KNOWLEDGE AND TECHNOLOGY TRANSFER IN COOPERATIVE RESEARCH SETTINGS

CHAPTER 9

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KNOWLEDGE AND TECHNOLOGY TRANSFER

One of the primary reasons that companies join cooperative centers and programs is to be closer to the action in terms of linkage to new research and technology. Indeed, one of the primary reasons firms leave such centers is the failure of the center to transfer enough technology or useful research findings to industry. Despite the rapid growth of cooperative research centers, institutes, and programs in both academic settings and elsewhere over the past 15 years (Coursey and Bozeman, 1992; Etkowitz, 1991), these programs are always at risk unless there is a constant flow of technology to their sponsors. Unfortunately, IABs and directors of self-sustaining I/UCRCs graded their centers lowest on technology transfer among all operational areas (Gray, et al., 1991). Far too often the leadership of cooperative centers takes technology transfer for granted. As we shall see, member firms are often large, complex entities to which transfer will rarely take place without highly focused effort.

Changes in the Basis of Economic Competition

There are three fundamental reasons why knowledge and technology transfer are critical issues for cooperative research centers. The first concerns the impact the center has on its society, while the other two concern the very survival of the center itself.

Technology-based new products and processes are key components in how companies battle one another for markets and survival. The proportion of successful new products based on research-derived technologies is increasing (Mansfield, 1991; Nagle and Dove, 1991). The companies that are succeeding are those which have adopted a "first-to-market" business strategy (Sanderson, 1992; Gupta and Wileman, 1990; Reiner, 1989). Rapidly changing tastes and desires of customers are best addressed by being first with the most technologically feasible product. The implication for industrial participants in cooperative research programs is technological advantage must be extracted quickly, and the cooperative research program must facilitate it.

The Key to Member Retention

Not only are companies becoming more adept at competing with one another, they are also becoming more careful about their investment in R&D. While many companies have cut internal R&D and sought to leverage their R&D investments by engaging in cooperative relationships, they have also become much more attentive to monitoring its costs and benefits. Companies join a center for student recruitment, corporate statesmanship, and other reasons but the best predictor of whether a company will remain in a cooperative R&D relationship is whether they perceive benefits of *knowledge and technology transfer*. Everything else pales by comparison. Companies may believe that researcher X in university Y is doing some of the most advanced work in the world, but unless some of that new knowledge and technology translates into their industrial use, it is irrelevant.

Missing Skills, Missing People

Of the people who lead, manage, or do the technical and scientific work of cooperative R&D programs, only a small fraction have formal training or experience in knowledge utilization and technology transfer. They tend to be unfamiliar with—and too often hostile to—the behavioral, economic, business, and social science knowledge that is embedded in the practice of using research and technology for business advantage. Technology transfer tends to be neglected until the end of the year report of technology transfer results and impact. A senior technology transfer manager at Semitech compared "hunting-gathering" vs. "farming" (Smith, 1993). Hunting-gathering is the search for technology intermittently when confronted with a critical, emergent need. Farming is the investment in technology for the long-term, nurturing promising ideas, abandoning bad ones, systematically over an entire life cycle. When all works well, centers can help convert technology hunter-gatherers into technology farmers.

Is It Knowledge or Technology?

Without getting too deeply into the complex and somewhat confusing literature on technology transfer and related concepts (see Tornatzky and Fleischer, 1990, for an introduction), there are a few key concepts that are essential for the reader to understand, if only to enable us to all hold common definitions. Unfortunately, there is a fair amount of sloppy language and slippery definition in the field of technology transfer. In particular, there is much confusion about the difference among research results, knowledge, and technology. Typically, research results yield new knowledge. In contrast, technology involves a tool with which people can extend their living and working environments. The essence of a technology is its practical value; its doing something vs. its understanding. However, technology does not necessarily imply a physical artifact, machine, or device. Often, practical value or utility can be embodied in a formula, a piece of software, or set of procedures. The important point is that technology implies the application of knowledge having practical value and utility. Research results are not the same thing as a technology. Research results, whether empirical findings, statistical relationships, or new conceptual schema, are new knowledge. Knowledge is the bridge between research and technology, but different from practical or useful application, which is at the heart of technology.

Knowledge Use

Industrial participants *use new knowledge* from research results. For example, they use it for in-house proprietary development. The average I/UCRC firm reports they invest over $160,000 per year in follow-on funding (Gray & Meyer, 1993). They may use research results to suggest technological applications or to drive their own technology strategic planning. Knowledge use might be considered as the feedstock of subsequent technology development.

