

# CREATING WIN-WIN PARTNERSHIPS:

## Background and Evolution of Industry/University Cooperative Research Centers Model

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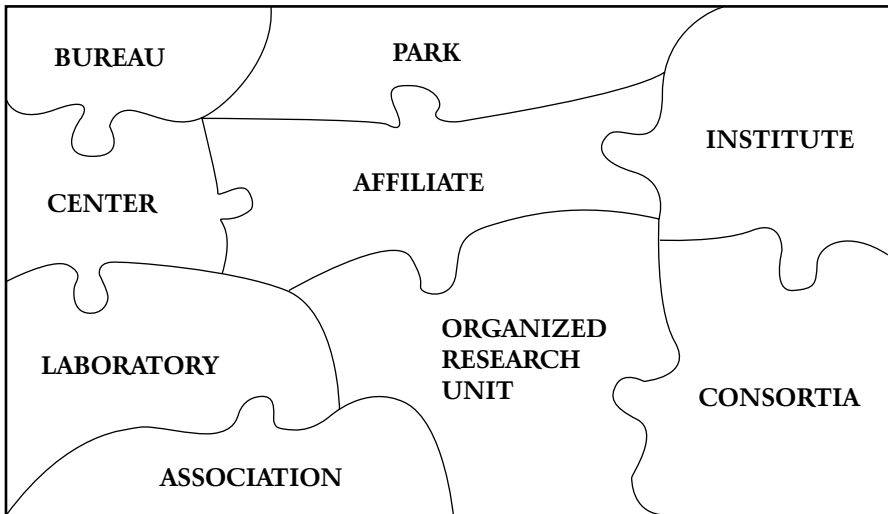
DENIS O. GRAY, *North Carolina State University, Raleigh*

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### INTRODUCTION

Research cooperation between industry and university has increased dramatically over the past few decades. Fueled by a number of social forces, including shrinking federal support for research, pressures from global competitiveness, and the increasing importance of science-based knowledge to the innovation process (Feller, 1997), industry's share of academic research has more than doubled over the past two decades, from 3.1 percent in 1975 to 6.9 percent in 1995 (NSB, 1996).

Interestingly, this growth has been accomplished without a commensurate closing of the "cultural gap" which separates institutions from these two sectors. Contemporary universities and industry continue to follow very different paths in terms of structure (problem-driven vs. disciplinary), time horizons (short vs. long), and goals/values (profit vs. education and knowledge dissemination) (Fairweather, 1988). How have industry and universities increased cooperation in spite of persistent cultural differences? The answer to this apparent paradox lies in the development, deployment, and widespread adoption of a diverse collection of specialized organizational "bridges," what we will refer to as *industry-university (I/U) linkage mechanisms*. These structures including centers, labs, and institutes, have allowed universities and industry to meet each other half-way, at their organizational periphery,



in spite of persistent core cultural differences. These structures have been so successful that most of today's industry-sponsored academic research is performed through various I/U linkage mechanisms.

Unfortunately, while I/U linkage mechanisms have increased the amount of interaction between these two sectors, they haven't always changed the *way participants interact*. In truth, much of the work performed through these mechanisms looks a lot like traditional academic or industrial research. In some cases, faculty do their own thing, but with support from industry. In other cases, industry gets specific problems solved, but the work is done by faculty instead of employees or contractors. Such arrangements have fueled a variety of criticisms ranging from, they offer nothing new to one side or the other is being exploited (e.g., Brooks, 1993). These one-sided exchanges stand in stark contrast to the long-term, truly collaborative and mutually beneficial partnerships forged by the National Science Foundation's (NSF) Industry/University Cooperative Research Centers (I/UCRC) Program.

In I/UCRCs, instead of working on small-scale, narrowly defined disciplinary problems, faculty work on large problems which are *both* scientifically important and relevant to industry. Instead of developing projects based on their personal predilections, faculty develop projects based on a meaningful dialogue with industry. Instead of working solo, projects are carried out in multidisciplinary and often cross-sector teams. While open publication remains their primary objective, faculty recognize the economic and social value of their research and take responsibility for pro-

tecting and proactively transferring knowledge and technology to the private and governmental sectors. In these partnerships, the stereotype of the “ivory tower” professor is a distant memory.

