considered program income and thus cannot be treated as “gift funds.” Funds raised with these fees can be lumped into a common ERC pot, or some ERCs elect to keep industrial member fees separate from thrust area-related research. In addition, in most ERCs industry can directly support a specific research endeavor; but this activity will operate independently of the thrust area work and is dependent only on its own budget. In some cases, research activities with industry require utilizing ERC resources to leverage industrial participation.

When considering the center's funding profile, it is important to maintain balance. For example, if most of the center's funding is from NSF, then the relevance to industry is somewhat suspect. Within industry, it is best to develop a diversified portfolio of partners ranging, if possible, horizontally across various industries and vertically from raw materials producers to parts suppliers to system manufacturers. If all the outside funding is from one industry, then there is a certain vulnerability if that particular industry goes through a bad patch. A balance between state and various federal government agency and industry funding is desirable because no one sponsor or sector then has an undue influence over the activities of the ERC. Maybe more important than all of these is to ensure the industrial advisory board has a balanced representation between small businesses and large corporations. Small companies may represent an important source of revenue beyond the 10-year NSF time horizon.

Center Director support and buy-in to the industry program is essential to its success, especially in the case of Gen-3 ERCs, which have additional requirements to stimulate startups, entrepreneurial activity, and other "innovation ecosystem" drivers. In the past, there has been a wide range of performance across the ERCs in this program element, which was so pivotal in the original funding of this program by Congress and by NSF. But as ERCs, and their industry programs in particular, have matured, those industry programs and their best practices have come to be very effective in enabling technology transfer and providing critical feedback and guidance to the ERC program. It is, therefore, extremely important that the Center Director, working with the center's Industrial Liaison Officer or Innovation Director, takes advantage of the center's relationships with its Industrial Advisory Board and the many communication mechanisms available through those relationships. The industrial collaborations are one of the key features that will enable the ERC to live beyond its 10-year financial time horizon of NSF funding.

The Director also must motivate the center's PIs to participate in the process of selling the center's technology. Because the Director must be personally committed to the process of technology transfer, s/he should take a very active role in company recruitment (also vital to center funding), in interacting with the IAB members, and in developing opportunities for joint research with sponsoring companies. S/He will also hire an Industrial Liaison Officer or Director of Innovation from outside of the academic framework and will give this employee the freedom to build strong relationships on an ongoing basis with companies interested in the center's technology. It is important in all of these instances that the ERC director also facilitates interactions between the ILO and Intellectual Property offices and Contracts & Grants offices at each institution. The development of a working Industrial agreement as well as the transfer of IP is based on the interactions that occur among these three groups—i.e., the ILO, IP offices, and industries—and represents a critical path to future successes.

2.3.3 Developing and Maintaining a Diverse Team and a Climate of Success for All

Developing a diverse team of researchers and staff represents a formidable challenge for an ERC, given the demographic distribution that currently exists in academic engineering. It is an important topic because some of the metrics that the ERC reports on an annual basis are directly related to the diversity of the culture within the ERC. In the diversity area, it is important that a Director form an initial research team that is competent and represents a distribution of team members with different demographics and backgrounds. This distribution is important to infuse new/different ideas and thoughts into the research and developmental areas, rather than relying on a monolithic culture with a myopic research focus. Diversity within the ranks of the primary investigators also sets the tone for future students recruited into the center, helping to ensure that "success for all" is ingrained in the ERC culture. While this may be the first important diversity decision a director may make, the second is wisely choosing the Education Director(s) and, in many cases, a Diversity Program Director. In some centers the Education Directors, both University and Precollege, have improving diversity as an integral part of their education program responsibilities. Where both Education and Diversity positions exist, they collaborate in developing and pursuing the center's diversity goals.

Candidates for both these positions need to be chosen with several important attributes in mind. These include: understanding the challenges facing engineering students and faculty from diverse backgrounds; being willing to make bold changes to promote a heterogeneous environment; and having established relationships needed to "grow" a diverse program within the ERC. The Diversity Director (or Education Director responsible for diversity programs) will first be faced with issues of working with Principal Investigators (PIs) to increase diversity within the graduate and postdoctoral sectors. This is challenging because most PIs typically use a narrowly focused process for selecting graduate students and postdocs. The Diversity Director may find more willingness on the part of the PIs to begin increasing the diversity of the undergraduate student population within the ERC, since these students feed the pipeline for the graduate and postdoctoral programs.

Some ERCs have developed the view that overcompensating at the undergraduate level will help recruit more diverse students into the graduate curriculum of the ERC. This may be especially true for programs focused at the K-12 levels, with the drawback of a significantly long time horizon to have an impact on the ERC's diversity. Nonetheless, the K-12 student population may represent the most important impact an ERC can have on diversity. It is here where engineering has fallen short—i.e., not doing an adequate job of attracting a diverse population to engineering studies and careers. One ERC uses the concept that educating K-12 students about entrepreneurial concepts might encourage more diverse students to enter engineering studies. Here, it may be important to educate the K-12 students on the life-long career benefits an engineering degree offers. One fact that has been useful is that the number one degree of CEOs in S&P 500 companies is typically engineering, not business. Therefore, if you want to be a CEO, a pathway to that goal is through engineering. Second, engineering represents a truly enjoyable experience that has lifelong rewards, and YES, it is fun to be an engineer. For the latter, it is important for the Center Director working with the Diversity Director to develop a climate that is inclusive and enjoyable for all. To that end, it is not sufficient simply to conduct research but it is also necessary to develop a climate that supports an "engineering family" type of environment.

2.3.4 Managing Research at the Interface of Disciplines

One of the distinguishing features of the ERC Program, an area in which it was a pioneer in contemporary academe, is its emphasis on cross-disciplinary research. In most cases the complex systems nature of the research naturally requires the ERC to be highly multi-disciplinary. Individual ERCs have devised many ways to facilitate cross-disciplinary interactions among the faculty. In a number of centers an absolutist approach is taken: i.e., projects without cross-disciplinary interactions will not be funded through the center's resources, or else the evaluation criteria for project continuation will include cross-disciplinary collaboration. In other centers the requirement is not so absolute for all projects, although there is a strong preference for cross-disciplinarity, and a strong message is given that collaboration is necessary if the ERC is to be successful.

Other mechanisms that are employed to encourage and facilitate these interactions include:

- specific requests for collaborative research to meet an identified need;
- special center funds made available for cross-disciplinary projects and proposals;
- inviting researchers from a range of fields to center research meetings and retreats;
- structuring center research so that project teams cannot complete their assigned projects without obtaining assistance from other teams;
- developing a set of "end-to-end" demonstrations, within and between research clusters, that illustrate how the tools and methodologies work together; and
- engaging in design activities with center industrial affiliates (which commonly involve participants from more than one project or research thrust).

2.3.5 Acquiring Facilities

Operating a well-run ERC involves bringing together the necessary resources, including not only personnel but also facilities and funding. Facilities required to carry out the ERC's research mission include so-called "signature space" for housing the center administrative offices, conference room(s), and general space for center-supported activities such as a computer laboratory, student library, and lounge where faculty, students, and staff can gather to discuss their work. Distributed laboratory space is necessary for developing basic materials, device, and system-level competencies. Usually the Dean of the College of Engineering and the Chairs of the individual departments make the signature space available to the center. Individual laboratory space is usually made available to faculty on a have-need basis. Some centers have succeeded in obtaining new buildings or significant expansions to existing buildings. Space is perhaps best negotiated at the time the final proposal is submitted to the NSF.

2.3.6 Some General Guidelines for Center Management

The three pillars of the ERC Program are research, education, and technology transfer. However, it is clear that the first (research) is a *sine qua non*, in that the educational and/or technological advantages are derived from the research program. Also, all ERC Directors quickly come to understand that NSF site visit teams have been instructed by NSF to view research as the first preference "gate" when assessing the extent to which an individual ERC has succeeded in its mission. Thus, research project choices represent a key component of a successful

ERC.

Investing center resources in specific research projects must be guided by the strategic plan in which the center is united. When that critical time of each year rolls around in which decisions have to be made about how resources should be allocated to the various thrust areas, the Director will find himself or herself in a situation that will be dictated by choices s/he has made at the outset. Either there will be a clearly stated strategic plan that makes the finance committee's job possible, or there will be a struggle for funds and the Director will have to make all of the final decisions. If there is a clearly stated strategic plan, the Director should be vigilant to discern the real authorship of key inputs to that plan. The strategic plan of a center can be manipulated by a small group of faculty with preconceived notions of what direction they want the center's research to take or, at an extreme, by a single strong personality, often the Director, who simply tells the troops that this is what s/he has decided. The smaller the coterie of influential insiders, the more NSF money there is for each individual in that group. But NSF Program Directors and site visitors can detect such a situation fairly easily and will not tolerate it. ERCs have failed to win renewal because their research program lost its cohesiveness and collapsed into a collection of loosely connected single-investigator projects. It is important to always have pathways back to the larger picture defined theoretically by the unified strategic plan, as visualized in the classic ERC 3-plane chart (see Figure 1).

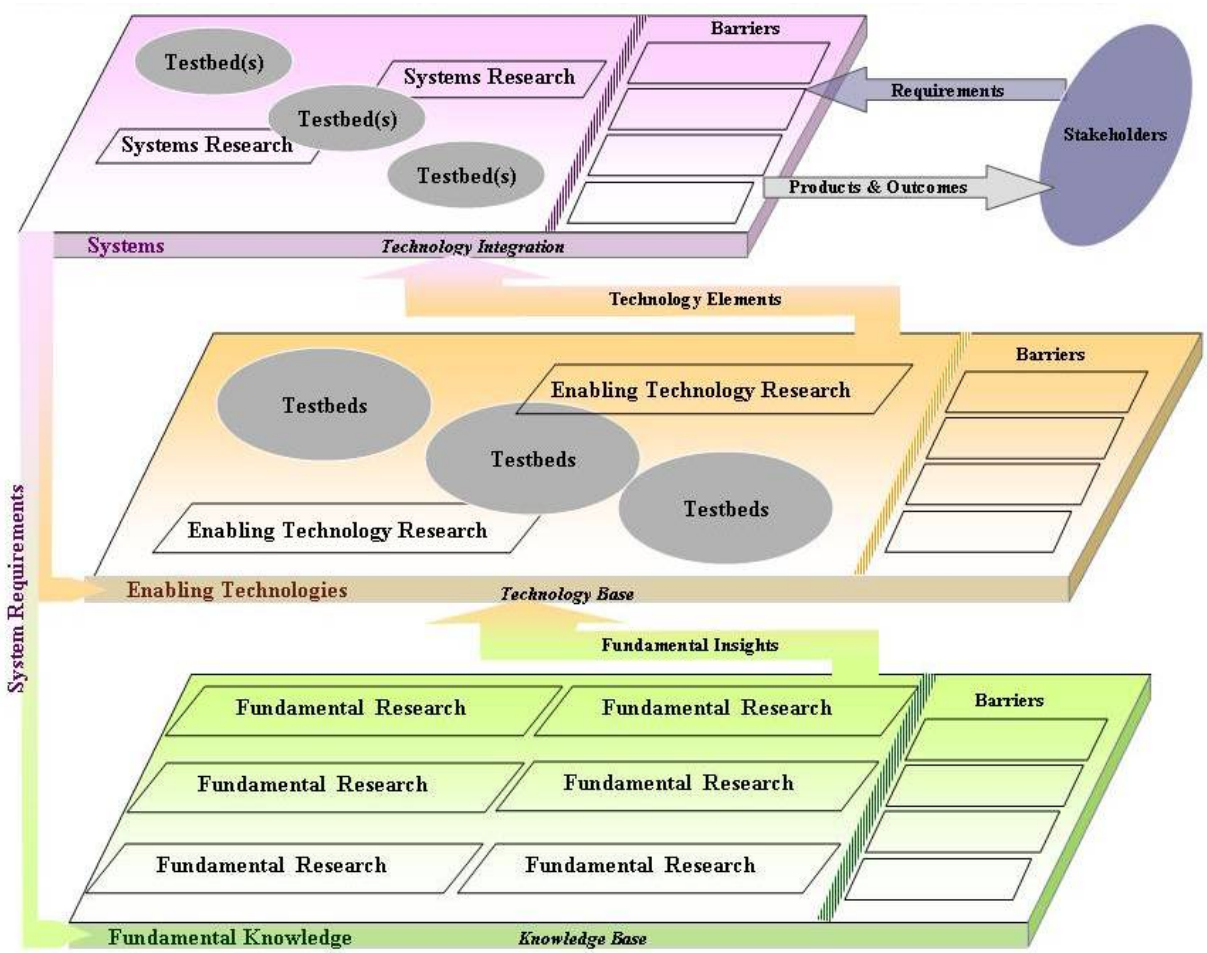


Figure 1. An ERC's strategic framework can be visualized via the 3-plane chart that connects the fundamental research, enabling technologies, and systems levels of the center's work.

There are many kinds of problems that can lead to failure for an ERC. Difficulties in leadership and management (including financial management), problems in research planning and execution (including disintegration and failure to address its vision), and failure to engage with industry positively and in the proper ways are all sources of serious trouble. However, some problems are less programmatic in nature and can be ameliorated to some extent by specific actions of the Director. One issue that nearly all ERC Directors cite as a serious problem is the heavy workload placed on the Director. Regardless of the extent to which responsibilities are delegated, the Director is still almost always subject to potential burnout. One Director describes the problem as "a major flaw in the ERC concept"; even after serving for the entire NSF-funded lifetime of a center as an ERC Director, he has found no real solution to the problem. The most prevalent approach to reducing the excessive burden on the Director is sharing responsibilities with the Deputy Director. Delegation of the implementation of the ERC plan to carefully selected key staff members, including the Industrial Liaison Officer and the Education Director, also removes some pressure. Several Directors point to the enormous importance of having a highly capable Administrative Director who can handle many of the day-to-day operational tasks.

An ERC still represents a relatively new type of organization in academe, even though ERCs have now been around for more than 25 years. At each university where a new ERC is established, the members of the ERC faculty and staff generally have to feel their way along in forming a cohesive team because, typically, the university is not set up to service an ERC. Effective leadership from the Director is indispensable to this process. However, formal training in team-building and organizational interaction in this novel university setting can be highly effective in speeding the development of these skills.