Technology Transfer

In contrast, the term technology transfer is much more immediately tied to business interests and objectives. It is embodied in tangible artifacts, devices, or tools. Technology implies practical value, and often that value is proprietary intellectual property protected by patents, trade secrets, copyrights, or licenses. Thus, technology transfer often involves legal and business transactions as much as knowledge. As far as the operation of cooperative research centers is concerned, the domains of knowledge transfer and technology transfer represent qualitatively different activities.

Technology transfer and knowledge are important to the participants in cooperative research centers but the way they are handled differs greatly. Because knowledge is not protected as is technology, publication is critical for the academic participants. In contrast, technology is almost always protected in some way, or its value is greatly diminished.

The Technology Life Cycle

Implied in this discussion is the notion that knowledge gets transformed or reconfigured as it evolves from research findings into a tool or product that can be used by a customer. These stages and phases are often described as the *technology life cycle*. This means that a given technology evolves or matures over time. For example, computer pointing device technology was basic research done at MIT and other universities which became applied research at Xerox PARC which developed the first mouse. A wide variety of product developments in mouse configuration, track balls, and light pens followed. The columns in Figure 9-1 show one version of a technology life-cycle from research to routinization.

The total life cycle involves a variety of different organizations and individuals more or less linked together. Not surprisingly, these individuals may have different views or perspectives about the nature of their work and its importance relative to other stages, phases, and participants. Of course, without all participants in the life cycle, there would be no practical application of technology. The rows in Figure 9-1 show the different types of individuals and organizations and when in the life-cycle they might be involved. Unfortunately, too often we see university professors disparaging the level of intellectual contribution required to turn their ideas into technology, and industry engineers disparaging professors for their lack of connection to the real world. A good "hand-off" between these groups is critical for the success of the life cycle.

A small but important microcosm of the total technology life cycle is played out in the context of cooperative research centers. Typical transactions and sub-stages that occur in the life of a center

Figure 9-1 Technology life cycle.*

	Developing			Using		
	Research	**Development**	**Deployment**	**Adoption**	**Implementation**	**Routinization**
Environment	research labs	advanced manufacturing facilities	plants	plants	plants	plants
Organization	university, company R&D	technical centers	design centers, plants	companies	companies	companies
Work Group	I/UCRC+	company product development groups	manufacturing industrial engineering	manufacturing engineering	manufacturing engineering	manufacturing engineering
People	researchers	product, process design staff	production engineers	plant staff	plant staff	plant staff
Timeframe	Years to Decades			Weeks to Years		

*Adapted from Tornatzky and Fleischer, 1990.

project include idea generation and project development, proposal review and project selection, project execution, review, and oversight, communication of findings, and post-project activities.

An Ongoing Process

Knowledge use and technology transfer are parts of an ongoing process which unfolds over time within the center and beyond. People and organizations play different roles in that process: *inventor*, *commercializer*, *technology champion*, and so on. The important point is that while these roles exist, they are not full-time jobs or responsibilities (or even legitimated) for those who occupy them, and that they all need to mesh with one another in order for the process of knowledge use and technology transfer to unfold over the whole life cycle. In order to get a sense of the potential complexities involved, the reader is referred to Chakrabarti and Hauschildt (1989), who describe the various roles that constitute the division of labor in innovation management.

PLANNING AN OPERATIONAL STRATEGY

The concepts just described may be expressed operationally in different ways, depending on the cooperative research setting. We will discuss operational options primarily in the context of our experience with the National Science Foundation's Industry-University Cooperative Research Centers (I/UCRC) Program. While we believe most of what we say will apply to most cooperative research settings, the reader should note any differences between this program and the one in which s/he operates, and act accordingly. This section will briefly summarize some operating principles, and then discuss their expression in terms of the project life cycle in centers.

Ensuring a Meaningful Voice for Industry

Almost everything a center does depends on a robust dialogue between industry and academia. The best way to ensure knowledge use and technology transfer is for this dialog to take place early and often in the project life cycle. The reader should refer to Chapters 5 and 6 for a fuller discussion of research planning and communication.