The changes in industry involvement are equally dramatic. Instead of using the university as a convenient and cheap sub-contractor for solving short-term problems, firms make long-term commitments to universities to support fundamental research and also to team with other firms, often competitors, in these activities. While knowledge, technology transfer and commercialization are the primary industry objectives, student educational needs and publishing findings in a timely fashion are high priorities too.

In short, I/UCRC collaborations, and others which successfully imitate this model, are “win-win” partnerships that have strengthened the ability of our universities to conduct high-quality and relevant research and the ability of industry to compete globally.

Since industry’s support for basic and applied research and federal government support for civilian research are expected to decline over the next decade (Council on Competitiveness, 1996), the need for research cooperation is expected to grow. As a consequence, we believe there will be an even greater need for I/U partnerships in the future, particularly the “win-win” variety. Unfortunately, precious little attention has been devoted to understanding and explaining how to start, manage and sustain these new and complex industry/university organizational forms. The purpose of this book is to begin to fill this void.

In this chapter we describe the circumstances that have supported the growth of IU linkage mechanisms. We then describe the development, impact and principles behind a model, pioneered by the National Science Foundation’s Industry-University Cooperative Research Center (I/UCRC) program, for creating win-win partnerships.

## **Cooperative Research: An Historical Perspective**

Until relatively recently, relations between industry and university traditionally have been very strong in the US. A variety of factors including support of higher education by a pragmatically oriented state government (as opposed to federal), enlightened public policy like the Morrill Act of 1862 and the Hatch Act of 1887 (which created the land grant university system and the agricultural extension system, respectively), and integration of engineering training into mainstream universities all contributed to close, if informal and short-term, ties between universities and local industry up

till the 1940s (Gray et al., 1996). This changed in the 1950s and 1960s. Expanded federal support for university research after World War II, which emphasized training the next generation of professors, and disillusionment with industry and the military-industrial complex greatly weakened relations between industry and universities.

During the 1970s most of the forces that contributed to the decline in cooperation either abated or reversed themselves: federal support for research leveled off and then declined, the demand for graduate-trained scholars lessened, and bitterness toward the military-industrial complex began to fade. Thus, it was only natural that the level of cooperation and interaction would begin to rebound in the universities and departments (e.g., the land grants, engineering) that historically had strong ties to industry (Nelkin & Nelson, 1987).

However, the expansion in industry-university interaction witnessed over the past two decades is both quantitatively and qualitatively different from what preceded it. We would attribute this growth to two factors: competitiveness pressures which caused U.S. companies to pursue an innovation-based strategy for competing in the new global economy; and an emergent public policy that has attempted to aide and abet this strategy, in part, by trying to encourage and support research cooperation with universities. While discussing both of these developments in depth is beyond the scope of this chapter, a brief overview of government efforts is warranted.

### **Government Efforts**

Government policy toward industry-university cooperation has had two foci. The first has been a series of legislative reforms, including the Bayh-Dole Act, Stevenson-Wydler Act, and the National Cooperative Research Act, designed to remove a variety of institutional disincentives (e.g., patent rights and anti-trust penalties) to public-private partnerships in general and to industry-university partnerships in particular (Gray et al., 1996). The second, more interventionist thrust, promoted by both federal and state policy, encouraged more intense and meaningful cooperation by promoting the adoption and implementation of a variety of I/U linkage mechanisms (Coburn, 1995) such as the NSF I/UCRC program.

These efforts have proven very useful. The number of universities reporting they receive 10 percent or more of their funding from industry has doubled. In fact, increased support from industry accounts for most of the growth in academic research during this period (National Science Board, 1993). These efforts

have also resulted in a fundamental change in the way industry supports universities. Increasingly, firms are bypassing traditional mechanisms (e.g., contracts, gifts) and providing support through I/U linkage mechanisms.