Rewarding center participants for strong performance is an excellent morale-booster and an incentive for further success. Many kinds of reward are available for Center Directors to bestow. One of the most prevalent and effective is continued or increased research support, including seed funding; increased compensation is of course another mechanism. Additional travel funds for making presentations at conferences can be provided out of center

unrestricted funds, as well as scholarships and fellowships. Increased visibility and support for making presentations at program reviews is appreciated as a career-enhancer. Success should also, of course, lead to promotion and tenure for junior faculty in the center. Several of the centers nominate their deserving staff for university awards and undergraduates for university-sponsored and professional society awards. (For Directors themselves, nomination to membership in the National Academy of Engineering is an appropriate form of recognition; several Directors have achieved NAE membership.) Some ERCs find it important to build a culture that actively pursues awards for its faculty across the board, i.e., from junior to senior. Recognition in the center newsletter and at annual meetings is an intangible but appreciated honor. Finally, nothing replaces the personal recognition and appreciation expressed by the Director and other center managers for a job well done.

2.3.7 Evolving or Restructuring the Management Team

One ticklish area of delegation that should be mentioned concerns perhaps the ultimate delegation, that of the directorship of the center. Succession is an issue that many ambitious executives, in academe as well as business, find difficult to address. If one is performing well and enjoying oneself as a Director, it is perhaps counter-instinctive to make plans to replace oneself. Nevertheless, several ERC Directors have stepped down over the years, and three have passed away, two of them suddenly. As a responsible manager with a major investment of energy and commitment in the center, it is only prudent to provide a viable contingency plan for one's succession and thereby minimize the turbulence that would ensue in the event of the Director's departure. Of those who have established a plan for continuity of leadership, most have appointed a Deputy Director or an Associate Director (often for Research), who will take over the leadership role until a search can be organized to select a new Director (who may or may not be the Deputy). NSF now requires every ERC to have the Deputy Director position.

[1] See, for example: National Research Council. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: The National Academies Press, 2004..

2.4 Recruiting and Restructuring the Faculty Team

The Director’s role in recruiting is pivotal to the center’s success. This process starts with the formation of the team that assembles the initial ERC proposal and includes all subsequent new-faculty and on-campus recruiting, as well as the involvement of faculty from core-partner universities and other institutions on a project basis. Many of the university’s faculty researchers will watch the center develop with interest, but far fewer are willing to do the hard work required to make the center successful. From the very beginning, the Director needs to define and disseminate the value proposition of being part of the ERC. In particular, s/he has to make it clear from the outset that, large as it may seem, an ERC budget gets sliced thinly, often to the extent that any given faculty member only sees the equivalent of an NSF single investigator grant. Faculty who are truly invested will be “in” for reasons besides the funding. Effective administration of any research enterprise calls for a careful balance between the superstars and the sometimes equally talented workhorses, and the new Director should carefully select those individuals who are committed to working toward the success of the center and not just toward the furtherance of their self-interest.

Further, it is up to the Director to form a cohesive team who will work well together. This is especially challenging with regards to faculty at the partner institutions, who the Director is unlikely to know well. S/he therefore has to depend on the leads at those institutions to serve as his/her emissary in recruiting. One model that works well is to recruit faculty who already have a history of collaboration with each other because they will have likely worked through/past interpersonal issues.

The Director must also hold to his/her vision and keep the objectives of the ERC Program in mind; and to do that, he or she must recruit faculty who can build a truly world-class research team. It is not essential that all center faculty be also talented in education and technology transfer, but they must—at minimum—acknowledge, respect, and support those equally important center activities. A particular hang-up can be the ERC’s intellectual property policy, which in general will require the ERC to give members of its Industry/Practitioner Advisory Board some consideration even ahead of the inventors. Potential consequences include thwarting the inventors’ ability to form a start-up company or open-sourcing their invention. Again, the Director needs to make that abundantly clear. (Some ERCs even require all participants to sign a form acknowledging that they understand the nuances of the ERC’s intellectual property policy.)

Perhaps the best evaluation strategy the Director can apply throughout the process of recruiting, is to project his/her honest enthusiasm about all of the center's activities and listen very carefully for any signs of arrogance or superiority, both of which are attitudes that do not mesh well with the team culture of an ERC.

2.4.1 Recruiting for the Proposal Team

Experience has shown that the dedicated band of true believers that surround the prospective Director during the proposal stage does not always survive intact to form the nucleus of the funded center. This may actually be fortunate, because a diverse and evolving difference in attitudes, opinions, and approaches among the center’s main contributors often helps to form the vision of a really exciting ERC. Such a group may also include people with different perspectives on the needs and best directions in the center’s chosen field. For this reason, the faculty who constitute the university's critical mass in the chosen research area will serve as a good platform on which the prospective Director can begin to focus and define his/her vision of the embryonic ERC. The eventual interdisciplinary nature of the ERC will be determined largely by the strategic plan and the composition of the organizing group.

The prospective Director is well?advised to approach the respective Deans and Department Heads for their support and buy-in before recruiting faculty and graduate students from other departments. Doing so helps ensure that their considerations are understood and respected (and helps get them onboard for the long haul). Conversely, not doing so could lead to undesirable tensions between ERC and departmental goals and procedures. For example, at some universities, collaborations with other faculty members (as opposed to an investigator leading his/her own research) penalize young faculty working toward tenure; hence, participation in an ERC can actually constitute a threat to the career objectives of talented young people at those institutions.

2.4.2 Recruiting for the Initial Center Team

The first few years for the fledgling ERC are a critical time in its development. Faculty who were interested only in funding opportunities will begin to fall away, and the Director will need to rely on a significant commitment from his/her "recruits to the vision" for the process of delegation that will determine success or failure for the ERC. At least one, and preferably several, members of the successful organizing group should have a commitment to education and/or to technology transfer. NSF monitors these activities from Year 1 but, much more importantly, the full vision of the ERC Program cannot be expressed until pivotal ERC faculty embrace these parts of the vision. This is a period in which the Director must shape the initial team and aim it toward success at Year 3, but still keep his/her eye on the long-term vision for the center. This is also a time of exciting expansion and the Director should assess which disciplines need to be represented in the center in order for it to achieve world leadership, and make preliminary moves toward bringing the most effective proponents of those disciplines into the center .

To ensure that the allocation of research activities to affiliate institutions or PIs is successful and the activities are well-integrated with the center's educational and technology transfer protocol, it is also vital during these early years to have an established research alliance and a well-defined memorandum of understanding or equivalent binding inter-institutional agreement.

During the initial flush of the ERC's success, it is imperative that the new Director leverage the center's newly minted prestige to seed the long-term projects that, in his/her judgment, serve the center's vision. Conventional departments are looking for long-term center funding for new faculty, and the Director is now in a strong position in dealings with the university hierarchy to help achieve this. This is the time to staff the "long lines" of the Director's personal strategy for realizing the center's vision. This is the time to recruit, both from outside and from on campus, the people that the Director sees as being necessary for success at the third-year milestone as well as the people that he/she sees as being vital to the long-term vision of the center. Normally at this early stage of the center's development, these new recruits will be readily welcomed into the center.

Recruiting approaches can vary, depending on the ERC and its relationships with the departments involved, but some approaches are fairly standard. Usually one of the members of the Directors' executive committee is a member of the search committee in their respective departments. Center members attend the interview seminars, meet with the candidate in one?on?one discussions, and offer comments to the search committee based upon their experiences with the candidate. The decision about areas in which faculty should be hired usually remains with the individual department heads and their faculty. However, it is vital that the Center Director, as well as the participating faculty, be actively involved in the recruitment of faculty. The success of the center critically depends on the quality and interests of the faculty being recruited. Similarly, the Director and center faculty must work closely with the departments involved to ensure that the individuals recruited ultimately add value to both the center

and to the department. This can be a major challenge. To make it easier, it is ideal if the center can be proactive in strategic planning with the departments with regard to mutual opportunities and responsibilities. The Director should try to meet regularly with Department Chairs in order to keep lines of communication open, and should make known the center's needs for faculty with particular qualifications. In some centers the ERC has taken the lead in recruiting a new faculty member.

ERCs can generally hire non-faculty research staff and other professionals devoted entirely to the center without a direct appointment in an academic department. Such individuals play an essential role in the management and operation of every ERC. Although this capability is valuable, it is important to realize that if the center’s strategic plan changes, these individuals may not fit into the new plan and may need to be reassigned or even terminated.

2.4.3 Restructuring for Years 3?6

The period between the third and the sixth year is the stage in the development of each ERC in which the Director must play an essential role in maintaining the center's vitality and renewing its vision. Because it is easier to write an internal justification for a portion of the existing ERC grant than it is to write a free?standing proposal to a granting agency, many center PIs will view with suspicion any new recruits who threaten their previous allocation of NSF money. The Director must control the funds that support recruiting at this and all stages of the center's development, and he/she must encourage the integration of new recruits through the systematic allocation of funds to these new faculty members, enabling them to hire and support graduate students. Established PIs, many of whom will have received substantial NSF support via the ERC, should now begin to decrease their reliance on center support, while new recruits now should be thoroughly integrated into center research teams with thrust area funding attached. Often some faculty who formed the initial nucleus start to drift away as the Center matures. This is natural and to be expected. As Director, remember that your principal task is to remain true to the Center’s vision, not to warp the vision as individual interests change.

Decisions that an ERC Director makes during this vital stage in the center's development will not only have a profound effect on success in Year 6 but, again more critically, will determine the structure that exists as the center faces the scale-down of NSF support following Year 8. If faculty are allowed to selfishly emphasize their own research interests or de-emphasis education or technology transfer opportunities, the Director may be forced to initiate measures to broaden the research and educational programs of the center and to lead to a shared vision, so that the center is revitalized as it tackles its greatest challenge, which is that of sustainability for several decades.

In the early part of this stage in the development of an ERC, it is essential that a certain attitude becomes embedded within the center. Conflicts and competitions will be inevitable as long as the center's research establishment sees the NSF grant as a source of funding from which each party hopes to receive a portion whose size is commensurate with his/her own perception of their talent and potential value to the center. The Director should reinforce the attitude that the center is in fact a consortium of talents in which participants can conduct a large and varied number of research and education activities, thereby satisfying their personal desires and fostering the growth of the center while serving the center's equal interests in education and technology transfer.

2.4.4 Restructuring for the Mature Center

A mature ERC represents a considerable investment of NSF funds that otherwise would probably have been used to initiate other centers. To be favorably evaluated at the critical sixth-year milestone, a mature ERC will need to have achieved world leadership in its chosen field of specialization. In most mature ERCs, the university, the state, and industry will have invested more than twice the NSF total of funds and all parties will have begun to see concrete accomplishments in education and technology transfer that will justify their enthusiasm and their confidence. It is at this time that the Director's recruitment activities will become both more important and more difficult.

New recruiting may become more difficult because the Director can only offer center support for tenure-track appointments in allied departments, and the research must be aligned with the center’s strategic plan. Few academics would accept a faculty appointment exclusive to an ERC at this stage with only two or three years of NSF funding remaining. The center may not hold together if it has become strictly a web of research alliances, but it certainly will find continuity if its technology transfer programs are valuable to member companies and if its faculty have learned to appreciate the power of collaborative research. As the center matures, the Director may choose to recruit a fresh cadre of faculty with specific interests and talents in the area of team?oriented, industrially related, interdisciplinary education; this transition, however, cannot be abrupt but must be implemented in a smooth and steady fashion.

It is clear that the Director of an ERC is the keeper of the center's vision and that recruiting is his/her most effective weapon in the realization of that vision. The Director will make pivotal decisions on center administrative and research management structures, but these structures are only as good as the people that the Director can call on to staff them and make them work. If the vision articulated by the Director of an ERC inspires and sustains interest within the engineering and scientific communities, many of his/her colleagues will be interested in affiliations with the center that may range from simple exploratory visits to total commitment. This interest facilitates recruitment strategies that include the recruitment of established research faculty from the university and its core-partner universities, and the well-orchestrated opening and filling of new faculty slots in areas that strengthen both the center and the affiliated departments. The Director may face a challenge from established center members, but the recruitment and integration of new center faculty is the key to the revitalization of the center and to the center's response to new opportunities in the field. Many centers report that an intellectual atherosclerosis results when the strategic direction of an ERC remains unchanged because of the personal research interests of established PIs, so recruitment of new participants is the Director's most effective weapon in preventing this natural aging process. As the center matures, cooperative and imaginative recruiting can form the basis of excellent relationships with allied departments because win?win recruiting aligns the Center Director's main weapon with a means for Deans and Department Heads to bring new life into their faculties or departments. Recruiting must strive for balance and it must serve the interests of the education and technology transfer programs that assume special importance as the center matures and plans for self-sufficiency.

2.5 Marketing and Fundraising

Although the NSF provides generous financial support for conducting core ERC program activities, most centers continuously pursue additional external funding opportunities. Many ERCs have been successful in leveraging the NSF investment by more than three-fold when associated activities are added. These additional funds are used to deliver greater services to students, the engineering community, and the center’s home institutions and to broaden their research activities, conduct enhanced education programs, and carry out additional innovation and translational research activities.

The NSF generally supports, and in fact encourages, these external funding activities, provided they complement the research mission of the center and raise the visibility of the core program. Centers must be mindful of their core competencies and not stray too far from their key strategic vision. The additional funding also helps centers lay the groundwork for sustainability and continued operations after Year 10. From the beginning, a center should promote an entrepreneurial culture and develop the processes and administrative infrastructure that allow faculty and key stakeholders to work to secure external funding.

Communicating the value of the center and its key strengths to external audiences is an important ongoing function of the center leadership. Outreach, engagement, and raising the visibility of the center and its programs is of the utmost importance. Most centers work to achieve recognition and awareness within the professional scientific community they are associated with, primarily for their scientific prowess. This is accomplished through a wide variety of actions, typically undertaken by staff at the lead institution. The benefits of actively marketing the center are many and include gleaning additional market sector insights, delivering and communicating value, setting the stage for long-term growth, and attracting new members and collaborators.