Benefits-Sharing vs. Proprietary Interests

The I/UCRC program is premised on several assumptions about corporate interests and behaviors, and the reasons that companies join centers. For one, it assumes that a consortium of companies can derive benefit from a process in which they guide the R&D agenda, and in which they share equally in the derived research. This typically results in procedures by which all member companies get early research results, and if a research-based technology is patented all get royalty-free licenses for internal use. Industry is at the same time trying to gain and maintain clear proprietary advantage over their competitors. One principle of center operations is to constantly maintain the balance between proprietary interests and collective benefits-sharing. If narrow proprietary interests prevail, leveraged research work won't take place; if benefits-sharing dominates, particularly in a way which erodes proprietary interests, companies may gradually loose business interest.

These processes tend to work well in most cases and centers, particularly when industrial members come from different industries or have different applications. The fact that most university research and proprietary technology is in such an early stage of the technology life cycle also keeps peace among the members. Consider the following real-life case from the I/UCRC for Dimensional Measurement and Control in Manufacturing at the University of Michigan.

> Members of the I/UCRC for Dimensional Measurement and Control in Manufacturing at the University of Michigan include all three of the major U.S. auto manufacturers, a machine tool manufacturer whose primary customers are the auto firms, and a vendor of non-contact gauging equipment whose primary customers are the auto firms. The center developed a new approach to optical measurement of sheet metal with the active participation of the gauging vendor and all three auto manufacturers. The gauging vendor has just begun the process of turning the technology into a product with all three automakers lined up to be its customers. The machine tool vendor is learning about the capability of the new gauging system so that the next generation of machine tool will meet the enhanced accuracy.

In this case a symbiotic relationship has developed among the university faculty, the gauge vendor, and the automakers, with the machine tool maker an avid onlooker who will benefit, but only in the long run.

When a technology has clear and important applications for commercialization but no center member company can move it to production, the scenario changes. Consider the following case from the Center for Aseptic Processing and Packaging at North Carolina State University.

> Members of the Center for Aseptic Processing and Packaging at North Carolina State University include some of the country's largest food processors and manufacturers and manufacturers of food processing and packaging equipment. The center developed and patented a thermal memory cell semiconductor device which measures the temperature of a food particle as it moves through the thermal system. Member firms were very excited about this technology because it might allow them to speed up processing times and win FDA approval for processing new food lines. Unfortunately, none of the firms was in the business of manufacturing semiconductors. In order to facilitate the commercialization of this invention, member firms waived their intellectual property rights. The center has spent a great deal of time developing a prototype and finding a commercializing partner. This process has taken more than two years and negotiations are still in process.

Successful transfer can occur, but it involves a great deal more effort and flexibility by both members and center. Later in this chapter we discuss alternatives to the typical non-exclusive intellectual property arrangement some centers may want to consider.

There are some rules of thumb for balancing shared benefits and proprietary interests. If a center goes along for several years and no company member or external partner generates process improvements or products from center research, then perhaps the agenda has shifted too far. On the other hand, if the fraction of one-on-one contract projects begins to exceed the core work, and there is limited enthusiasm for discussing early stage or basic projects, then the center may be turning into a university-based contract development organization. The solution in either case is to consciously and publicly shift the center's agenda.

The Role of Communication

One of the most common clichés in the technology transfer field is that it is a "body contact sport." Like most clichés this one has a large core of truth. The simple fact is that neither new knowledge nor technology is self-implementing. Moreover, one cannot assume that the potential users of knowledge or technology are waiting for it. In order for knowledge use and technology transfer to occur, it is important to communicate activities often, to as many constituencies as possible, in all media available to the I/UCRC. See Chapter 7.

Periodically members should receive some form of communication from the center or its faculty. This communication should be crafted to accommodate or overcome the communication system that exists within the member company. Center managers should not assume that the representative will pass on information to important others in his/her company. Often the representative is isolated by status or function. For example, a center representative from a company's R&D function may have little or no contact with people from the same firm's manufacturing function. The center must seek to develop multiple contacts within member companies so as to maximize the spread of information about the center and its activities. Some of the more explicit ways in which communication media can be deployed are as follows:

- **Academic Papers**. A key task in any university is to publish and disseminate scientific papers. Industrial participants can derive as much or more benefit from early or unpublished versions of the such papers. Make it a practice to provide drafts of papers and use industrial participants as early reviewers if they are so inclined. The Center for Advanced Computing and Communication at North Carolina State University and the Center for Dimensional Measurement and Control at the University of Michigan catalog all such papers in a technical reports series which is shown to prospective members and shared with new members. Publications are also made available on the Web. Other centers include research abstracts in their newsletters.