### **Industry-University Linkage Mechanisms**

*“Among the most interesting changes in American colleges and universities over the past quarter of a century is the rather prolific growth of institutes, centers, laboratories, bureaus, and other research and service units that parallel the conventional departmental structure. No easy description of these additions to the academic landscape is possible. They carry out a bewildering variety of purposes, use many different organizational models, are supported at widely disparate levels of investment, are sometimes housed in the obscure corners of the campus, and are found at all levels of the organizational hierarchy.”—Ikenberry, 1973*

What is an I/U linkage mechanism? An I/U linkage mechanism is an organizational structure (e.g., department, unit) designed to house and support transactions between industry and university. In the organizational literature, this relatively specialized organizational form is referred to as a boundary-spanning structure (Aldrich, 1977). Boundary-spanning structures can be as simple as a role (e.g., liaison to an outside organization) or as complex as an organization with its own structure, goals, and strategy.

I/U linkage mechanisms are relatively complex boundary-spanning structures because they must link dissimilar institutions and buffer conflict or friction. They achieve this, in part, by adopting features which represent a compromise between corporate and academic norms. For instance, staffing is usually multidisciplinary but not industry matrix-level. These compromises allow I/U linkage mechanisms to handle large-scale, multidisciplinary, applied, task-related projects which could never be handled through an academic department (Freidman and Freidman, 1986). At the same time, I/U linkage mechanisms can be a catalyst for incremental change in core structures like departments.

Universities have been interacting with outside institutions, including the government, via linkage mechanisms like research institutes since before W.W.II (Kidd, 1959). According to Baba (1988), at least 28 different industry-university linkage mechanisms have evolved since the early 1900s. Some of the most prominent research linkage mechanisms are described in Figure 1-1.

However, the popularity of these structures in recent years has been nothing short of phenomenal. According to Cohen, Florida

<b>Figure 1-1</b>		Research linkage mechanisms.		
<b>Linkage Mechanism</b>	<b>Innovation Stage</b>	<b>Participants*</b>	<b>Scope</b>	<b>Impact</b>
Industrial Affiliates	Research and Development	I: Large firms U: Research universities F: Regular faculty G: Minor to no role	Suffering from major decline; replaced by I/UCRCs	Minor
Applied Research Institutes	Development to Applied Engineering	I: Large Firms U: Research Universities F: Full-time staff and faculty G: Joint sponsor of some institutions	Widely used; small to very large budget	Conduct a significant amount of applied research
Firm-sponsored laboratory	Research	I: Large R&D intensive; biotechnology U: Private universities F: Regular faculty G: No involvement	Very limited; large budgets; received great deal of publicity	Not clear
IU Cooperative Research Centers	Research to Development	I: Large R&D intensive firms U: Research universities F: Regular faculty G: Major federal role; state participation	Widely used mechanism; budgets average about \$1 M per site	Data on I/UCRC demonstrate effectiveness in transferring knowledge and technology; education benefits

*continued*

Figure 1-1 Research linkage mechanisms (continued).				
Linkage Mechanism	Innovation Stage	Participants*	Scope	Impact
I-U Projects	Development to Applied Engineering	I: Large and small firms U: Diverse group F: Regular faculty G: Primarily state	Widely used; small budgets	Focuses collaboration on downstream knowledge and technology transfer
Small Business Technology Transfer	Research to Development	I: Small firms; U: Open to all but research universities dominate F: Regular faculty G: State and federal support	Widely used by states; small budgets	Focuses collaboration on downstream knowledge and technology transfer
Industrial Associations and Consortia	Research to Development	I: Diverse; Agriculture U: Diverse F: Regular G: Little or none	Widely used; unknown	Unknown; expect similar to CRC
Research Parks	Commercialization	I: Diverse; U: Research universities F: Regular G: State	Widely used, > 100	Positive interactions; economic development unknown

\*I = Industry; U = University; F = Faculty; G = Government

& Goe (1994), there were over 1,000 I/U research linkage mechanisms in the US in 1990 with total expenditures of \$4.12 billion, approximately \$2.53 billion of it for R&D<sup>1</sup>. This represents almost 15 percent of university research expenditures. Industry's share of these costs (\$779 million) represents an astounding 69 percent of all industrial support for academic research and development! In other words, I/U linkage mechanisms have become the primary vehicle for industrial support of academic research. However, in spite of their popularity, it would be a mistake to believe that this diverse collection of I/U linkage mechanisms is the cure for all that ails I/U relations.