One strategy for motivating faculty to actively market the center is to appoint center “Ambassadors.” These Ambassadors are typically senior faculty who travel widely and hold important committee positions in professional associations, standards organizations, governing bodies, government agencies, public policy making organizations, and other appropriate external organizations. As Ambassadors, their role within the organizations they are involved in is to represent the center, spread the message about the center’s programs, and bring back important information to share within the center. These Ambassadors can be offered a small travel stipend for their services.

Industry members can also serve as important ambassadors of the center. Industry members that have forged close relationships with the center are often happy to promote the center and its programs to their professional network and stakeholders; and as “customers” of the center, their opinion carries weight. Some industry members will invite other companies to join the center based on their perception of value and history of positive experiences. Industry members who have a particularly wide reach in their domains or practice area can help spread valuable

information to particular constituencies about the center and its programs.

Other marketing activities such as sponsoring booths at major conferences, supporting organizing committees for major industry events, and active, high-level participation in professional associations can help raise the visibility of the center. The value of marketing materials such as brochures, newsletters, and conference “swag” is often debated. There are many more electronic tools available now for disseminating a targeted message about the center that cost less and can arguably be more effective in educating different audiences. Social media and other information tools should be exploited to the greatest degree. The inexpensive logo giveaways and knick-knacks might not be the best investment of center resources.

The center’s website is perhaps its most visible external image, with virtually unlimited variations and creative variations for conveying important information. A professional looking, easy to navigate, well organized website is a powerful marketing tool. Maintaining an up-to-date website and populating it with the appropriate information can be a fairly large burden for busy center staff; but it is vitally important as it is often the first introduction to the center that external stakeholders will see.

2.5.1 Potential Funding Sources

For most ERCs, their industrial partners are a primary source of funding to supplement the NSF award. This funding comes in the form of membership fees, sponsored research contracts, student stipend support, fellowships, in-kind donations, gifts, and intellectual property royalties. Membership fees for most centers typically range from $1,000 to over $250,000 per year, depending on the benefits and/or intellectual property (IP) received. When considering industrial financial support, it is critical for ERCs to maintain balance. Too little industrial funding could cause the NSF to question the center’s relevance to industry. But an over-reliance on industrial funding, especially if it is from one industry, could create a vulnerability during distressed economic situations and increase the center’s susceptibility to choosing short-term problem solving over longer-term basic research. Industrial financial support is discussed further in Sections 2.3 and 2.6 as well as in Best Practices Chapter 5, Industrial Collaboration and Innovation.

There are a large number of competitive solicitations that are released by other federal agencies throughout the year, and many ERCs continuously apply for supplemental funding through this mechanism. The ERC and all that it conveys is generally viewed positively by other funding agencies and is seen as a stable, well supported platform for related R&D programs.

There are also a small number of NSF supplemental funding opportunities restricted to ERCs and other existing program participants, and centers which actively seek out these special solicitations can readily enhance their finances. Though very competitive, these are very attractive to centers because the pool of prospective applicants is relatively small, which increases the probability of success. The best known of these awards is the Small-business/ERC Collaborative Opportunity (SECO). The NSF programs aimed at accelerating commercialization of technology; such as Partnerships for Innovation–Accelerating Innovation Research (PFI-AIR) and similar grant opportunities are particularly well suited for Gen-3 ERCs; with their focus on commercialization. Similarly, the Research Grants in Engineering Education (RIGEE) and Catalyzing New International Collaborations (CNIC), or REU Site awards and similar NSF grants that can help to enhance an ERC’s education and international engagement programs, are particularly attractive targets of opportunity.

Although the time horizon is long and it requires a considerable amount of up-front relationship building, centers can also pursue large, endowment-like support from corporate or private donors. It can take several years of meetings, discussions, and networking to lay the groundwork for soliciting this type of gift, but these large gifts can help to provide a modest but reliable source of operating funds for the center. Typically, approximately 4% of an endowment can be spent each year, while preserving the principal. The University development office, engineering foundation, or similar organization needs to be involved in this type of fundraising endeavor. Sometimes, a dedicated foundation or similar account is established for the center to receive this type of funding. There may be restrictions on the use of the funds and various University policies to comply with, but large gifts acquired from corporate foundations, high net worth alumni, and other similar donors are certainly worth pursuing. Naming rights for a lab, classroom, or test-bed facility can be part of the enticement to potential donors for these gifts.

2.5.2 The Director’s Role

The role of the Director in marketing and fundraising activities is key. The Director creates the vision for the type of

organization the center will be and must make the case that marketing and fundraising are important processes for achieving that vision. The Director must set goals, motivate staff, and guide staff in establishing the mechanisms and strategy for marketing and fundraising. The Director must work to create a culture where these activities are highly valued and where all center participants see their role in these activities. This can be a challenge, as scientists and engineers typically undervalue the importance of marketing, fundraising, and similar “soft” programmatic functions. The value of these activities in the life of the center and its sustainability and the potential benefit for all center participants that contribute to these activities must be conveyed.

It can be useful to establish annual targets for key metrics in marketing the center such as:

- Companies formally invited to join
- External corporate visits
- Proposals to be submitted
- Dollar value of proposals submitted
- Key conferences to participate in
- Others as appropriate.

The Director must also be an innovator in devising programs that keep the industry engaged and encourage higher membership levels. Thinking creatively and cultivating a good relationship with the University’s Contracts and Grants and Sponsored Programs Office are essential if the center is to meet the evolving needs of its membership.

Working with the staff of the center, the Director must constantly reiterate and reinforce the value of marketing and fundraising activities. To have the greatest reach, partner universities must be fully involved in all facets of the center’s marketing and fundraising programs. There should not be the perception that the lead University is the key actor and the partner universities are lesser participants. The center must be seen as a tightly knit, focused enterprise with a unified vision and programs.

2.5.3 Role of Center Staff

In addition to the Director, all Center staff also have a role to play in this important process. The most important of these is the role of the faculty, the Industrial Liaison Officer, and the Administrative Director.

The faculty make up the largest pool of talent within centers. In addition, they typically have large networks of professional associates as well as talents and experience in many of the skills that can contribute to effective fundraising and marketing. This typically applies to senior faculty, but junior faculty should be encouraged to contribute as well, as part of their professional development. The challenge is in helping faculty see the value of these activities and convincing them to take them seriously. To some degree, they should view the health of the center to be in their own self-interest. Faculty members at all campuses need to be involved, not just faculty members from the lead University. It can be a challenge to keep partner schools, particularly those with a small number of students and faculty and who may be receiving a somewhat modest amount of funds, involved in the center.

The Industrial Liaison Officer will typically be responsible for the marketing and fundraising activities directed at potential industry members. Although membership dues often provide a small percentage of total operating funds during the 10 years of NSF funding, the long-term sustainability of the center can be supported by industry membership and participation. The ILO will typically work with the Director to devise the specific objectives for the industry marketing program. The approach taken to meet these objectives will vary based on the target audience. Small businesses, big business, national labs, public organizations, and other types of groups each require a slightly different approach. In each case, the building of a long-term, mutually beneficial relationship with tangible and intangible positive outcomes is the ultimate objective.

Creation of brochures, video, PowerPoint presentations, a social media presence, and other marketing materials that target industry and highlight the strengths of the center is the responsibility of the ILO, in collaboration with a Communication Director (or equivalent), where one exists. Dissemination of these at conferences, company visits, or visits to the center, are the primary means of distribution. Prompt follow-up after the initial contact for more detailed discussion about the value of membership is key to securing new members. Equipment donations and other services and intangible support can also be sought.

The Administrative Director also has a key role in the marketing and fundraising of the center. In many instances the AD is the initial contact point from outside sources, as all inquiries to the center are monitored by the AD. The AD must communicate the information to other staff members for follow up and action through phone calls and/or emails. Once marketing projects and fundraising activities are underway, the primary responsibility of the AD is to manage the expenses and revenues and ensure that they are accounted for appropriately. Care must be taken to ensure that there is traceability for all monies expended and received. The source of funds for creation and dissemination of these marketing materials and expenses associated with their dissemination will likely be from different sources such as the industry membership pool or gift accounts. The AD is also responsible for being aware of the applicable university regulations around fundraising and financial management activities and advising the director and others with regard to compliance.

2.6 Partnership with Industry

2.6.1 Range of Interactions

ERCs interact with industry in multiple ways, and there is a spectrum of types of relationships between center personnel and the employees of the companies with which it interacts. Since ERCs are required to build multi-tiered industrial memberships, the most common mode of interaction is with companies who become members of the center. Typically, these member companies attend periodic Industrial Advisory Board (IAB) and technology review meetings where they receive information about ERC research progress, provide input about the direction of projects, and interact with center faculty and students. However, additional interaction modes within the context of the membership program are also possible and, in many cases, are highly desirable. These include member companies becoming actively involved in the ERC strategic planning process (discussed in the next subsection) or in the centerâ€™s research, education, business or membership development activities.

Participating in specific research projects, either as hands-on participants that perform some of the work required to advance the project or as mentors, generally involves member companies meeting periodically with ERC researchers to discuss the project progress and future directions. This mode of interaction can be formalized by inviting each member company to allocate a certain number of mentors to specific projects. Examples of participation in educational activities include industry providing guest lecturers, facilitating industrial internships for academic researchers, providing student stipend financial support, conducting workshops and short courses for both academic researchers and for representatives of other companies, supporting entrepreneurial education for ERC students and post docs, etc. Among these activities, a high-value opportunity that is rarely used is to request member companies to provide summer internships for young faculty. This mode of interaction is an excellent way to expand the training and the funding perspective of faculty, and is a fast way to accelerate the development of collaborative relationships between ERC faculty and member companies.

Member companies can also help support ERC industrial membership development by reaching out to other potential member companies and encouraging them to participate in the ERC and center business development activities, by helping ERC researchers evaluate the potential value of patentable ideas, and by helping to create and evaluate business plans for possible spin-off companies.

In addition to the modes of interaction just described, several other ways of interacting with industry are possible, many of which do not require a company to be a member. The most obvious of these is for companies to sponsor research activities at the ERC. In this mode of interaction, a company, or a group of companies, provide funding for specific research of interest to the company(-ies). Since these research projects often build upon ERC research, when such projects are of interest to companies that are not current ERC members, the opportunity to participate in this type of research projects provides an additional, very compelling argument for them to join as members, thus avoiding or minimizing IP conflicts between members and non-members.

Member companies also often sponsor research projects as a means to expand the scope of the ERC research in directions of interest. This creates opportunities for further leveraging research efforts. The first opportunity for leveraging is that a member company that provides additional support often becomes a demonstration site for ERC technologies, which can create a very compelling model for other ERC members to follow suit and also become more involved. Another is that, since ERC engineered systems often require the integration of multiple technologies, this kind of â€œassociated projectâ€• also creates an opportunity to pursue projects funded by multiple ERC member companies, which can join into â€œmini-consortiaâ€• of shared interests (more details

later).

Cooperative research contracts also allow the sponsoring company to see the center and its students in a very positive light and the company will offer hire center students, especially if they have been mentored by the company or placed in industrial internships. In fact, some centers report that member companies consider the ability to access and hire center students as being the best by-product of the centerâ€™s research program and a highly valued benefit of center membership.

An additional, very attractive mode of industrial interaction is when industry is actually a true partner in the development of technology. This can take multiple forms, such as when a company is interested in adopting an ERC technology and needs to customize it for its own specific requirements, which often include addressing the issues of safety, regulatory compliance, and marketing that typically fall outside the scope of ERC research. Another is when industry is capable of providing technology building blocks that expand the usefulness of the integrated system.

A useful way of promoting all of these interactions is to regard the ERC industrial membership as an ecosystem organized around a technology value chain. In this ecosystem, academic researchers provide the long-term fundamental research efforts required to conceive, integrate, and demonstrate new technologies. Industrial members engage in the value chain in multiple ways and play multiple roles. Some members are technology suppliers. They provide technology components that are needed for the technology to function. These can include equipment components, software, sensors, and control systems. Other members are technology integrators. Typically, these companies take components from other companies, and also from academic researchers, and build integrated systems. Suppliers of control systems are also often commercial integrators. Still other members are technology commercialization companies. They often take the responsibility for supplying the integrated system to end users. Another type of industrial member is the technology end-user. This type of member would use ERC technologies to make goods and/or to provide services to the marketplace. A final category of potential members are companies, non-government entities, and government agencies that engage in the management of technology operations. This includes companies that provide consulting services to other companies regarding the use of the technology (for example, environmental compliance experts), private foundations that are active in the promotion of certain technologies or are invested in proper uses of technology, and government agencies with direct regulatory responsibilities (i.e., EPA, FDA, DOE, FAA, etc.).

When the industrial membership program is regarded in this manner, the modes of interaction between academic researchers and industrial members become self-evident. As the role of each member company in the technology creation and commercialization process is clearly specified, then the companyâ€™s key interest is also made clear, and the optimum mode of engagement around ERC initiatives can be easily articulated

This ecosystem concept is also very useful in developing a strategy for attracting member companies. Typically, the end users of technology are everyone elseâ€™s customers. Thus, it is often useful to attract them first to the membership program. Once enough technology end users have joined the ERC, it is relatively easy to attract their suppliers. This concept is also useful in designing the multi-tiered structure of the ERC. It is relatively straightforward to understand the typical size of the different types of participants, and whether their corporate culture is favorable to supporting academic research programs, and if so, in which ways and at which level. For many ERCs, the top membership tiers are populated by technology end users, technology integrators, and large technology suppliers, while the lower tiers are often composed of small technology-component suppliers.

Finally, participation of government agencies with regulatory responsibilities needs to be carefully assessed. On the one hand, their participation can be attractive to companies interested in using the ERC as a forum for dialogue with the regulators, or who would like to engage the regulatory agency in the development or demonstration of a technology in order to facilitate the acceptance of the technology by the regulatory agency. These modes of interaction between academia, industry, and government can be very useful and can increase the relevance and the prestige of the ERC among industrial participants. On the other hand, companies could be concerned about exposure of their ideas and development plans in cases where compliance issues for the technology under development are not fully resolved. The best approach may be to engage in a frank and open dialogue with industrial members regarding the optimum way to engage the regulatory agency.