- **Personal Visits**. Although company representatives are supposed to disseminate center results within their organizations, some individuals do this job better than others. As a consequence, some centers require that all firms receive a certain number of visits each year and monitor this activity to ensure follow through.

- **Human Resources**. Graduate students trained under the auspices of a cooperative center and subsequently hired by industrial partners are a major technology transfer conduit. Some centers spotlight the work of students to get them working with company staff early in their training. Others have developed internship programs with member firms.

- **Doing Research**. In some centers, company personnel work side-by-side at a "bench level" with university faculty and students. In virtually all centers there is technical dialogue between company peers. Within the I/UCRC Program, NSF will cost-share "industrial sabbaticals" for faculty who spend at least a summer or semester working for a member firm. The firm must pay for part of the salary.

Transfer and Use Issues in Idea and Proposal Development

Project ideas come from many sources, not just from faculty. Successful cooperative centers have done a variety of things to ensure that a steady stream of project ideas emerge and reflect the effort of virtual teams.

- **White Papers**. One center asks industrial advisory board members to write short white papers on research issues that are then circulated among the IAB members and faculty.
- **Industry Presentations**. Another center has one industry representative each quarter make a formal presentation to the faculty and IAB members on the state of their field.
- **Brainstorming**. Other centers brainstorm separately from the normal center meeting. Brainstorming discussions are among faculty and industry members.
- **Request for Proposals**. Other centers use RFPs jointly crafted by center leadership, faculty and industry to generate proposal ideas.
- **Technology Transfer Plans**. At least one center asks for technology transfer plans in its project proposals. This forces faculty members to talk with industry about applications, concepts and practices.

The point of all of these techniques is to provide faculty and graduate students with some relatively clear boundaries and directions for useful proposals. Refer to Chapter 6 for a fuller discussion of additional issues and practices.

Transfer and Use Issues in Proposal Review and Project Selection

Perhaps the most highly leveraged technology transfer activity conducted by a center is project selection. Poor or undisciplined project selection will haunt the research agenda. The quality of the choices depends on the perspective of the stakeholder. Faculty and graduate students are inclined to pick projects with significant value to the scientific community and which will yield articles publishable in reputable academic journals. Although industry participants share those goals, they are more concerned about the problem-solving and business applications.

The cooperative center concept enables simultaneous accomplishment of these seemingly incompatible goals. However, in order for this to happen, it is important that the goals of the various stakeholders be discussed openly during project selection. Some portion of faculty project proposals should focus on expected industry relevance. Deliverables should be stated in industry terms. Development of this section should be based on prior interaction with industry participants.

Industrial participants need to play an active role in project selection, express their opinions, and be willing to work with faculty investigators to refine and re-craft a proposal. Industry participants should do more than vote up or down. See Chapter 6.

Transfer and Use Issues in Project Execution, Review, and Oversight

All should be attentive to transfer during project execution and should have a procedure for modifying or discontinuing projects.

During the semi-annual research reviews, there should be examination of any technical obstacles that will preclude practical or theoretical benefit from the project. If these obstacles cannot be overcome, the project should be discontinued. As the project progresses, do the originally-specified deliverables still make sense? Are there revisions needed? For example, if a research project begins to show promise of industrial applications, expected deliverables might be revised to a proof-of-concept prototype, sample material, or more tangible product. A review of budget will show if the project is over its expected spend rate, slow to start or needs new level of effort estimates.

Well-managed projects accomplish expected technical deliverables and facilitate the flow of knowledge use and technology transfer to industrial participants. Most centers should adopt fairly formal protocols, checklists, and benchmarks to assess the progress of projects.

Congruent with our previous discussion about shared benefits vs. proprietary interests, it is common that some companies will have a higher level of business interest in a particular project. Oversight and review will be enhanced if one or more industry "mentors" work closely with a project. This usually results in a better project as well as an acceleration of the technology transfer process.

Transfer Issues in Communication of Findings

In the university, publication of an article in a scientific journal, or presentation of a paper at a scientific meeting is the culmination of research but these modes of dissemination often do not reach the industrial audience. In order to increase the probability of knowledge use and technology transfer, the cooperative center must explicitly design and implement a dissemination strategy.

