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.

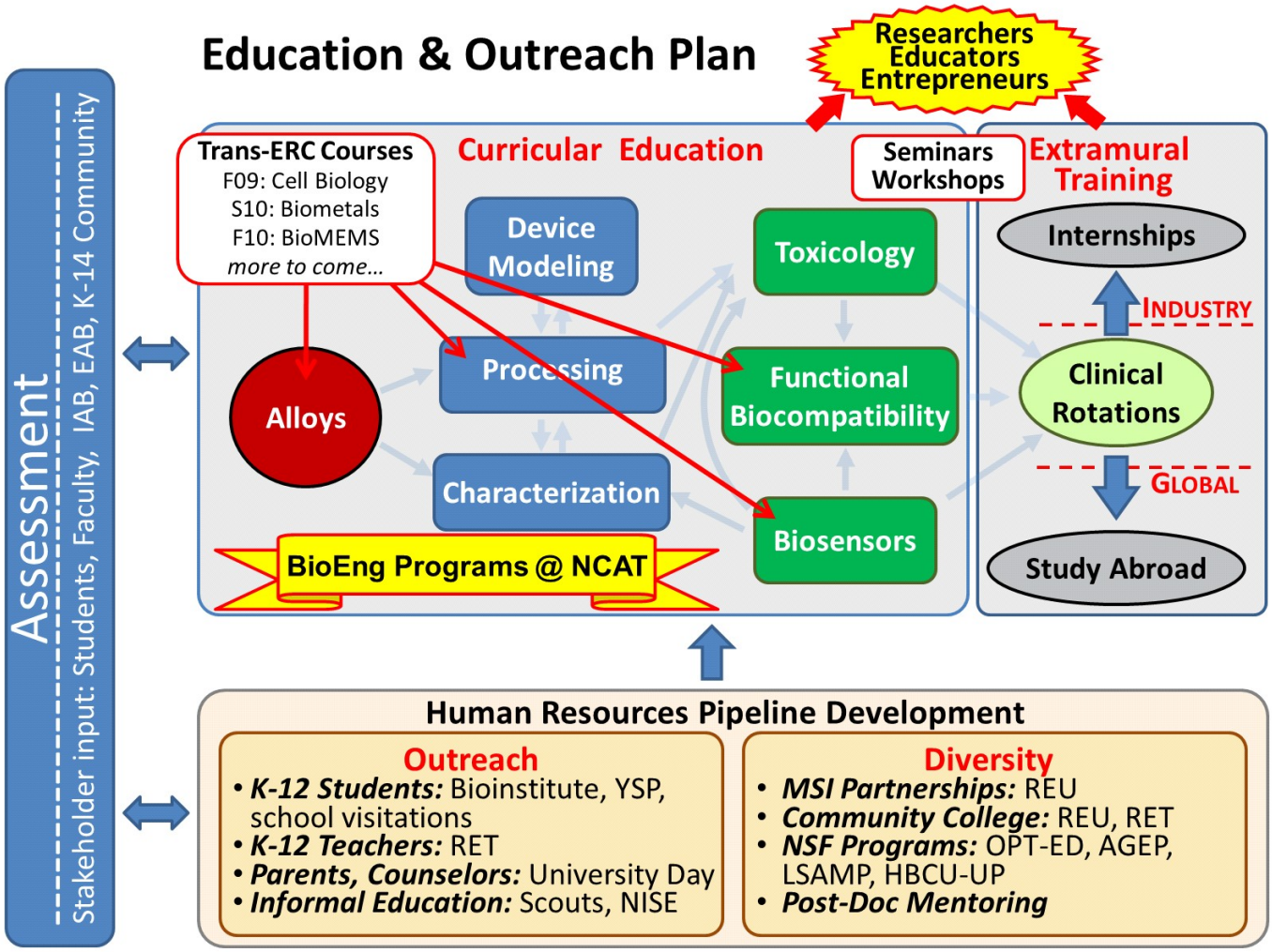
Implementing a coordinated curriculum-sharing education plan among all core partner universities in an ERC promotes knowledge exchange, identification of best practices, and effective ERC-wide availability of limited or

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.

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