2.6.2 The IAB's Role in Strategic Planning

Meaningful involvement of the IAB in ERC strategic planning is usually beneficial for at least two reasons. First, it

creates in the member companies a sense of â€œownership,â€• a stake in the success of the center. Second, it helps maintain the relevance and importance of technology development efforts. While the first of these two reasons is self-evident, the second one requires a bit more elaboration. Every ERC has a mission component that focuses on developing technology and transferring it to industry. Participation of the IAB in selection of technology development goals helps the academic leadership select the most critical targets, i.e., those that are of most tangible value to the companies that are the intended recipients of the technology. This is an important input that needs to be periodically updated, because the â€œmost valuable technologyâ€• is a moving target. As time goes by and technology evolves, and as companies participate in ERC research, their technology platforms will evolve, and goals need to be periodically assessed and updated.

In practice, participation of the IAB in strategic planning can be implemented in a number of complementary ways. One very useful role for IAB members is to perform gap analysis. This involves answering questions, from an industrial perspective, such as: What are the most important unmet scientific and technological needs in your industry, and in your company? What would be the advances likely to have the largest impact, and why? What would enable your company to develop products faster, more reliably, and less expensively? Answers to these questions are both excellent guidance in selecting broad directions for ERC research and very good targets for industrially sponsored projects.

Another important strategic role for IAB members is to participate in â€œroad mappingâ€• discussions. ERC leadership teams should meet periodically to examine the relevance of center program components, assess their criticality and their potential contribution, identify program components that are missing or not sufficiently emphasized, and select potential changes to the research program that would help maintain its relevance and maximize its impact. These discussions are typically best implemented among a small group of committed participants. Involving a small group of senior industrial representatives in such discussions is often profitable, since it provides a broader perspective as well as a measure of objectiveness regarding the actual practicality and usefulness of proposed research efforts. Moreover, since most large companies are very familiar with road mapping as a standard practice of business development efforts, they can assist the academic leadership in the organization and the moderation of strategic planning workshops.

An additional good practice is for the ERC leadership to present proposed changes to the overall research program to the entire IAB during plenary meetings. This gives an opportunity to the small companies that typically belong to the lower membership tiers to provide their perspective and to help renew a sense of engagement in the long-term center strategy.

2.6.3 Agreements & Expectations

Each center is unique in terms of the industry to which it is connected. It is also commonly the case that the transformational vision established for a center brings together companies in a new value chain that did not previously exist. Therefore, the Director needs to determine how the center is positioned relative to their prospective industrial partners and what the technological value proposition for their center is. These aspects are important, as they dictate two components of establishing the centerâ€™s relationship with industry, which are the membership and confidentiality agreements. Imbedded within the membership agreement is the intellectual property management plan for the center. The membership and confidentiality agreements are discussed in greater detail in the Industrial Collaboration and Innovation chapter of the Best Practices Manual (Ch. 5), with examples of each included, so the discussion here will focus more on the strategic implications of these agreements on the center, which the Director needs to consider.

Prior to establishment of a centerâ€”i.e., before the formal awardâ€”the center must recruit potential industrial members that agree to join the center when it begins. At this point of the relationship with potential industrial members, the Director should have the general outlines in mind for how the membership and confidentiality agreements and intellectual property will be managed so that the companies can begin to understand the nature and expectations of the relationship. These items will ultimately require review by the contracting personnel at the lead institution, partner institutions, and member companies. The review and iteration with all the parties will consume at least several months, so it should be initiated immediately at the inception of the center.

Creation of the industry membership and confidentiality agreements and intellectual property management plan need to be done very deliberatively and should incorporate input from the companies that agreed to be charter members of the center. With this input, the initial draft of the agreements will be composed by the lead institution, which will then be circulated to the company partners and partner institutions for their comments. The goal of the activity is to create robust agreements so that companies who join after the founding companies can find the

documents acceptable without further edits.

2.6.3.1 Industry Membership and Confidentiality Agreements

The Industry Membership agreement establishes what the member companies receive in return for their membership fees and the Confidentiality Agreement establishes how confidential information will be handled between the lead institution, partner institutions, and member companies. In principle, these two agreements can be rolled into one, but it is not uncommon for industry to want them treated separately. These agreements will need to be signed by the lead institution, each partner institution, and each member company.

From a center leadership perspective, the membership and confidentiality agreements are strategically important, as they set the parameters for the interactions between the signing parties. The membership agreement will state what the lead and partner institutions are contractually obligated to provide to the member companies in exchange for the company membership fees, as well as laying out the structure of the membership fees. It is common to have a fee structure that is dependent upon the size of the company as well as the rights the member company is obtainingâ€"e.g., whether or not the company is getting certain intellectual property rights. For instance, membership fees in some ERCs are as little as $1,000 per year, while others that provide free intellectual property licenses are as much as $250,000 annually with a three-year commitment. The agreement needs to also consider whether in-kind contributions from companies can be used in lieu of cash payments (generally in-kind payments are not a dollar-for-dollar equivalent to cash membership). If the center leadership team has decided that in-kind payments will be allowed, this should be clearly addressed in the membership agreement.

The confidentiality policy for the center needs to be either included in the membership agreement or be the subject of a separate agreement. It is important that the lead and partner institutions as well as the member companies understand and agree to the confidentiality policy, as the policy dictates how information can be exchanged. The policy needs to allow the academic institutions to freely exchange confidential information so the center can truly perform as a center. However, the confidentiality can be either a two-way or one-way agreement with the member companies. In either of these cases, the member companies need to agree to hold the center confidential information confidential within their organizations. However, companies might prefer not to provide the center with confidential information (a one-way agreement), so as to avoid contamination between the member companies. The choice of a one-way or two-way confidentiality agreement between the center and member companies should be made in conjunction with the founding member companies.

2.6.3.2 Intellectual Property

As mentioned above, how the intellectual property (IP) arising from the center will be handled must be addressed in the membership agreement. Importantly, the lead institution and all the partner institutions need to agree on how IP resulting from center-funded research (whether at the lead or partner institutions) will be handled vis-Ã -vis the member companies, and the center leadership needs to consider the strategic implications of the IP plan when it is established. Items to consider are: whether all member companies have the same IP rights (tied to membership fee structure); how long do member companies have to decide whether a specific piece of IP is of interest to them; and how are IP rights handled if more than one member company is interested. More details on IP, as it pertains to startup companies, can be found in Section 2.6.5.

Several relatively new considerations make the handling of IP even more critical for ERCs. First, patent law in the U.S. has shifted from first to invent to first to file. This situation needs to be managed by the center when sharing â€œin progressâ€• confidential information with member companies. A second complicating feature is the Gen-3 expectation that the ERCs will spin-off startup companies as part of their innovation activities. While unique IP is generally the key underpinning of an ERC startup company spinoff, IP generated by base-award NSF funding to the ERC must be handled as prescribed in the membership agreement. Therefore, it usually is not possible to â€œsequesterâ€• ERC-generated IP for a targeted startup company. Instead, the eligible member companies must all first decline to pursue the IP. Given the complexity of the issues surrounding IP management in the center, the Director needs to be sure there is a clear understanding of how IP will be handled amongst the lead institution, partner institutions, and member companies.

The culture of the industry represented by the charter members of the center is another important consideration in developing an intellectual property management plan. The companies in many industries aggressively pursue patents in order to establish proprietary market positions and therefore prefer exclusive arrangements with center-developed technology. Companies in other industries, however, are sometimes mostly interested in ensuring that

they are not excluded from using a technology development and are more accepting of universitiesâ€™ providing broad member access or even allowing public access to technology developments through publication.

Best Practices Chapter 5 includes a discussion of IP management and delivery in Section 5.3.2.

2.6.4 Meeting Industry's Needs and Expectations: How Far to Go?

ERCs must find a balance between the practical, hands-on activities that are of most immediate interest to industry, and the long-term, fundamental research goals that are needed to advance the scientific mission of the center. The need to balance these two perspectives is in fact an opportunity that helps maximize both the relevance of the long-term efforts and the scientific value of technology development activities.

One important observation is that a significant fraction of the â€œdisagreementâ€• between these two perspectives is often just a matter of semantics and interpretation. Most industrial members understand that technological advances are based on scientific progress. Likewise, many engineering academics enjoy and appreciate an opportunity to maximize the practical impact of their research. Thus, a relatively easy way of bridging the gap between the short-term perspective characteristic of industrial researchers and the longer (sometimes endless) time line of academics is to promote active discussion between both parties, preferably in the context of specific projects. In this respect, integration of project teams including both academic researchers and industrial mentors is a very useful approach for maximizing alignment of perspectives.

The preceding discussion notwithstanding, meeting industrial expectations is critical in order to maintain industrial interest. One way to accomplish this is to require every project to identify and spell out its technical and scientific deliverables, and to implement the practice of providing a timetable for completion of project milestones. This practice is standard in industry but is rarely implemented in academic research. Adoption of this and related practices, such as preparation of Gant charts and other project management practices can help create in industrial participants a sense of confidence that goals are being met and progress is being achieved, while at the same time giving the academic members the freedom to focus on the enabling scientific issues.

A more substantial way of meeting expectations and maintaining interest is to deliver what is promised, and to do so on a timely basis. This truism is not as easy to implement as one would hope. Specifically, when developing integrated technologies, research and development activities often must be carried out in a sequential fashion by different team members. Such coordination of activities is fairly common in industrial R&D efforts, but it is often outside the experience of academics, who tend to work in an entirely independent fashion. Once again, program management practices that are widely used in industry can be very helpful to academics who suddenly find themselves working interdependently.

2.6.5 Impact of Innovation Strategy on Member Companies

With the Gen-3 requirement that ERC innovation strategies will include technology transfer via startup companies, the Director will need to be able to explain how the center will handle startup companies relative to member companies. At first blush there would appear to be a clear conflict between the goal of translating technology to member companies versus translating technology to startup companies initiated by the center. Particularly worrying to companies is whether the center will hold back the â€œbestâ€• IP to be vested with startup companies. If the membership agreement has adequately addressed how center-generated IP will be handled, this concern should be alleviated.

Typically, any center-generated IP available for use in a startup company must first have been declined by the member companies. This progression needs to be considered if center personnel are hoping to initiate a startup company based on the IP in question. In reality, there will be many examples of center-generated IP that are still too early in the development cycle for member companies to be willing to license. For these cases, member companies are commonly supportive of the technology being further de-risked by a center-initiated startup company and may in fact want to establish some relationship with the startup. The advantage of moving funding for the technology translation work from base funding is the ability to explore additional funding opportunities with the startup company that are not available if the technology translation work only stays within the center. Additionally, moving the technology translation work into a startup company means that subsequent IP associated with the translational research is not convoluted with IP generated under the purview of the membership agreement.

The most complicated aspect of the centerâ€™s innovation strategy with respect to the member companies is when a startup company formed by center personnel becomes a member company. If the startup company pays a

membership fee that includes IP rights, they have the same IP rights as any other member company. The aspect that needs to be appropriately managed by the center is when a startup company is launched, relative to the IP becoming available to member companies. Even when a center is working to be completely transparent with their member companies, the center researchers will know about potential IP before the member companies do, so this situation must be considered when the center launches a new startup. The concern of appropriately handing IP relative to center startups will be mitigated by the fact that IP rights mean that member companies have the right to negotiate a license for the IP. Therefore, the ultimate disposition of the IP is in the hands of the IP office of the university having ownership of the IP and not in the hands of the center.

CASE STUDY:

The Data Storage Systems Center at Carnegie Mellon University (1990-2001), began as a totally industry-funded center with several million dollars in funding from US companies who were threatened by competition from foreign (mostly Japanese) companies. Initially, the industry was so delighted to have a university involved in this area that they put almost no restrictions on how the money was used. Later, as the DSSC became more sophisticated in its research and as profit margins for the industry declined, industry attached more and more "strings" on how the money was to be used. The Center's Director became a broker for industrial research projects for Center faculty, and although the research was cross-disciplinary and all the technologies involved in data storage systems were being addressed, because each company had different objectives there was no systems-oriented focus. The ERC award was then sought and won, and with the NSF funding, long-range, systems-oriented goals were defined and pursued.

In its 10th year as an ERC, the DSSC received $4.8M in funding from 50 industrial members, which accounted for 39% of its total revenue. Membership fees ranged from $60,000 per year for Affiliate Members to $250,000 per year for Associate Members who received royalty-free access to the Centerâ€™s intellectually property. The ERCâ€™s research and education program involved 36 faculty, 14 postdocs and visiting researchers, 8 full-time research staff, 88 graduate students, and 23 undergraduate students.

Shortly after receiving ERC funding, the Center helped guide the industry into forming the National Storage Industry Consortium (NSIC), which helped to coordinate the long-term precompetitive research of the US Data Storage Industry as well as all the universities working in this area. In 1996, NSIC was involved in over $50 million in research. The DSSC did everything it could to support the consortium, even though a large part of NSIC funding went to other universities. For example, in 1998, the DSSC wrote a proposal and received funding for a Frontiers of Magnetic Recording Program that, over a three-year period, published over 192 papers and funded 87 students at 16 different universities. The NSF contributed $1.89 million to this program while NSIC contributed $3.37 million. The Director of the DSSC was also the Technical Director for this program. By 2002, the US Data Storage Industry was no longer severely threatened by foreign competition and NSIC was reincorporated as the Information Storage Industry Consortium (INSIC) and allowed foreign firms to become members, in order to better serve the worldwide information storage industry.

The DSSC has continued to thrive as a successful industry-funded center since graduating from NSF support in 2001. During its 25th anniversary celebration in 2008, the DSSC noted that during that period it had granted 132 masters and 200 PhD degrees, collaborated with 60 different industrial partners, spun off 6 companies with over 900 employees, and created 90 inventions and obtained 32 patents. In addition, the Center introduced 14 new and 60 modified courses into the Carnegie Mellon curriculum over those 25 years.