This implies several subtasks. One is to clearly identify the information users in member companies. That is, one should not assume that results will be transferred from the official IAB member to other users within his/her company. Some centers send their reports to the technical libraries in member firms. Others have their technical reports on-line so they can be accessed electronically.

Many industrial scientists and engineers lack the time or inclination to read full blown scientific reports. With little effort, it is possible to capture the essence in a much smaller document. Some cooperative centers have developed families of one page reports (often included in newsletters), executive summaries, or full-fledged academic versions. Other centers provide IAB firms with half-hour briefings on-site. Not only does more robust dissemination occur, but much good will is created as are ideas for follow-on projects.

Findings demonstrated in early-stage physical prototypes, software, or demonstrations are another means. Technology transfer is much easier when potential users touch and feel it. Centers with faculty who fail or refuse to take a research project from theory into practice lose an important opportunity to promote transfer.

Transfer Issues in Supplementals and Enhancements

Many centers become involved in *supplemental* or *enhancement* projects funded separately by IAB members and dedicated to more narrowly-defined research and deliverables (see Chapter 11). In some centers, these projects are *de facto* proprietary projects that do not share results with other members. Often, sponsoring companies have the right of first refusal to license inventions that result. In other cases, sponsoring companies are willing for the projects to be treated like any core project. In exchange, they get favored indirect cost and set the agenda for the project. Some centers double their research budget this way. Consider this example from the Center for Dimensional Measurement and Control in Manufacturing at the University of Michigan.

> One of the ongoing, shared projects in the Center for Dimensional Measurement and Control in Manufacturing at the University of Michigan is learning how to reduce variation in the production of large stamped body panels for automobiles. This involves a variety of smaller projects to understand how to measure and control such variation. One of the center's large auto makers funded an enhancement project to investigate specific processes for variation reduction. Results of the project are available to all center members including their competitors, who are also center members.

The project is conducted at one of their plants. One advantage to the auto maker is learning more than the others, since the project is in its plant. It also benefits from reduced variation on the specific process that is the focus of the project. This technology transfer is immediately tied to the business interests of the company. However, there is danger for dedicated, company-specific projects to dominate the overall center agenda and eliminate the incentive for other companies to participate.

Transfer and Use Issues in Center Evaluation

One means of retaining and accentuating that focus on technology transfer is to explicitly build it into periodic evaluation data-gathering. See Chapter 8. Besides a handful of questions that are asked in center evaluation surveys, centers should gather information from industrial participants on their knowledge use and technology transfer practices, industrial member roles, processes in the company setting, and additional IAB participants.

TACTICS AND IMPLEMENTATION

Given the preceding conceptual discussion, we can now move on to specific tactics and ways to implement them. In this section we will provide specific advice in five areas: (1) roles and responsibilities; (2) staff training and development; (3) procedures; (4) tools; and (5) intellectual property.

Center Roles and Responsibilities

The only way to ensure that knowledge use and technology transfer will happen is to assign the responsibility to someone. After the Center Director's job, this is the second most important function in a center. If knowledge use and technology transfer don't happen, companies will leave the center. The technology transfer person should have a title equivalent to associate director and report to the Center Director. Ideally, the individual should have substantial industrial experience, knowledge and experience about the management and movement of intellectual property, and the ability to oversee the communication practices and programs of the center. Depending upon the size of the R&D program and the volume of results and technology suitable for transfer, this might be initially a part-time position. A retired industry executive or manager is often ideal. A senior faculty member with substantial industry exposure may also lead this effort.

If neither of these are available, other resources on campus may offer technology transfer help on a reduced cost basis. The university's office on patents and licenses may be able to dedicate some percentage of staff to the center. In some universities, this office may provide little or no useful advice. Student interns are a particularly rich source of help on some campuses. Several business schools have developed degree programs or specializations in technology management or its equivalent and are anxious to place promising interns.

Staff Training and Development

It is useful to assume that none of the faculty or students attached to the center know anything about the theory and practice of technology transfer or the promotion of knowledge use. All this suggests formal training of them can enhance the technology transfer process. Training ranges from a few-hours, to two to three days (Tornatzky, 1992). In most cases, anything beyond a half-day program will inhibit much-needed participation. Faculty members should be the prime audience. Avoid programs that concentrate on legal details of intellectual property. Try to find one geared to faculty interests.

It is also useful to involve or create separate programs for the industrial participants in a university-based center technology transfer training program. In fact, the blockages are often as much or more pronounced on the industrial side. The solution for center managers is to involve a wide range of company participants through joint training events involving both faculty and industrial partners.