### **Effects of Linkage Mechanisms**

Cohen, Florida and Goe (1994) found huge differences within the sample of linkage mechanisms they studied on a variety of performance measures. Some did very well on publications or technology transfer or down-stream commercialization while others fared poorly. While they didn't have much luck identifying the source of these variations, we believe these differences are due to two factors they didn't examine: organizational form and management.

Since each type of I/U linkage mechanism is a slightly different organizational form, some types will be better suited than others for performing certain kinds of research and achieving certain goals. Consistent with this premise, our own research has demonstrated that I/U projects, typified by a bench-level collaboration between an industrial and university investigator on a specific project, are much more likely to result in research targeted at patent and product development than I/U centers (Gray, et al., 1986). Similarly, there is a broad consensus that the industrial affiliates model, providing early access to faculty findings for an annual fee, usually results in very traditional academic research, and the research institutes model, typified by individually funded projects performed by a team of investigators, usually results in relatively applied and short-term projects.

At the same time, how a linkage mechanism is managed will also affect performance. Consistent with this view, one industrial observer estimates that only four percent of university-based

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<sup>1</sup>Cohen and Florida use the term center in this report. However, they define a university-industry center as including university-affiliated research centers, institutes, laboratories, facilities, stations or other organizations. In order to avoid confusion with the centers discussed in this report, we will use the term "linkage mechanisms" to describe the general class.

centers actually exceeded corporate expectations (Hesselberth, 1991).

Not surprisingly, these principles reflect the standard organizational axiom: “do the right thing” and then “do things right.” In other words, decisions about which specific I/U linkage mechanism one chooses (e.g., affiliate, institute, center) and how well one manages that form will influence the kinds of outcomes one will attain.

But what constitutes the “right thing,” if you’re interested in creating win-win research partnerships between industry and university? We answer that question in the next section by describing the development and outcomes of the NSF I/UCRC program. We turn our attention to “doing things right” in the remainder of this volume.

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## **I/UCRC PROGRAM AND MODEL: A BRIEF HISTORY OF THE I/UCRC PROGRAM**

The Industry-University Cooperative Research Centers Program began as part of the Experimental R&D Incentives Program (ERDIP) initiated by the National Science Foundation during the early 1970s. The ERDIP was a time-limited, experimental program to test the viability of different R&D initiatives. It included four public sector-oriented components: the Cooperative Research and Development Experiment (which evolved into the Industry-University Cooperative Research Centers Program), the Laboratory Validation Assistance Experiment, the Innovation Centers Experiment, and the Medical Instrumentation Experiment (Colton, 1982). These four programs were supposed to increase non-federal investment in R&D, and increase the rate of adoption of the results of science and technology in the private sector.

During the one-year planning phase of the Cooperative Research and Development Experiment 14 grant recipients defined and proposed different cooperative models and sought industrial support. During the four-year second phase, three models of cooperative research were implemented and evaluated: an R&D extension model which emphasized low technology operational problems (Furniture Applications Institute at North Carolina State University); a model using a third-party broker between industries and universities (the New England Energy Development Systems, run by Mitre Corporation); and a university-based research consortium (MIT Industry Polymer Processing Center). An independent evaluation concluded that while each model showed

technical achievement, only the MIT Industry Polymer Processing Center demonstrated an ability to attract sustained industrial support and proved to be a profitable approach, both scientifically and administratively (Burger, 1982).