2.7 Relationships Among the Lead and Partner Universities

2.7.1 Leveraging University Resources

The establishment of an ERC constitutes a major commitment on the part of both the NSF and the host universities. Given the multi-institutional structure of Gen-3 ERCs and their mandate to achieve global impact and stature, it is essential for the universities to perceive the mutual win-win that is possible by providing adequate resources to ensure success. If the university is really committed to the objectives of the ERC Program, it will

become a part of the university's own strategic plan at the highest levels. The university administrators will make specific long-term commitments to a new ERC in terms of both space and personnel. The university will also make significant changes in curriculum, and even in departmental structures, to nurture the center as a permanent part of its revitalized programs. Research alliances come and go, but a center can become a permanent part of a university if researchers stay together because of the value added by interdisciplinary research teams and by an education process predicated on cooperation between departments and in cooperation with industry. With this as a foundation, an ERC can innovate, translate, and create next-generation workforce leaders, thereby becoming a world-class resource to strengthen U.S. industrial competitiveness. Strong interplay among the ERCâ€™s accomplishments and leveraging the universityâ€™s resources are the nucleus of sustainability beyond termination of NSF support.

2.7.1.1 Negotiating for Space and Facilities

Perhaps no decision that the Director of an ERC will make during his/her tenure is more important than the pivotal decision to press hard for contiguous space for the center. Especially if the center embraces several traditional disciplines, it is helpful for its faculty members, researchers, and students to be housed in contiguous space in order to develop the cohesiveness that is the life blood of an ERC. Proximity is a great facilitator; and the center will develop very differently in contiguous space. A technology-enabled and dedicated conference room for easy convening of *ad hoc* meetings, both local and virtual, is an essential ingredient. Faculty members will adopt a spectrum of arrangements that mirror the extent of their commitment to the center, in that some will have labs and offices in the center and work exclusively with center research teams, while others will retain offices and labs in their home departments and attend research team meetings and seminars in the center. Each lab should excel in its own area, while simultaneously promoting collective paradigm-shifting scientific advances and technological innovations. The key to this is that all center students will be housed in contiguous space, making the center their home on evenings and weekends, and integrating to form informal research teams and supportive friendships that will make them profoundly different from conventionally trained students. The ERC Program has been very effective in changing the pattern of graduate education in engineering and science in many universities. As a case in point, one current ERC has established a seamless offering of undergraduate and graduate (BS and MS) degree programs in bioengineering at a stand-alone facility, with graduate office spaces contiguous with the research labs.

For a new center, the advantages of contiguous space can occur in a couple of ways. It can happen through the allocation of a dedicated building, or through the repurposing and augmentation of an existing research facility, with the same end result. However, the chances of having that space allocated are directly proportional to the level of commitment of the university to the new ERC. That commitment is, in turn, influenced by the university's prior experience with research centers. If the university has built up relatively few centers, and really plans to build its research and education programs around these focused areas, it will certainly try hard to find contiguous space for an enterprise that will bring in significant extramural funding and positive global exposure to the university over the next decade. If the engineering faculty is highly research intensive, it may have developed a specialized building within which a number of research centers jockey for space in a pecking order that derives from their current and potential levels of funding. In such a situation, the new ERC should be able to find at least sufficient space for central administrative offices and lab space for specialized equipment that is central to its mission. However, engineering faculties in heavily endowed universities are commonly very short of space, so the new ERC may be forced to be a "virtual" center that exists in the common will of its participants and in the vision of its Director, but whose physical being is a distributed network of office, laboratories, and personnel connected by electronic linkages.

It should be noted, however, that the schedule and challenges in the creation of new research space and establishment of research infrastructure should not be allowed to impede timely progress on the centerâ€™s overarching deliverables. Given that establishment of a fully functional new research space takes time, the ERC team, with the support of the university administrators, should be mindful of the negative impact if performance falls below the benchmark expectations of the NSF site reviewers in terms of Gen-3 ERCs.

It is essential to ensure that both the ERC faculty and students understand clearly the mission and goals of the center and how they relate to the way things are done in the center. Nothing is more deadly than the perception, by a site visit team or any other visitors, that the students have no idea what the center is all about. Real integration into interdisciplinary research teams occurs best in common lab space, and real bonding most often occurs when undergraduate and graduate students occupy contiguous space and develop a true *esprit de corps*. Hallways lined with center posters and echoing with spontaneous birthday parties for center students, group meals, poster sessions, and other social/academic gatherings are often the heart of a truly effective ERC education program. Most of the ERCs have a Student Leadership Council or comparable organization that facilitates interaction and a sense of common purpose among the students.

2.7.1.2 Direct Financial Support

A variable portion of the annual budget of ERCs comes from universities. Most ERCs have been able to obtain substantial financial commitments from their host universities, including annual support in addition to new faculty positions. For many ERCs, this annual support package includes equipment support, salary support for research staff as well as for new faculty positions in the centerâ€™s field, operating costs including maintenance, and laboratory up-fitting costs. Further, core university partners often provide substantial cost-sharing support through the provision of administrative positions and student stipend, travel, and tuition costs.

University cost-sharing is often flexible in use and carries no indirect cost burden. Several of the ERCs have had new buildings constructed for the center, using funds provided partly by the university and in large part by the state. A dedicated building and/or state-of-the-art equipment and facilities make recruiting of faculty and graduate students easier, and also improve the attractiveness of the center to industry and funding agencies. A few ERCs have developed world-class experimental facilities for use by the center faculty and others; the funds have come from the university and the state government. The cost share serves as an indirect litmus test of the universityâ€™s faith in the positive impacts and outcomes expected of the ERC. Naturally, the universityâ€™s continuous commitment both during and after the centerâ€™s tenure is highly intertwined with its high performance and effective spinoff of innovative ideas.

2.7.2 Relationships with the University Administration(s)

In any university housing an ERC, the senior administration of a successful Engineering College is confronted almost daily with demands for support of specific programs by forceful proponents. The Director of a new ERC must present his/her vision of the center persuasively enough that the Engineering Dean and the university's Provost and Viceâ€‘President for Research, who are rarely both engineers or even scientists, buy into the vision to the exclusion of competing demands. The concept of the ERC is inherently exciting, and the objectives of an ERC are unique, but the center will not thrive if it does not capture the strong support and commitment of the university's senior administration.

To engender that support, it is imperative that the ERC be recognized throughout the university community as being on a plane of intellectual and scholastic excellence that equals or exceeds that of any other research unit at the university. Even 10 years after it is established, the center's accomplishments in fundamental and translational research, innovation, education and outreach should loom large in the university's own public assessment of its strengths. If the ERC does not dominate the internal priorities and self-image of the university, no amount of NSF planning and/or support will guarantee its continuity as an effective unit when it "graduates" from NSF support.

The Dean of Engineering must be willing to commit space and faculty slots to the nascent center. This individual in particular must be a dedicated supporter of the center. The Dean can be invaluable to the ERC and its Director as a facilitator, a "fixer," and an all-around strengthener of the center within the university. A few ERCs have had a Dean of Engineering as their Director; in other cases, ERC Directors have been promoted to positions in the Deanâ€™s office, the Deanship, and beyond, including university President. The best relationship here is a close and supportive one. To that end, the Director should not hold her/himself aloof from such College functions as Parent's Day or alumni functions, because loyalties and goodwill are bidirectional.

The support of other senior administrators is also vital. The Provost must be willing to reinforce the College of Engineering with funding for new faculty slots and with approval for new programs, and s/he should see the center as an excellent model and an effective catalyst for interdisciplinary team research. The Provost and the Dean of Graduate Studies should be proactive in support of the acceptability of thesis work done on center research teams. The Viceâ€‘President for Research should help in the acquisition of contiguous space for the center, and s/he should support the center financially by helping to secure state funding and by returning a portion of the indirect costs (IDCs) on center grants.

Eventually, the Viceâ€‘President for Research should be so impressed by the center's success in team research, interdisciplinary education, and technology transfer that s/he will be willing to commit significant portions of her/his disposable funds to the establishment of additional *de facto* centers, even outside of engineering.

Given the Gen-3 emphasis on translational research as well as the multi-institutional configuration, the Office of Technology Transfer within the Division of Research has to work very closely with the ERC scientific team as well as with counterparts in the partner institutions. With the development of joint intellectual property across institutions, including potentially global institutions rising out of the Gen-3 structure, the role of the Vice-President for Research

becomes even more critical. Meetings should routinely be scheduled among the ERC research team and these administrative units to tackle the problems arising out of these configurations well ahead of time.

The ERC Program can really benefit a university if its senior administrators become believers in the process, as they win and then run an ERC, so that the ERC ideas are "cloned" and expressed in other areas in which the institution has a critical mass of talent and experience. Public land-grant universities vastly outnumber heavily endowed private universities in the United States. For this reason, changes brought about as a result of ERCs in the public institutions may ramify to produce huge changes in national research and education policies, if the top university administrations capture the essential vision of the ERC Program.

2.7.3 Relationships with Academic Departments

The ERCâ€™s relationships with academic departments are critical for its impact and success during the NSF funding period as well as for sustainability upon graduation. Thus, the ideal would be to have associated departments, the center and the Dean operating as one team, and to effectively use that engine of innovation to pull the center and the school to achieve maximum impact across all their domains of research, translation, education, and outreach. Most of the time, an individual ERC may involve many different departments, and people from these different faculties may be among its participants. The Director of an ERC as well as participating faculty members must realize that the departments are the continuing administrative entities of the university. Most center faculty will hold tenured or tenure-track positions in conventional departments and virtually all graduate students will actually be registered in these departments. A centerâ€™s impact and success is very closely tied with the support of the departments associated with it; a difficult relationship that must constantly be nurtured. In fact, as the center grows, it will become a two-way street, with the center leading cross-cutting, application-focused research and the department supporting associated education and outreach activities. The ERC Director must continuously persuade the power brokers of key departments that the center enlarges their research horizons and enhances their students' educationâ€”a win-win situation for all.. Most of the time, departmental support comes through the offering of center-specific courses, sharing in the cost of equipment, support for maintenance, travel expenses, ERC student tuition, fellowships, etc. This symbiotic relationship serves to enable Gen-3 ERCs to effectively deliver on their goals of developing the next-generation workforce and promoting broad thinking across research areas, disciplines, and groups.

Another factor of utmost criticality is the Deanâ€™s full understanding and strong support of the ERCâ€™s deliverables. The Dean as a connector with senior administration plays an important supportive role during the centerâ€™s times of need, and also serves to make all parties involved understand that working in a positive manner with the center is in the best interest of the departments, college, and university itself. These acts can lead to recognition of the center, its Directors, and the members as a force to reckon with in the shaping of the schoolâ€™s own future direction. As a case in point, one ERC enabled the hiring of four new bioengineering faculty who have worked closely with faculty in other departments including mechanical engineering, industrial engineering, animal science, and education in creating innovations in biomedical research and education.

Many of the real problems that will challenge an ERC Director will involve affiliated departments directly, and the Director simply cannot afford to ignore this critical academic interface. Some departments will be only distantly related to the center, but normally few of these will be intimately involved. Divisive issues will include department faculty who "disappear" into the center and then expect recognition within the department for ERCâ€‘related accomplishments that most department faculty may not even know about. The worst scenario could be a faculty member getting credit for the ERCâ€™s accomplishments without actually having contributed much to the ERC, leading to unnecessary dissention within the ERC family itself. The lesson learned is that the operations need to be well laid out such that Director, Chairs, and Dean remain aware of the issues and stand together in all critical actions. ERCs are powerful in terms of funding and the inherent appeal of their vision. However, they can also engender resentment in the allied departments/schools that may surface and confront the unwary ERC Director when s/he least expects it.

These are potentially serious problems, but they can be avoided by a perceptive and personable ERC Director. Regular communication and information sharing with the heads of affiliated departments and the Dean can help the ERC as well as departmental/college administrators to "flag" faculty and student problems before they become too serious. Faculty slots that are allocated to the ERC should be filled in a way that benefits both the center and the department concerned. The Director should work with the departments to ensure that the filling of these slots not only benefits the center, but also contributes to the long-term interests of the department and the College /School. The ERC Director should apprise the department Chair of plans for increased research activity that will draw specific faculty away from teaching responsibilities, so that alternate plans can be made in a timely fashion. The

ERC Director may submit a written assessment of the ERC-related performance of each faculty member to his/her department head, in ample time for its inclusion in the department's annual report.

The issue of promotion and tenure deserves special attention. Promotion and tenure decisions are made in the departments, and any animosity felt toward the ERC can easily be objectified in adverse promotion and tenure decisions that impact center junior faculty. In addition, the possible adverse evaluation of team research and multi-authored papers has been a point of uncertainty for many faculty and students considering participation in an ERC. However, a survey of ERC Directors showed no such experiences. In most cases, there is considerable collegial interaction on these matters between the departments and the center. Generally, the Director and/or senior center faculty provide departments with letters of assessment and/or support for candidates. In many cases, senior center faculty hold positions on the departmental review committees and college committees, where they have the same privileges as faculty from the departments. In certain instances, it is reported, the input of the Center Director has been the deciding factor in a positive promotion outcome. More than one Director related that participation in the center is viewed as favorable, not unfavorable, for promotion and tenure. Even in the few cases where the center has no direct influence on departmental and college review committees, the outcomes have been favorable for center-associated faculty.

Actually, this is not surprising, since the emphasis of ERCs on goal-oriented research, publication and interaction with other faculty, and excellence in teaching all mesh well with the concept of academic advancement. This will also lead to a culture change on campus by the university recognizing the importance of centerâ€‘related crossâ€‘disciplinary research to serve a knowledge-based economy.

The ERC should cooperate with allied departments in the recruitment of graduate students, and the ERC Director along with the appropriate department chair should pay special attention to the composition of the advisory committee for center graduate students. In the simplest case, the student's thesis advisor will be a member of his/her host department and other members of the advisory committee will also belong to that department. In other cases, a graduate student may be supervised by an advisor from outside his/her home department and the advisory committee may be a smorgasbord. Especially in this latter case, it may be important to have the student give regular seminars in the home department, in addition to center seminars (they require no additional preparation), so that departmental people are not blind-sided by the final thesis. If the vision of the ERC is truly innovative and really addresses the cutting edge in the field, the student's thesis may well seem like fantasy or heresy to members of the home department, and departmental faculty should have adequate opportunity to get used to these new concepts.

In practice, this could also happen to young faculty members working in the centerâ€™s cutting-edge research while being part of a department having many senior faculty members engaged in traditional disciplinary research.