Procedures

The desire to increase knowledge use and technology transfer will remain just that unless center procedures are instituted to make it a normal part of daily operations. Laboratory notebooks should be assigned to every faculty and student researcher with instructions for documenting technology development along with a center handbook, describing in 10 to 15 pages the technology transfer mission, goals, and procedures (see Figure 9-2). The handbook should be reviewed annually in an open center-wide staff meeting. The Center Director might also adapt the Association of University Technology Managers (AUTM) 1994 guidebook on technology transfer.

Figure 9-2 Technology transfer procedures manual.

- **Invention disclosure and publication permission forms** should be readily available to all researchers attached to the center, along with instructions for their use.
- **University policies** on technology transfer, intellectual property, royalties, licensing, and related issues should be distributed and discussed annually.
- **Written guidelines** for communicating with industrial partners should be developed and circulated among research staff. These might include sample or form letters for routine correspondence.
- **Market research templates** or approaches should be developed for exploring the market potential of a technology. These might include data collection and presentation. A template for a technology transfer prospectus should be developed.

Tools for Knowledge Use and Technology Transfer

In addition to the more mundane procedural aids described above, center managers should also think about the emerging set of tools which have recently been developed to assist the technology transfer function. A good metaphor for this development is that of *technologies of technology transfer*. Various computerized databases, expert systems and decision aids, paper and pencil checklists, and training games also promote knowledge use and technology transfer. For example, the Industrial Technology Institute has produced a live action simulation game called ADVANTIG to help people understand some of the problems of introducing company-wide technological change (Southern Technology Council, 1993). In addition, there are commercial databases of thousands of university-based researchers and their areas of expertise which identify research partners at other institutions. Databases of intellectual property are available for license in which centers may list their intellectual property. Databases organized by company technology enable technology transfer, and member and commercializing partner recruiting. A company called CORPTECH publishes national and regional directories of high technology companies and their products (Southern Technology Council, 1994). In fact, most universities' centers have access to such databases. The university's business school and marketing department may also help in marketing new technologies.

The Technology Transfer Society publishes a catalog which describes 58 tools and methods for assisting the technology transfer function (Nicol and Roeske, 1993). The Southern Technology Council (1994) also publishes a tools catalog. Center managers would be advised to become familiar with these tools.

Inventions and Intellectual Property

Intellectual property implies that an invention is or can be protected by law. Moreover, intellectual property often derives *value* from the fact that it can be protected. Many researchers fail to understand that an invention is different from a protected piece of intellectual property. They need to learn how to get to the latter, without impinging on their research creativity and productivity.

Invention Patents

According to U.S. patent law, an invention is patentable if it is:

- **Novel**. Not yet known or disseminated through any medium of communication;
- **Useful**. Has practical value so anyone skilled in the art can put it to use;
- **Non-obvious**. Non-obvious solution or application to someone skilled in the art.

The Invention Disclosure

In a university, when there is an invention from research work, an *invention disclosure* is filed with the institution's intellectual property or technology transfer office. This is evidence of the date of the invention, and identity of its inventors. U.S. patent law follows a principle of first to invent to define intellectual property ownership. The inventor may be asked to document work leading to the invention. All researchers should have an up-to-date laboratory notebook that can provide such information. In many nations, primacy is established by who *files* the formal patent application first. As this book goes to press, there is much debate about whether the U.S. should adopt this "first to file" approach to intellectual property.

Public Disclosure

Filing an invention disclosure does not secure patent protection so university researchers must be cautioned against openly discussing their research in public in formal speech, paper, published article, or informal conversation. Such public disclosure eliminates the possibility of protecting an invention by the trade secret approach or may preclude securing a patent outside the U.S. and thus eliminate effective entry into lucrative markets. It may preclude copyright protection, unless copyright has been claimed from the start. Finally, and perhaps most critically, it starts the clock on the U.S. patent process. At the point of public disclosure, the inventor will have one year to apply for a U.S. patent or lose all patent protection. Since the patent application process often can be lengthy, this is no trivial matter.

Obviously, the law concerning public disclosure has all the appearance of being contrary to the norms, practices, and habits of the practicing academic. How can one publish, interact with colleagues, and promote the free interchange of knowledge and still be involved in technology transfer? The solution lies in the *sequence* of how one does things. If the faculty researcher files an invention disclosure and files for a patent before publishing an article or presents a paper, the invention will be protected. Failure to do this is often the result of ignorance. More often, the faculty member is unaware of the importance of this sequence as a deadline for a favorite conference or journal approaches.