In spite of these findings, not everyone was convinced of the value of the so-called "MIT model." Mirroring these sentiments Baer (1980) concluded, "A principal question is estimating how many successful university-based centers can be created on the MIT model. Professor Suh's success at MIT may be so unique that few individuals and institutions can emulate it without descending into research mediocrity and administrative nightmares" (pp. 19-20). In essence, Baer was questioning the generalizability of what has become known as the "I/UCRC model." Was the Polymer Processing Center's success the product of good timing and effective local leadership or had NSF identified a model, a social technology if you will, that was broadly replicable?

## **Contemporary Development**

The I/UCRC Program began in earnest around 1980. Since then it has become one of the country's largest cooperative research programs cited as an administrative, scientific, and technological success (Hesselberth, 1991; Illman, 1994).

By 1997, the I/UCRC program included 55 cooperative research centers encompassing over 80 universities; 700 member firms; over 800 faculty; almost 800 graduate and over 250 undergraduate students; and a budget of over \$75 million. Center technologies run the gamut from advanced telecommunications to steel processing. Approximately 70 percent of the centers are still operating after 17 years.

More importantly, the I/UCRC program has resulted in a win-win partnership for university and industry. One indication of this is the fact that 90 percent of industrial representatives and faculty report they are satisfied with their involvement. I/UCRC evaluations over the past dozen years, provides additional support for these assertions (see Figure 1-2). In brief, they demonstrate that faculty receive substantial research support and conduct industrially relevant fundamental research, report higher levels of interaction with other faculty, and continue to publish at a high rate. Students rate their educational experience higher, continue to enjoy academic freedom, and receive more job offers than their departmental peers. Industry reports leveraging their research investment 30-to-1 in a given center, recruiting talented students,

**Figure 1-2** Indicators of success for the I/UCRC program (as of FY 1997).**Administrative and Financial**

- 55 I/UCRCs in operation at end of FY1996; 60 percent of these five years or older
- Approximately 75 percent of I/UCRCs funded over the past 17 years are still in operation
- Total effective I/UCRC Program budget is \$75 million
- I/UCR centers average \$1.1 million in direct funding per year
- NSF provides less than 7 percent (\$4.1 million) of the funding received by I/UCRCs

**Generalizability of the Model**

- Diverse technological areas
- Implemented by small and medium-sized universities and a variety of academic departments
- I/UCRC models are operating successfully in Europe

**Impact of Model**

- Over 80 universities involved in I/UCRCs
- Over 800 faculty and 800 graduate students and 250 undergraduate students are actively involved in conducting research within I/UCRCs
- Over 700 industrial memberships held in I/UCRCs

**Scientific**

- On average, faculty member publishes three papers and two journal articles per year based on I/UCRC research
- On average, faculty member supervises one dissertation to completion per year
- Faculty awards from academic and professional associations

**Student**

- I/UCRC students rate their educational experience more highly than departmental peers (Scott and Schaad, 1991)
- I/UCRC students perceive as much academic freedom as their departmental peers (Gidley, 1989)
- I/UCRC students report more job offers than their departmental peers (Scott and Schaad, 1991)

**Technological**

- Average center produces at least one disclosure and patent per year
- Annual follow-on research averages \$170,000 per firm, \$2 million per center, and \$100 million for the program
- Over 70 percent of members report a knowledge or technology transfer success; 79 percent of these report transfer resulted in technical advances or development (Scott and Schaad, 1994)
- I/UCRC research has resulted in the development of number of significant commercial products and processes developed

Note: Unless noted otherwise the source for these findings include: Gray, D.O. and Lindblad, M. (1997). *NSF Industry-University Cooperative Research Centers: Structural Information 1995-96*. Raleigh, N.C.: North Carolina State University; Gray, D.O. and Lindblad, M. (1997). *NSF Industry-University Cooperative Research Centers: Process-Outcome Results 1996*. Raleigh, N.C.: North Carolina State University. Gray, D.O. and Lindblad, M. (1997). *NSF Industry-University Cooperative Research Centers: Memberships and Milestones 1995-96*. North Carolina State University; Gray, D.O. and Lindblad, M. (1997).

making new internal research investments of over \$170,000 per firm per year, and achieving high levels of technology transfer.