Good relationships with allied university departments should be effortless and natural, and they are vital in the solution of many of the problems noted by Directors (such as faculty recognition and student integration). For example, attending meetings of department heads called by the Dean may strike the new ERC Director as a waste of time, because many issues may not really involve the center. However, regular attendance builds good relationships and common interests and reassures the Dean and the department heads that the talented Director of this "hot" research unit, the ERC, views himself as just another member, like themselves, of the university leadership community.

2.7.4 Relationships with Center Faculty

Based on the experience of the ERC Program for the past 25 plus years, it has become clearly evident to NSF ERC Program Directors that certain characteristics of background, ability, and personality tend to be associated with success in directing a successful ERC. Of course there is NO one perfect model or behavior, but there areoverwhelming indications of a true leadership pattern with â€œoutside the box thinkingâ€• that leads to best performance. Certainly there is a range of leadership characteristics, and any given individual will be stronger in some areas than in others. In addition, the "ideal" profile will vary across different fields, universities, and industry bases. Finally, there are all the intangibles of team chemistry, timing, and luck that may play as significant a role as any other more objective factor in one's ability to lead an ERC effectively.

Interpersonal skills that involve team building are valuable whether you are a Center Director or a Thrust Leader. Given that the center involves activities with faculty members from different partner institutions, team efforts that give appropriate recognition to the key player(s) are of utmost importance. Management in an academic environment is often a delicate operation, so it is strongly advisable that the Director and faculty members be diplomatic, tactful, and empathetic as well as perceptive, alert, and determined. Given the enormous demands of

the job and the personal sacrifices it entails, the ability to make a total commitment to the center is vital and the center should communicate that commitment as an important requirement for all those involved in the center.

In general, the prospective Director must have gathered together a group of colleagues and junior faculty, in relevant fields, who are willing to form the core of the ERC faculty team. It is also very important to have an industrial support base (or at least strong contacts) established through consulting, participation in a previous center, industry employment, etc. It is useful if the individual has good relations with the university and departmental administrators, although these relationships can be built after the center is established. Also valuable are other federal, state, and private support bases (e.g., foundations) beyond NSF.

The Director and the leaders of the ERCâ€™s research, education and outreach programs should understand the opportunity the ERC provides to change the engineering education/research culture of the university and the potential to have an impact beyond engineering. S/he should be interested in integrating the results of the ERCâ€™s systems perspective into the curriculum in new and innovative ways.

Finally, in terms of attitudes and personal orientation, an ERC Director should be a team-oriented coalition-builder who welcomes change, since technological and "cultural" change are what the ERCs are all about. The person's attitude toward the encouragement of women and underrepresented minorities to pursue engineering education and research must be genuinely positive. S/he should be oriented toward focused basic research that integrates science and engineering with long-term benefits for industry, because this is the fundamental rationale for the ERC Program. Finally, the Director should be oriented always toward achieving a center in which the integrated whole is greater than the sum of its individual parts, and not driven by the power nor the prestige of the position. It is critical that the Director through his/her actions makes the team players feel the ownership of the center and drive its deliverables because they believe in it.

A balance of research talent and commitment to the center's vision is essential; and interdisciplinary education and technology transfer will not reach their full potential unless the Director chooses his/her teams wisely. It is naive to expect that every center faculty member will excel in all center activities, but a subset must be capable of world-class work in each of the major areas of research, education, and technology transfer.

Within the university framework, an ERC Director must choose his/her style of interaction. A measure of persuasion and firmness may be necessary to obtain contiguous space, at the outset, and to take full advantage of the university's pledges of support for the center. As the center matures and begins to concentrate on the continuity of its research, education, and technology transfer programs, cooperative relationships with allied departments and the appropriate parts of the university hierarchy come to the fore. Mutually beneficial recruitment is the Director's most potent asset in this matter and a confrontational approach by a mature center may leave it surrounded by enemies at a time when it most needs friends. It is the stated intent of the ERC Program that the centers should make lasting changes in university education and also significantly improve the competitiveness of American industry; and most ERCs actually accomplish these objectives. Clever recruitment and excellent relationships within the university can extrapolate these changes by passing the center's vision to the university departments and faculties that constitute the operative researchâ€“educationâ€“technology transfer mechanism of our university system.

2.7.5 Inter-University Agreements

2.7.5.1 Intellectual Property

With the focus on multi-university collaboration (among each other and with industry) in a Gen-3 ERCâ€™s innovation ecosystem, effective domestic interâ€“university agreements are crucial to facilitate true symbiotic research and facilitate ground-breaking scientific and technical advances. Since the research as well as the membership of the research team is dynamic and interdisciplinary, it is to be expected that multiple partner universities will contribute to generating the intellectual strengthsâ€”and, often, IPâ€”in connection with any given research topic. This necessitates that a clear process be in place amongst the universities when the collaborative research leads to joint IP and eventually a possible patentable process.

It is also important that the partner university economic development offices work together from Day One to get the necessary Memoranda of Understanding (MoUs) and other legal documents in place to facilitate joint IP development, patent prosecution, and revenue sharing to minimize potential disputes and concerns when reality kicks in and advances occur in the labs. The MoUs among the domestic partner universities must thus unambiguously encompass protocols for innovation disclosures and potential patent prosecution and revenue

sharing issues.

In addition to focusing on domestic inter-university agreements, one also has to pay close attention to the foreign university partner/s due to the requirement for Gen-3 ERCs to attain global leadership status. The following paragraphs from the Industrial Collaboration Best Practices chapter 5 (Section 5.1.1.3) discuss the ERC agreement with foreign universities in more detail.

â€œOne area that merits further discussion is the formulation and execution of international agreements with foreign university partners. This originally was a required component of a Gen-3 ERC, but because of the complexities outlined below, beginning in FY 2013 a Gen-3 ERC may enter into a focused partnership with a foreign university governed by a formal agreement with mutually protective IP policies, or faculty-to faculty collaborations. In either case, the partnership/collaboration must allow for ERC students to spend at least 30 days working in the laboratory of the foreign partner/collaborator.

â€œThe establishment of the ERC/foreign university partnership agreement can involve a steep learning curve, concentrated on the complexities of international law and the vast differences in scientific culture and legal environments, especially in intellectual property ownership and business law specific to the partnering universityâ€™s home nation. The â€œharmonizationâ€• of the final international agreement can take a great deal of time and expense that an ERC has to bear. These agreements need to engage the highest levels of the administration on both sides (university presidents, university system officials) from a policy and legal standpoint.

â€œAs exchanges occur and joint IP becomes an issue, the agreement needs to include some mechanism to capture that IP under mutually protective terms. Additionally, ITAR and export control restrictions, especially with the development of new materials, need to be addressed in terms of international agreements. This could impact the exchange of information, materials, samples, and prototypes. Faculty-to-faculty collaborations would operate under less formal terms, as is traditional in academic research. However, the ERC still needs to be mindful to protect ERC-funded IP.â€•

CASE STUDY:

A partnership was formed between the Revolutionizing Metallic Biomaterials ERC (RMB) based at North Carolina Agricultural and Technical State University and the University of Hannover Medical School in Hannover Germany. North Carolina A&T, as the host university on behalf of the ERC, negotiated a fixed fee with a local law firm with international business and IP law expertise to interpret German law and to draft a harmonized agreement. The German Inventors law differs from the Bayh-Dole Act in that, rather than assigning intellectual property rights to the University, German scientists and engineers retain rights to their inventions. German Law allows for a period of time in which a German employer (University) may secure rights to an invention in return for fair compensation to the inventor at the time of transfer of rights. If this option is not exercised in a timely manner, IP rights remain with the inventor. This arrangement tends to limit the nature of the global interaction between Hannover and the ERC to student and technical exchanges, as the ERC cannot ensure that IP obligations under Bayh-Dole will be met in cases of joint inventorship between an ERC investigator and a German investigator. It may be possible to address this concern. Opportunities for the ERC to participate in the option discussions between the University and the German inventor are being explored.

2.7.5.2 Industry Members

As might be expected, the IP sharing process can get further complicated when the ERC partner universities also collaborate on joint IP with industry and/or innovation partners. As always, a thoroughly thought-out agreement and plans for foreseeable contingencies will greatly facilitate the process. This subject is discussed in more detail in Section 2.6 of this chapter.

One of the first lessons that a new Director, along with the Industrial Liaison Officer (ILO), learns as s/he begins to get involved in technology transfer, is that there is a spectrum of different forms of potential interaction between any company and any academic entity. Some ERCs allow industrial members to license IP at reduced royalties; some agree to collaborate with their industrial partners in filing for joint IP when both are inventors; and some provide royalty-free IP to specific membership levels.

As was outlined in an earlier section, creation of the industry membership and confidentiality agreements and intellectual property management plan need to be done very carefully in the multi-institutional environment of an

ERC. The initial draft of the agreements will be composed by the lead institution, with input from the partner institutions, before circulating the documents to the company partners and partner institutions for their comments.

CASE STUDY:

During the recession, while many companies were trimming employees or just holding steady, molecular detection and imaging solutions company â€œDaylight Solutionsâ€• was growing rapidly and, in 2011, relocated to a larger (35,000 square foot) facility in San Diego. The company is commercializing an advanced technology, quantum-cascade laser (QCL) systems, developed by a partnership with the NSF-funded Engineering Research Center (ERC) Mid-InfraRed Technologies for Health and the Environment (MIRTHE).

Daylight Solutions uses modular designs, meaning that any commercially available QCL chips can be deployed inside its systems. The lasers are based, for the most part, on InGaAs/InP material systems. Different vendors may be better at different parameters (e.g. wavelength selection, power, efficiency, etc), and allows the company to have a great deal of flexibility when designing their laser systems for a variety of customers and applications.

The growth of Daylight Solutions is in response to the growth of important commercial applications for QCL systems. Chemical imaging, such as cancer detection, pharmaceutical quality control, and materials inspection can use QCL technology. Others applications include alcohol breath detection and glucose sensing, marine stack emissions monitoring, atmospheric monitoring, and homeland security.

MIRTHE, like other NSF-funded ERCs, is a multi-institutional Center that brings together universities and industries with the goal of advancing technologies developed in the lab to a point where they can be commercialized by industryâ€"in the case of MIRTHEâ€™s technologies, this means reduced to compact, easy-to-use devices that are inexpensive enough to be widely deployed. MIRTHE is headquartered at Princeton University, with partners City College New York, Johns Hopkins University, Rice, Texas A&M, and the University of Maryland Baltimore County. The Center encompasses a world-class team of engineers, chemists, physicists, environmental and bio-engineers, and clinicians. MIRTHE specializes in developing mid-infrared (3-30 Âµm wavelength) optical precision trace gas sensing systems based on new technologies such as quantum-cascade lasers or quartz-enhanced photo-acoustic spectroscopy, with the ability to detect minute amounts of chemicals found in the environment or atmosphere, emitted from spills, combustion, natural sources, or exhaled. The partnership between MIRTHE and Daylight Solutions is a perfect example of how world-class engineering research can be brought to bear on tackling big problems while fostering economic growth at the same time. Dr. Timothy Day, CEO and CTO of the company, is a member of the ERCâ€™s Industrial Advisory Board.

2.7.5.3 Articulation for Curriculum Sharing

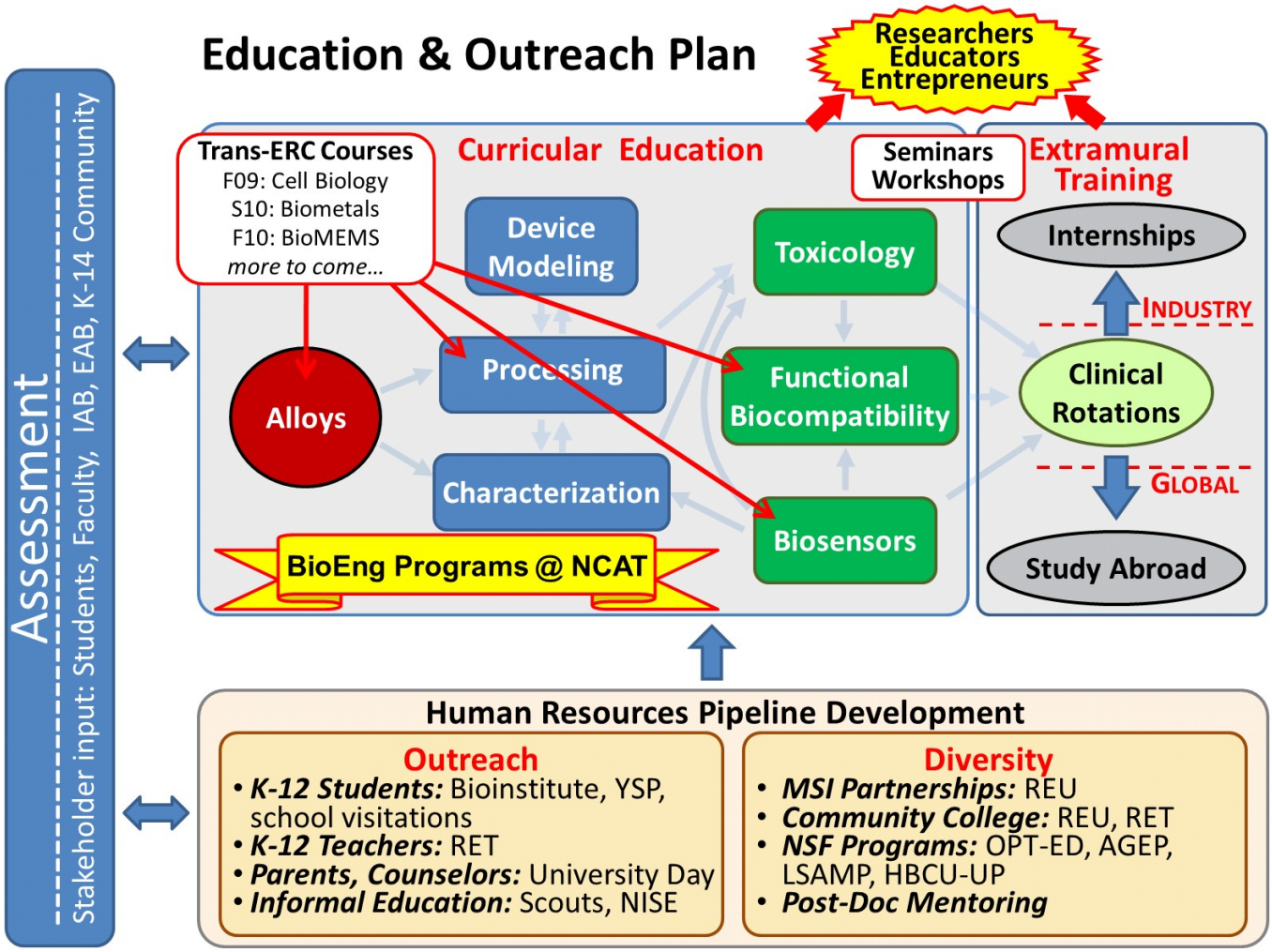
With the proper focus, articulation for curriculum sharing can become a great asset in connecting the partner universities, industries, innovators, and even the advisory board members in an ERC. This will subliminally facilitate the entire ERC student body and the members to become one ERC team. The intellectual depth envisioned by the ERCâ€™s three-plane chart and its research operational strategic plan can be smoothly connected with the ERCâ€™s educational and outreach strategic plan (as an example, the Center for Revolutionizing Metallic Biomaterialsâ€™ plan is shown in the following case study) through this articulation for curriculum sharing. ERC-wide, using this plan, researchers and educators can work effectively towards the goal of educating creative, adaptive, and innovative engineers who are also well-grounded in the underlying science and engineering principles of the ERCâ€™s engineering domain.