In the context of a cooperative center, if the faculty invention derives from center-funded research, the industrial participants will want to learn about the discovery. However, industrial participants and all visitors at center meetings should sign a non-disclosure agreement to promise to maintain the secrecy of the invention, but these agreements are inherently leaky and provide little more than a temporary protection against disclosure. Faculty and institution need to move smartly to secure more formal protection.

- **Patents**. This is the preferred protection for university-originated inventions to exclude others from making, using, or selling it. Once granted, the patent has a 17-year term. The details of the invention are published by the U.S. Patent Office. Most patent applications are turned down. It will take another couple of years of re-application and discussions before it is granted. Some organizations intentionally may drag out the process to secure a longer *de facto* protection period. Once granted, a patent can be licensed to one or more third parties.
- **Trade Secrets**. In some industries and technical areas, trade secrets are the preferred approach to securing intellectual property protection. A trade secret derives value from participants keeping quiet about the technical details of an invention. While some people argue this is impossible in academic settings, some inventions involve novel and useful technology that has little scientific value. The faculty inventor will have no interest in publishing such information. Other inventions constitute know-how or craft knowledge more easily protected through trade secrets. In one example, a master's thesis developed a sophisticated optical instrument that was ultimately licensed to a company as a trade secret. The scientific questions being addressed in the thesis were such a small part of the prototype instrument, the trade secret arrangement worked.
- **Copyright**. A copyright protects written expressions of ideas, rather than the idea itself. Besides seeking patent protection for the core invention, one might also seek copyright protection for relevant documentation, training tapes, records, or films. In addition, copyright protects software (although there are software patents as well). Copyrights are easy to obtain in a few months. The term of a copyright for an individual is life plus 50 years; for an organization, publication plus 75 years, or creation plus 100 years. Copyright notice should be on every technically relevant center publication or document. While protection is not complete until copyrighted material is registered, on a *de facto* basis protection is realized by that simple procedure.
- **Trademarks**. A trademark is a distinctive name or logo that is attached to goods or services. If there is some logical and catchy name that you have been using to describe the invention, go ahead and register it as a trademark. Eventually, if

and when you get to the point of licensing the invention, the protected trademark adds more value. Trademarking is relatively easy to do, its term is as long as the trademark is being used, and it may have more value ultimately than the technology itself.

Toward a Center Strategy for Intellectual Property

Normal practice in NSF Cooperative Research Centers, when an invention has been developed, is to protect it through patenting or other means, and then make it available to all of the industrial participants on a royalty free, non-exclusive basis. In most cases member companies also share in the costs of patenting. This approach has worked well; however it may create some disincentives for full commercialization. This is particularly so when the costs of development are large and the time frame of getting to product is lengthy.

Each center-originated invention should be approached individually, with an eye toward maximizing the benefit to the center as a whole, and to the industrial members. Every invention has its own unique aspects, and center management should craft the response accordingly. As a consequence, some centers have adopted intellectual property by-laws in which non-exclusivity is the default but which involve a number of other options spelled out in a decision-tree. The decision tree might allow any one of the following: non-exclusive royalty-free for all members; limited but royalty-bearing license for member who shares in filing costs; exclusive license if only one member is interested; or exclusive license for a non-member if no members are interested. Mechanics of intellectual property agreements in the context of cooperative research (including sample contract language), can be found in a recent publication of the Government-University-Industry Research Roundtable (1993).

EMERGING ISSUES

Much of what has been described above derives from the accumulated experience of the NSF Industry-University Cooperative Research Centers program during the late 1970s to the mid-1990s timeframe. However, during this period developments have been occurring in other venues, which are, in effect, re-defining the terms of what cooperative research is, and how it is organized. Some of these developments are in an early stage, and many derive from consortia that are much larger or not university-based. Nonetheless, they may be instructive for center managers, researchers, and industrial participants. We will discuss four areas of new trends and developments: (1) next generation media and communications approaches; (2) new approaches to project selection and execution; (3) new structural models for cooperative research relationships; and (4) new trends in relevant public policy.