Examples of I/UCRC faculty achievements and awards and some of the commercially successful developments which have come from their research are described in Figure 1-3 and Figure 1-4, respectively. Not surprisingly, given these findings, the I/UCRC program has provided the basis for designing a number of other programs including NSF's Engineering Research Centers and State-I/UCRC programs and a variety of state university-based centers of excellence.

Remarkably, this growth and success has required only a modest amount of federal funding. While the NSF I/UCRC Program budget has increased from \$1 million to \$4 million since 1980, funding per center has actually declined from approximately \$250,000 per year to \$50,000 per year. NSF provides only seven percent of the program's budget, with industry (45 percent), state (13 percent), other federal sources (28 percent) and the balance university (8 percent).

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## I/UCRC FORMULA FOR SUCCESS

What accounts for the high and widespread success achieved by the NSF I/UCRC Program? In our view, its success can be attributed to three program components: the "I/UCRC model," the organizational form which has been refined and elaborated to the point it represents a reliable "social technology"; the screening and selection process used by NSF; and financial and technical support provided through a multi-year grant.

### I/UCRC Model

The I/UCRC model is a complex hybrid organizational form which incorporates features found in three other I/U linkage mechanisms: organized research units, industrial affiliates, and R&D consortia (see Figure 1-5).

At a fundamental level, an I/UCRC is an **organized research unit**. That is a semi-autonomous research unit which exists within the university independent from academic departments (Friedman & Friedman, 1986). As such it is better equipped than an academic department to draw faculty from across departmental boundaries, provide norms and incentives which encourage multidisciplinary and problem-driven research and manage large multi-task projects for its sponsors.

**Figure 1-3** I/UCRC faculty and student awards and achievements.

National Medal for Technology  
 IEEE Prize, Best Paper (twice)  
 Recipient, NSF Career Development Award (twice)  
 Basic Energy Sciences Award, Sandia National Laboratory  
 American Chemical Society's Ralph K. Iler Award (twice)  
 Lockheed Martin Nova Corporate Award for Technical Excellence  
 Student Awards, Mentor Graphics/Sun VLSI Design Contest  
 Student Award, SPE Polymer Modifiers and Additives Division Scholarship  
 Finalist, American Chemical Society Sherwin Williams Award  
 Boulder Faculty Award for Excellence in Research and Faculty  
 Silver Medal, Technology Transfer Society  
 IEEE Circuits and Systems Society, Darlington Award  
 IEEE Presidential Faculty Fellow  
 American Control Conference, Best Paper

**Figure 1-4** I/UCRC commercial success stories.**Plastics Recycling**

A plastics recycling research center developed a large-scale (5 million pounds per year) pilot plant for recycling plastic bottles for 21 licensees. One licensee invested \$10 million in a 60,000 square foot recycling plant that processes 40 million pounds per year of reclaimed plastics from the northeastern US.

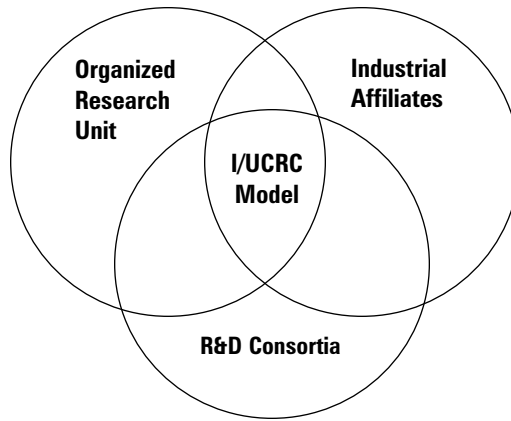
**Better Fit for US-Made Autos**

An I/UCRC developed a dimensional measurement methodology that allowed Chrysler Corporation's Jeep Grand Cherokee plant to reduce the dimensional tolerance in the assembly of automobile body panels from 5mm to 2mm. This standard tolerance improvement makes Chrysler a world-class competitor against foreign automobile manufacturers.