Implementing a coordinated curriculum-sharing education plan among all core partner universities in an ERC promotes knowledge exchange, identification of best practices, and effective ERC-wide availability of limited or unique human and/or infrastructural resources. Such a plan would provide for the offering of key courses, workshops, and training that might not normally be available at partner institutions or those that add considerable value to the student researchersâ€™ knowledge and skills in relation to the ERCâ€™s specific mission. Such articulation in education and training also promotes true multidisciplinarity at a multi-institutional level, enabling the ERC to achieve greater things than the sum of its parts. Typically, shared courses would be taught by key thrust leaders or advisory board members with related expertise. Thus, curriculum-sharing articulation among the ERC partner universities moves them towards the fulfillment of the Gen-3 ERC mission as envisioned by NSF.

CASE STUDY:

The North Carolina A&T/Pitt/UC partnership via the ERC for Revolutionizing Metallic Biomaterials (RMB) has resulted in the development and offering of research-relevant graduate courses on a trans-ERC basis using the institutionsâ€™ distance learning facilities and cyberinfrastructure. This articulation helped in the offering of at least three â€˜special topicâ€™ graduate courses shared among the partner institutions where ERC students participated.

Certain logistical issues must always be planned for to enable smooth articulation among institutions with differences in policies and operations. ERC-wide evaluation of the effectiveness of a shared curriculum requires its own set of institutional (IRB) clearances. As an example, one challenge encountered initially in the RMB trans-ERC course offerings was the mismatch in timingsâ€"North Carolina A&T and Pitt have always operated on a semester schedule, while UC used to operate on a quarter schedule, requiring allowances and adjustments at the start and end of courses. Assessment and evaluation have required the assessment lead at North Carolina A&T to coordinate with a local sponsor at the partner institution (for example, UC) to obtain IRB clearance of survey instruments shared among campuses to evaluate trans-ERC courses.



CASE STUDY

The Center for Biorenewable Chemicals (CBiRC), an NSF-funded Engineering Research Center (ERC) headquartered at Iowa State University (ISU), has embraced a very broad view of its role in stimulating multi-faceted dialog around ideas, innovations, and inventions. CBiRC now visualizes its role as operating in the front half of an open-innovation ecosystem, which flows and matures over time from concept generation to knowledge and patents, then to product research and development (R&D), and finally to commercialization.

Working with its industry members and startup companies, CBiRC narrows down the focus of incoming ideas and concepts to a subset of the most viable innovations. Sometimes (depicted by arrows in the figure) these come from outside; other times they are internal or flow outside or even between companies. The most advanced ideas flow to the project R&D stage and eventually broaden-out into the commercial realm. Also, from time to time there is an opportunity to incorporate early-stage ideas into a translational research opportunity.

What became clear from the multi-way discussion within CBiRC is that early-stage innovations still retain significant risk. In this form the ideas do not readily transfer to member companies and a different mechanism was needed. This led to formation of the CBiRC entrepreneurship course for graduate students, which has many similarities to the NSF I-Corps program. The course acts as an idea incubator, creating a framework supporting the formation of multiple startup ideas and nurturing early-stage startups through technology-led entrepreneurship. One aspect of the course is that it provides explicit experience within the context of a bio-based economy. It emphasizes actual guiding of students through the steps required to found a startup company. Although run by CBiRC's Innovation Director, the course includes individual classes given by local CBiRC innovation Partners. The course culminates in a â€œDragon's Den,â€• in which course presenters become a panel of techno-commercial evaluators from whom students seek support and guidance regarding their technologies and readiness for startup funding. Students deliver presentations on company ideas and the panel responds with what the members like or dislike about the proposals. The best ideas from the course are offered further support if the sponsoring students are willing and

interested.

Initially, the course was within the Graduate Minor in Biorenewables, but it has now expanded to become a requirement of other ISU graduate programs called the â€œBiorenewable Resources and Technology Program,â€• run by the ISU Bioeconomy Institute. The Graduate Minor allows students from a variety of allied disciplines to understand opportunities for developing bio-renewable chemicals via a combination of bio-catalytic and chemical catalysis steps. Students in the minor gain a background in the general issues related to the emerging bio-based industry, production, and processing of bio-renewable resources as well as exposure to the economic and environmental realities of the chemical industry. The course also delivers a process that allows students to visualize how technologies can lead to entrepreneurship, and it has led to identification of a need for greater support to nurture fledgling ideas. This need for support has evolved into the CBiRC Bio-based Innovation Startup Foundry.

Several startup entities have succeeded in gaining funding from translational research grants. For example, Glucan Biorenewables has a project funded under the 2010 ERC Translational Research Fund (10-617) as well as under the Grow Iowa Values Fund (GIVF); SusTerea and SolysTE have a project funded and one pending under the Iowa Innovation Green Fund (i6-Green); and OmegaChem gained funding from the NSF-I-Corps program.

Communication Among the Lead and Partner Institutions

It is unnecessary to belabor the importance of continuous, regular, and clear communication among the partner institutions in an ERC. This applies to all ERC deliverablesâ€”research, technology transfer, education, and outreachâ€”and among all stakeholders: faculty, staff, and students. Given that most Gen-3 ERCs are composed of widely-dispersed institutions, it becomes essential to rely on telephones and the cyber infrastructure for active communications as well as asynchronous data access. Administrative leads play a key role in the scheduling of teleconferences and the generation of agendas and minutes and task item checklists. The commitment and regular participation of the ERC leadership provides direction and motivation for the rest of the ERC team to follow suit.

Communication techniques that provide the opportunity for face-to-face interaction include cross-ERC courses on topics of shared research interest that engage students from all partner institutions over a semester, or longer, and involve at least one faculty member at each campus in communications over the duration, in planning together for the success of their students. Interactions of a shorter duration are cross-ERC seminars, internal conferences and jointly-organized symposia at national and international conferences. These are effective in allowing the sharing of interesting speakers and topics. Workshops, such as those focused on the ERCâ€™s specific topics targeting researchers/professionals from government, or those that engage all ERC students and deal with student leadership and ERC Biennial Meeting competition preparation, are also good tools for interaction and communication between institutions.

Regularly scheduled teleconferences and/or video conferences between the lead and partner institutions are effective in promoting the personal touch without the need for participants to travel. ERC directors, deputy directors, administrative leads, and industrial liaisons often find this technique useful for discussing administrative, leadership, and strategic direction issues. Teleconferences are also a good vehicle for promoting discussion on research issues between research thrust team members and on education issues among education and outreach team members. E-mails and the intranet are effective for providing offline discussion and within-ERC result-sharing and serve as valuable archives for report generation.

Leadership strategy planning meetings, pre-site visit preparation meetings and scientific, industrial, and educational advisory board meetingsâ€”whether face-to-face or through teleconferencingâ€”are other valuable interactions between the lead and partner institutions. In addition, external dissemination venues provide further opportunity for partner institution collaboration and planning, which helps open up communication channels. These could include:

- joint journaland trade magazine publications;
- collaboration in maintenance of a unified cross-institution ERC website; and
- regular publication of student-generated SLC newsletters.

2.8 Other Collaborations and Outreach

2.8.1 Purposes and Mechanisms

In order for the U.S. to operate from a position of strength in research, innovation, translation, education, and economic impact, the mindset of the next-generation workforce is critical. To help address this need, a major goal of the ERC program is focused on producing graduates who will be creative U.S. innovators in a globally competitive economy. To that end, the ERC engineering workforce development program needs to include not only university-level education strategies but also strategies that attract precollege and non-traditional students to engineering careers, as well as strategies to involve a broad array of collaborations with government labs and innovation centers and foreign institutions. These involvements should include assessment to monitor progress and impacts over time and to improve the program as needed.

The role of Gen-3 ERCs is to strategize and impact the above through appropriate partnerships. Collaborations with and outreach to other institutions for research and education enable Gen-3 ERCs to disseminate more rapidly and widely the "ERC culture." This can be accomplished through a variety of mechanisms, including joint proposals, exchange of faculty and/or students, direct funding for specific research tasks, consulting activities, and other means. The goal is worthy, and in fact the results of these interactions have largely been worthwhile. This section of the chapter outlines generally followed operating principles, with some examples and lessons learned.

Experience has suggested that best practices for engineering workforce development partnerships include the following:

- This collaboration should be driven by a passion for engineering education and by strong leadership. Partnerships are successful and the results and impacts are profound when both parties are on the same wavelength, moving toward a common (and lofty) goal.
- Successful alliances can be established only when both parties benefit from the collaboration.
- It is necessary to identify those institutions that have capabilities and facilities that are complementary to the goals and mission of Gen-3 ERCs. In this way the interaction becomes a win-win collaboration that benefits both sides.
- For research collaboration, discussion among the ERC thrust area leaders should identify the appropriate individual(s) to contact at the other institution. The approach is then made and, if there is an interest, joint discussions are held to ensure that the outreach institution participant(s) have the same goals and are willing to follow the procedures used in the ERC. It is important to ensure that there is a strong intellectual match-up. Experience demonstrates that financial support alone is not a sufficient basis for a strong partnership.
- It must be realized that failures can occur. Therefore, it should be made clear at the outset that, if the interaction is not successful, the alliance will be terminated.

2.8.2 Academic Institutions

2.8.2.1 Non-partner Affiliated Universities and Colleges

NSF encourages the ERC, as it makes sense, to include as affiliated (non-partner) organizations one or more institutions participating in research and/or education programs, such as universities or colleges that are contributing affiliated faculty groups. To increase the impact of the ERC on the technical workforce, the ERC may partner with community colleges and or technical colleges.While the core configuration of an ERC allows up to four domestic partner universities in addition to the lead university, non-partner affiliated universities and colleges must be selected based on the value they add to the overall mission of the center. Often the success of the ERC does not depend on the number of partners so much as on the quality of the partnership, as far as the mission at hand is concerned. For example, the ERC-RMB, led by North Carolina Agricultural and Technical State University, includes

only two domestic partner universities, the University of Pittsburgh (UP) and the University of Cincinnati (UC). The partnerships were initiated based only on inherent synergies and past track record. This gave the time and resources for judicious selection of non-partner colleges and universities, community colleges, and other institutions. In RMBÃ¢â‚¬â„¢s case the non-partner affiliated 4-year institution is California State UniversityÃ¢â‚¬â€œLos Angeles (CSULA) This approach is having a positive impact on many fronts, from multiple research proposals to graduates entering professional programs in medicine, to the studentsÃ¢â‚¬â„¢ winning of national-level recognition based on team research across the institutions.

Another type of ERC collaboration and outreach with non-partner universities and colleges is the Research Experiences for Undergraduates Program (REU), which is described in more detail in Section 2.3.2.4 of this chapter and in Best Practices Chapter 4, Education Programs. The REU program, for which supplemental NSF funding is available, allows leading undergraduates from other universities and colleges to experience hands-on ERC research opportunities that hopefully will encourage them to pursue graduate education in science and technology.

2.8.2.2 Precollege Partners and Community Colleges

The ERCÃ¢â‚¬â„¢s partnerships with community colleges and or technical colleges serve to increase the impact of the ERC on the technical workforce. Precollege educational institutions are included in order to bring engineering concepts to the classroom and stimulate student interest in enrolling in college-level engineering degree programs and in engineering careers. The partnerships also serve to strengthen the technical workforce and stimulate interest in careers in engineering.

The precollege education programs stimulate student interest in engineering careers and increase the diversity of domestic students studying engineering at the college level. This would include school districts and/or individual schools. A strong relationship with the above will create: (1) STEM teachersÃ¢â‚¬â„¢ involvement in ERC research and education programs, creation of educational modules for their school teaching activities, and integration into their curricula; (2) a strong impact on diversity and broadening participation of underrepresented groups, both teachers and students, into these engineering experiences; and (3) an infusing of creativity, innovation, and STEM leadership motivation among talented high school students through the Young Scholars program.

For example, some ERCs have formed partnerships with county school systems, middle schools, community colleges, and technical community colleges to provide outreach to secondary school teachers and K-12 and associate-degree level students. Some centers have also become involved in local science fairs, both as mentors or judges. This approach is creating a positive impact on many fronts: teachers and young scholars engaging in ERC research and pursuing national competitions, community graduates entering 4-year educational programs through a 2+2 articulation agreement, and organization of national education workshops.

2.8.2.3 Foreign Partners and Collaborators

Gen-3 ERC Programs aim to provide an opportunity for domestic students and faculty to collaborate in a globally connected university research and education environment. The collaborations established with researchers in foreign institutes should lead to the advancement of pre-competitive research. The judicious selection of foreign partners is just as crucial to the ERCÃ¢â‚¬â„¢s success as that of domestic partner and non-partner institutions. It should be based on the institutionÃ¢â‚¬â„¢s position of global strength and leadership in the ERC research area; the passion and motivation of the global partnership coordinator in working with the ERCÃ¢â‚¬â„¢s leadership to advance common goals, leading to accomplishments such as the joint organization of workshops, conferences, and knowledge exchangeÃ¢â‚¬â€•technical as well as cultural; and the opportunities for faculty-student exchanges. The foreign collaboration should add significant value to the research and also offer the ERC students the opportunity to work in a foreign laboratory for a mutually agreed period of time. Sufficient time in the foreign partnerÃ¢â‚¬â„¢s laboratories enables the ERC student to have a meaningful international research experience that is relevant to the student's research in the ERC.