Next Generation Media and Communication

We are entering a new era with the use of electronic media in technology transfer (Anderson, 1993). One such new communication medium is the rapidly-growing system of digitized information networks by which text and soon video and audio can be sent to literally millions of users. The Internet provides electronic mail, news, and high speed file transfer services to millions of sites around the world. A number of centers already use Internet websites for sharing research results, center activities, student vita and other information. with their corporate participants. The I/UCRC at Purdue University, University of Florida, and Oregon University may be the most advanced in this area: (http://www.cs.purdue.edu/SERC).

A related communication medium of interest to center managers is the video conference. There is large literature which indicates that communication richness and the conveying of subtle meaning is enhanced by combining visual and auditory cues with words. Video conferencing exploits this to reduce the number and cost of actual face-to-face meetings, increase the number of virtual face-to-face meetings, and enable a great deal of delicate and critical business to be conducted. Center managers can start by contacting their regional telephone company. In most areas of the country it is necessary for each participant to be in a specially-arranged studio facility, few of which are in the public domain. This medium is most appropriate and effective for small meetings of 4-8 people, such as an executive committee or meeting with a group from a potential licensee company.

Another group of communication media comes under the label of computer-supported cooperative work (CSCW) or groupware. These are software systems by which a group of individuals sitting in front of a networked computer terminal work together. There are commercial versions. An example is Lotus Notes®. The most likely application for centers is participants planning a research agenda or exploring applications of a research finding (Olson and

Olson, 1991). The Center for Management of Information at the University of Arizona has developed such a tool, the Electronic Meeting System, to support I/UCRC research reviews. Virtual reality demonstration of technology in real time is possible for technology transfer applications, too.

New Approaches to Project Selection and Execution

Many of the newer approaches to project selection and execution are taking place in industrially operated consortia. Rather than selecting and funding a single research project in a problem area, waiting for results, and then deciding upon subsequent development or transfer plans, a bundle of related activities or projects is launched more or less at the same time. This might mean going to early technology prototype even while the research project is still being finished. The new model also implies mixing people from different stakeholder organizations at the bench level to engage in project work.

The New Public Policy Environment

Virtually every federally funded science or technology initiative has to be linked to technology transfer results, commercialization, and economic growth. There is a strong belief that cooperative relationships, joint ventures, and linkages are essential to realizing the economic growth potential of federal investments in technology. This is reflected in NIST Advanced Technology Program and Technology Reinvestment Programs. Major government efforts to address the education and training issues that are involved in moving to a high value-adding economy is an interesting opportunity for cooperative centers. Because they already involve industry and university in a consortial arrangement, a number of I/UCRCs have competed successfully for funding from these programs. Other centers should consider them. (See Chapter 11.)

New University Culture

Many university cultures conflict with these new technology transfer roles and behaviors. Few universities include helping industry or enhancing economic growth as part of their organizational mission. Faculty rarely get tenure or promotion for filing patents or securing licenses as they do for refereed publication. For university-based technology transfer to work, this must change.

This is not to imply that universities should abandon their traditional roles in both fundamental research and education. Rather, it implies the university should view itself from a larger perspective, one in which its traditional roles are a critical part of a much larger process. In fact, if we look back a century to the founding of land-grant and technical colleges in the United States, it becomes clear that the new culture we are advocating is not so very different from the very roots of the American university system as a practical place to improve society and its economic well-being.

SUMMARY

Knowledge use and technology transfer are critical outcomes from industrial member participation in cooperative research centers. Differences between industrial and university participants in a cooperative center can be overcome; indeed, that is the reason for establishing such a center in the first place. *However, building a center only increases the probability that technology transfer will happen*. Bridging this gap requires persistent effort by both sides. In particular both sides must:

- **Recognize the Need to be Proactive**. Both university and industry participants must recognize the need to establish procedures and take action regarding knowledge use and technology transfer. These things do not happen by themselves. Creating a staff position in the center with explicit responsibility for knowledge use and technology transfer will facilitate this.
- **Use multiple media for transfer**. This includes paper and presentations, one- on-one visits, meetings, websites, and oversight by industry.
- **Consider Use and Transfer in Project Selection and Review**.
- **Train Staff on Intellectual Property Issues**. Make sure all investigators and all industry participants understand the intellectual property issues involved in a center.
- **Establish Procedures to Protect Intellectual Property**. Have forms and procedures in place to make it easy for investigators to make disclosures, file patents, and protect trade secrets.
- **Keep Informed about Emerging Trends.**

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