**Improved Handling of Materials**

A manufacturer decentralized sourcing for components across a number of plants in a large metropolitan area. The result was a high rate of between-plant transport, large inventories, and an uncertain supply of parts. Using technology developed at an I/UCRC devoted to material handling research, the company modified its material configuration. It reported that the changes reduced the work-in process inventory by \$100 million, reduced personnel costs associated with materials handling by \$3 million, and saved an additional \$10 million per year in carrying costs.

Note: These cases are included in the 1993 NSF I/UCRC Program brochure.

**Figure 1-5** A hybrid form of IU linkage: The I/UCRC model.

Because it involves collective support by a number of firms, as opposed to one-on-one support, an I/UCRC incorporates features found in the **industrial affiliates** model. Consistent with the affiliates approach, the collective format ensures that the center will focus on research that is of interest to multiple firms or a whole industry and thus be generic and precompetitive in nature. However, in contrast to the affiliates approach, the I/UCRC model provides a strong and prominent role for industry in all aspects of center management and thus draws heavily on an industrial linkage form, the **R&D consortia** (Davis, 1985). Since government often supports Centers, the prominent role given to industry ensures that the center will run based on “technology pull” (industry’s needs) rather than “technology push” (government’s perception of industry’s needs) principles.

### **The I/UCRC Model as Social Technology**

While it’s clear that the I/UCRC model is a complex hybrid organizational form, we think it’s more than that. We believe it represents an effective social technology.

Although it might come as a surprise to most engineers and scientists, innovation scholars have long accepted the existence of “social,” “organizational,” “administrative,” or “programmatic” technologies (Rogers, 1983). In order for something to be considered a social technology it should meet three criteria: a replicable set of structures, procedures, roles, behavior patterns; knowledge-

based; and demonstrable and replicable effects (Tornatzky and Fleischer, 1990).

The I/UCRC model meets these standards. The model is supported by a body of theory and research (e.g., Aldrich, 1977; Cummings, 1984). It has a replicable set of structures, procedures, roles, and practices for linking industry and university research needs and activities. More important, the effect of these procedures (e.g., focus on industrially-relevant fundamental research, education and technology transfer benefits) has been demonstrated over and over again in a wide variety of settings and circumstances. As a consequence, we would argue that the I/UCRC model can and should be viewed as more than a promising idea, it should be considered a proven, reliable social technology for creating win-win partnerships.

While a detailed description of the practices which constitute this social technology is beyond the scope of this chapter, some of the “core” features include (1) an organizational structure; (2) a membership agreement or bylaws; (3) a set of standard procedures related to periodic meetings, project selection, and other issues.

### **Building a Foundation: NSF’s Role**

While this volume will focus on describing the generic I/UCRC model and how to make it work with or without the assistance of a government sponsor like NSF, it’s important to recognize the valuable role NSF has played in the centers it has sponsored. As any student of the innovation literature will tell you: “Build a better mouse trap and sometimes people will beat a path to your door.” The fact of the matter is many superior technologies, social and otherwise, fail to achieve their intended effect. Remember beta format VCRs? Failure is usually related to two factors: how the technology is disseminated to potential users and the manner in which it is implemented (Tornatsky and Fleischer, 1990). In the NSF I/UCRC program, the model’s dissemination is enhanced by a screening and selection process and its implementation is supported by a financial and technical support system. These factors have also contributed to the program’s success.

### **Screening and Review: Providing the Right Ingredients**

NSF plays an important role in the creation and success of I/UCRCs by screening and reviewing center proposals. Five year center operating grants are awarded based on a peer review process which focuses on knowledge of the I/UCRC model, scientific merit

emphasizing multidisciplinary, leadership, industrial support, institutional support, marketing strategy and research strategy.

### **The Operating Grant Award: Empowering Success**

The NSF I/UCRC operating grant also contributes to the success of the I/UCRC centers. While the direct financial support provided through this award is minimal, it provides prestige associated with NSF and technical assistance in establishing and operating centers.