The foreign partner collaboration could be formalized through a Memorandum of Understanding (MOU) among the institutions, or less formal ERC-faculty-to-foreign faculty collaboration. The MOU approach is strongly recommended for future sustainability of the partnership. In both cases, there should be mutually protective Intellectual Property (IP) policies that could evolve over time to meet the requirements of the individual institutions. As an example, one of the current ERCs (ERC-RMB) had a global research partnership with Hannover Medical School (MHH) in Hannover, Germany, while the Indian Institute of TechnologyÃ¢â‚¬â€œMadras (IITM) provided

additional global entrepreneurship and cultural knowledge. Passionate leadership from the coordinators involved has resulted, in addition to an exchange of students for research, the organization of international workshops in the biomedical field, including at the FDA, helping the ERC to become one of the trailblazers in this area of technology.

2.8.3 Federally Funded Research and Development Centers

As outlined in Section 2.5, there are a large number of competitive solicitations that are released by many other federal agencies throughout the year, and many ERCs apply often for supplemental funding and collaborative research through this mechanism. The ERC Program is generally viewed positively by other funding agencies and is seen as a stable, well-supported platform for related R&D programs.

There are also a small number of NSF supplemental funding opportunities restricted to ERCs and other existing Program participants, and centers which actively seek out these special solicitations can readily enhance their finances and opportunities for collaboration with other groups (see Section 2.5).

Among the different collaborators an ERC may develop, Federally Funded Research and Development Centers (FFRDCs), commonly known as National Laboratories, present some great opportunities while at the same time creating a number of difficult challenges. First, it is important to recognize that a National Lab is not a funding source, but rather a partner in building up the ERCÃ¢â‚¬â„¢s research programs. The ability to align research activities that meet a common vision and mission is critical for a strong collaboration. This is not necessarily a trivial matter, due to the nature of NSF and the National Labs. NSF has historically depended primarily on university-led efforts, which rely on graduate students at a relatively modest cost, and the research proceeds in an open-ended fashion. National Labs, on the other hand, depend primarily on career researchers and the research is driven programmatically by the funding agency requiring clear deliverables. Even if these deliverables cover long-term research goals, they usually address a very specific national need, such as cybersecurity for infrastructure. This has a myriad of implications in practice. For example, the National Labs tend to be very strong at creating new experimental infrastructure and building research capacity in a particular field. Still in recent years, they have put greater emphasis on involving students, including post-docs, and working more closely with universities as well as industry. NSF has moved more towards targeted research and innovation with research. So the two research models are moving closer together, reducing some of the barriers.

The natural division of labor between an ERC and a National Lab is for the ERC to focus on long-term research goals, while the National Lab leads experimental setups and provides firm deliverables that match programmatic needs. One way to enable this division is through post-doc assignments at the National Lab where the former student more fully explores ideas from their dissertation. This is not to say National Labs have no long-term research objectives. In fact, they may have on staff many mathematicians and physicists, and so on, who are accustomed to longer-term research goals than in engineering. Still, even in the pure science fields they are focused on clear program goals and demonstrations. ERCs will collaborate best if they understand those goals. It is worth noting the contrast of the multi-year budget cycle at NSF relative to the typically yearly funding decisions for the Labs. This research has to be managed so deliverable deadlines can be met.

As with most collaboration, long-term sustainability stems from developing personal relationships and actively working together on research problems. For some centers, this arises naturally from past collaborations and proximity. For example at the CURENT ERC at the University of TennesseeÃ¢â‚¬â€œKnoxville, many faculty and even some staff have joint appointments at Oak Ridge National Laboratory (ORNL), which is located within a short driving distance of the university. This is an obvious advantage in understanding the different environments. Even without proximity, many of the National Labs maintain strong relationships with several universities. It is important to have faculty on the ERC team who have fostered these relationships and understand the programmatic approach of the National Laboratories.

2.8.4 University, State/Local Government Organizations Devoted to Entrepreneurship and Innovation

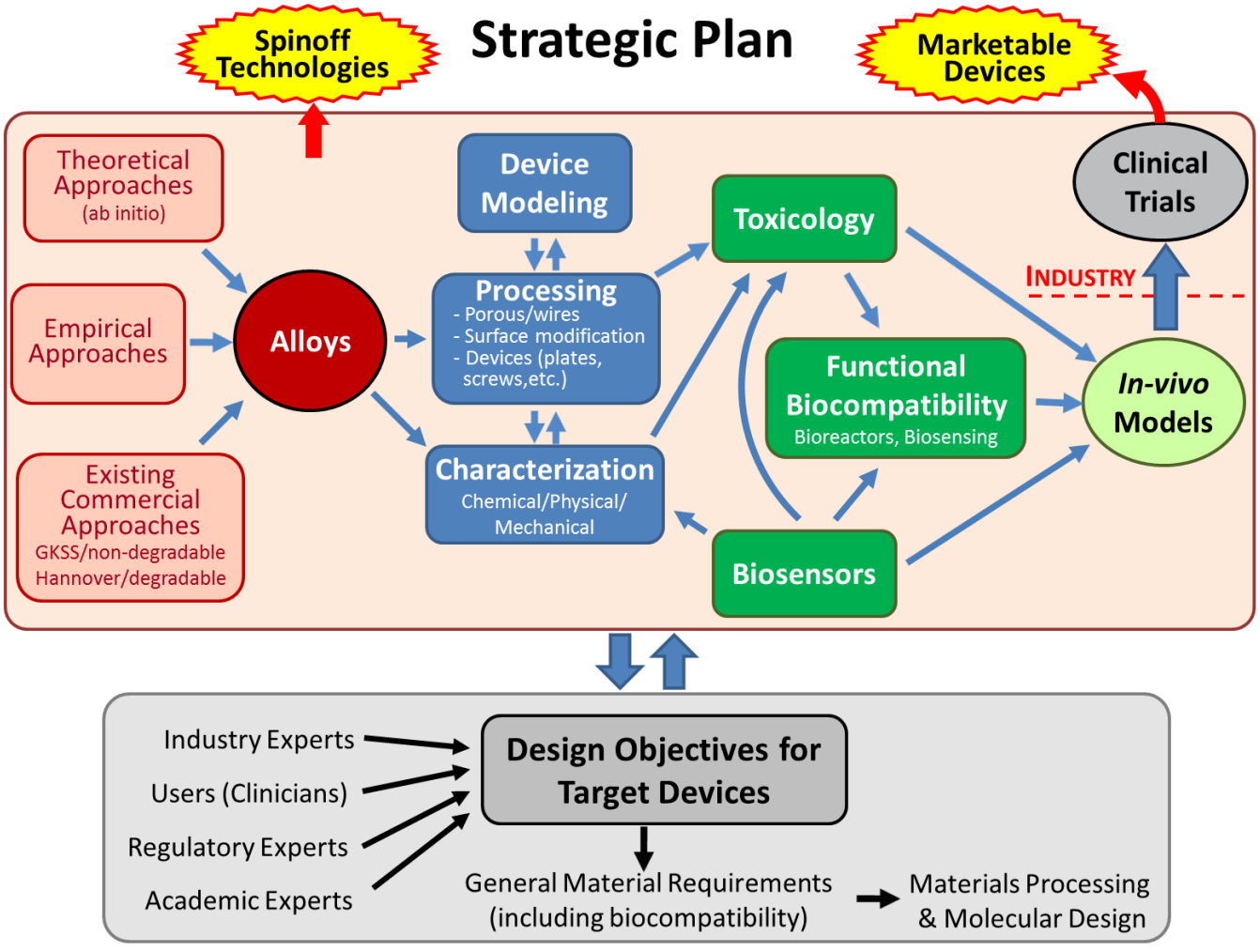
Partnerships with state and local government and/or academic organizations devoted to entrepreneurship and innovation is an important aspect of Gen-3 ERCs. With needs for job creation serving as a driver, state and local governments are increasingly looking to find ways to support entrepreneurs, and are partnering with universities in this effort. Government agencies look to universities to provide technical support to entrepreneurial efforts, provide training in business basics, and train and develop the workforce required for new ventures to thrive. They also look to universities as the source for innovation from which entrepreneurial jobs may grow, and may have programs to provide some financial support for innovation in business areas targeted by the state for economic development.

As such, it is important to engage representatives from these organizations in the ERC, preferably as innovation partners and advisors to the ERC leadership. The relationships built in this fashion will not only help to cement the centerÃ¢â‚¬â„¢s role in driving regional economic development, but help extent the center's contacts, as theseGovernment organizations are routinely sought out by entrepreneurs and are accordingly extremely well connected. While the exact nature of these organizations will vary from state to state, the State Department of Commerce is a good starting point for developing these relationships.

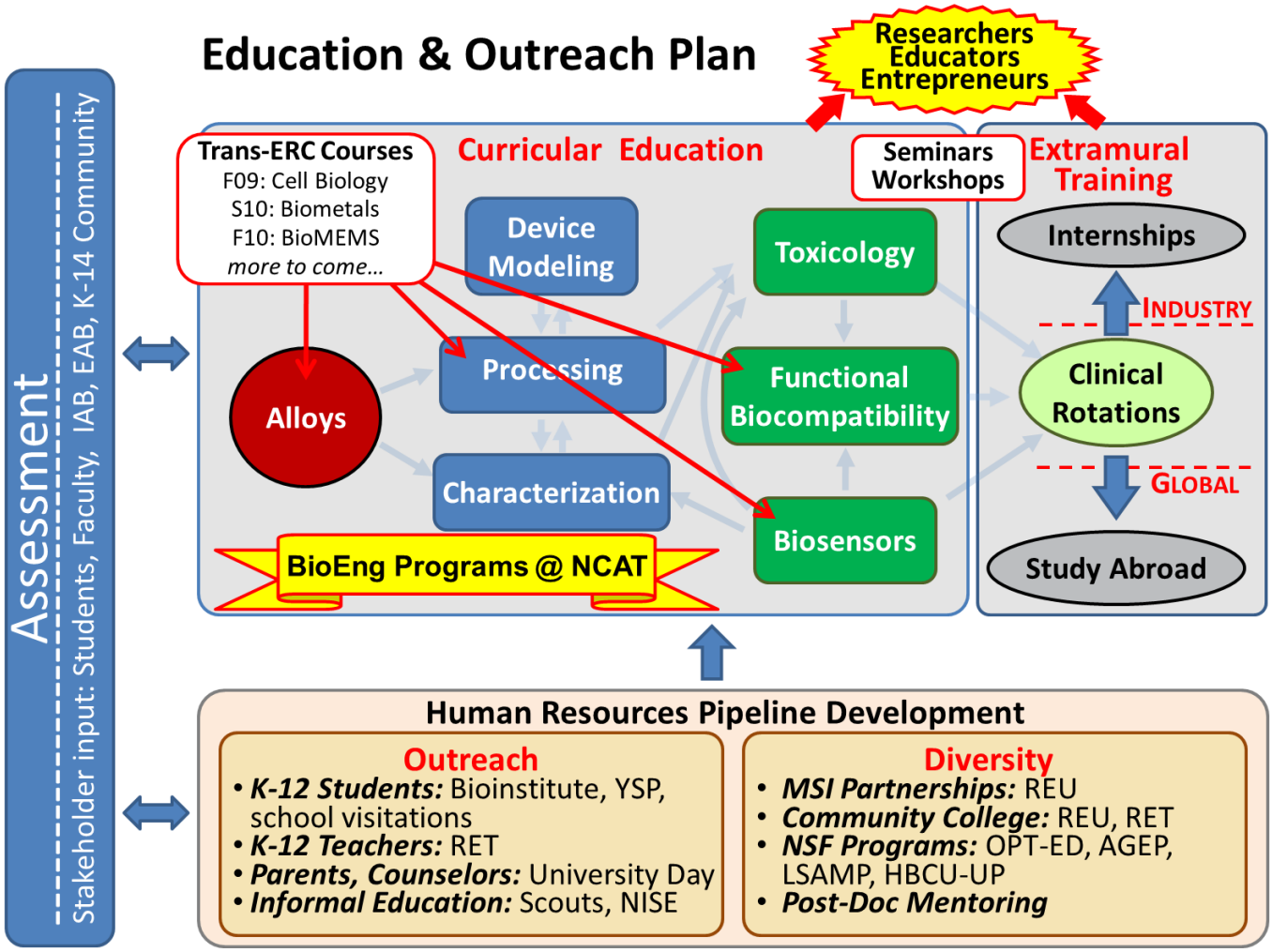
In addition to developing partnering opportunities, these organizations can help provide the ERC with resources needed to enhance entrepreneurship training for students. Many universities have established Centers for Entrepreneurship, and these groups should be formally engaged in the ERCÃ¢â‚¬â„¢s education and industrial affiliates programs. Similarly, staff and entrepreneurs at local business incubators can provide educational opportunities through seminars, workshops, and mentoring of students.

CASE STUDY:

The integrated research strategic planning and education and outreach strategic planning of the ERC for Revolutionizing Metallic Biomaterials at NC A&T State University (RMB) is one example of an ERC's approach to developing effective collaboration and outreach efforts. Both strategic plans have been carefully developed to be in support of each other, and both plans employ a uniform color-coding scheme to demarcate thrusts and pathways and to track the impact of the vision and mission of Gen-3 ERCs from research to education to outreach. All partner (as well as non-partner) universities, colleges, community colleges, and other precollege partners, along with foreign partners/collaborators, federal labs, and academic/state/local government organizations devoted to entrepreneurship and innovation, are embedded seamlessly through these strategic plans, resulting in maximum impact.



ERC-RMB Research Strategic Plan



ERC-RMB Education and Outreach Strategic Plan

2.9 Working with the NSF

Appendix A Contributors

Source URL: https://erc-assoc.org/content/chapter-2-center-leadership-and-strategic-direction