**Financial support.** It's difficult to argue that this modest amount of funding contributes substantially to the program's success. However, two incidental benefits may accrue from this situation. The program appears to attract only applicants who are highly motivated and entrepreneurial in orientation. It also reinforces a "customer orientation" (e.g., industry) among centers. Nonetheless, funding to plan a center and some cost-sharing undoubtedly reduces some of the risk involved in starting a new center.

**Prestige.** The NSF is the primary source of funding for academic science and engineering research within the US. It has a well respected system of peer review. It is held in high regard by both academic and industrial scientists. As a consequence, considerable prestige is associated with receiving support from NSF so its centers win approval and respect within their institutions. NSF opens doors to potential I/UCRC industrial sponsors. The growing reputation of the I/UCRC program has also helped in this arena.

**Technical assistance.** The I/UCRC model has evolved with help from NSF staff who took an active role in helping Center Directors figure out how to manage the uncertainties and problems inherent in running a center. As centers had their successes and failures, NSF staff communicated and reinforced the principles and practices imbedded in these experiences with new Center Directors. This process was enhanced and amplified by the "feedback-based continuous improvement" approach to evaluation used throughout the program (See Chapter 8). This continues to this day and has certainly contributed to the program's enviable success rate.

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## **SUMMARY**

Over the last 40 years, I/U linkage mechanisms have evolved from a novel organizational strategy to bridge the gap between indus-

trial and university participants to the dominant mechanism for industrial support of university research. Their proliferation, in fact routinization, on our college campuses may represent the most significant change to the way research universities operate over the past half century.

Cuts in federal R&D, industry's need for fundamental research no longer done in-house, and the university's need for financial support will almost certainly dictate expanded use of these intermediary organizations. However, neither industry nor university nor government can afford to invest time and energy in partnerships which don't deliver or are consistently one-sided. The I/UCRC model, social technology developed and championed over the past 20 years, offers hope in this regard.

While there are certainly a number of profitable mechanisms for industry and university to work together, the I/UCRC Program has established an enviable and long-standing track record of producing win-win partnerships. The results speak for themselves: a manageable model which generalizes across a wide spectrum of industries, universities, and academic departments; a powerful leveraging vehicle for federal and industrial sponsors; financial, scientific, technical and social benefits for universities, their faculty and students, and industry.

A number of programmatic ingredients have contributed to these results, including: a screening and selection process which insures that the proper factors for a successful center are present; an operating grant which helps reduce some of the financial risk involved in starting a center and provides prestige; and most importantly, a highly evolved "I/UCRC model" that has proven to be an effective and robust social technology—"the right thing" if you will.

Up until now, a system of informal and intermittent technical assistance offered by NSF, its network of directors and evaluators has helped participants "do things right." Unfortunately, because I/UCRCs are complex boundary-spanning structures, this ad hoc approach hasn't always been adequate to meet the needs of current and would-be I/UCRC directors, industry sponsors, and the federal and state program managers who would like to help universities and firms emulate the I/UCRC program's success. To meet their needs, we will attempt to document some of the research and experience-based know-how represented in the "I/UCRC model" in this book. This will involve coverage of a variety of topics including: planning and initiating a new center (Chapter 2), organizational structure (Chapter 3), membership (Chapter 4), planning the cooperative research program (Chapter 5), imple-

menting the cooperative research program (Chapter 6), communications (Chapter 7), control, budgeting and evaluation (Chapter 8), knowledge and technology transfer (Chapter 9), leadership (Chapter 10), growth and diversification (Chapter 11).

In closing, it's important to point out that *there is no perfect way to implement the I/UCRC model*. An effective social technology is usually comprised of a small number of essential or "core" principles and a variety of features which can and probably should be handled differently based on local circumstances. As a consequence, each chapter included in this volume includes an overview of the topic under discussion which emphasizes general concepts, principles and contingencies for action, followed by specific strategies, practices, sample forms etc. Our assumption is a reader who knows why a strategy works can improvise when his or her circumstances are atypical. We hope the combination of both perspectives will meet the needs of directors looking for "best practices," while encouraging the kind of experience-based experimentation which has contributed to the development and refinement of the I/UCRC model.

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