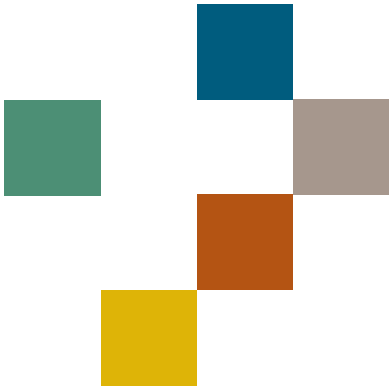
Industry/University Cooperative Research Centers Program



Industry/University Cooperative Research Centers: Model Partnerships

The National Science Foundation's (NSF's) Industry/University Cooperative Research Centers (I/UCRC) program is effecting positive change in the performance capacity of the U.S. industrial enterprise. Over the past two decades, the I/UCRCs have led the way to a new era of partnership between universities and industry, featuring high-quality, industrially relevant fundamental research, strong industrial support of and collaboration in research and education, and direct transfer of university-developed ideas, research results, and technology to U.S. industry to improve its competitive posture in world markets. Through innovative education of talented graduate and undergraduate students, the I/UCRCs are providing the next generation of scientists and engineers with a broad, industrially oriented perspective on engineering research and practice.

With industrial and other support totaling 10 to 15 times the NSF investment, I/UCRCs are a premier example of "leveraged" funding—a model for the Federal Government for how to cost-effectively synergize the nation's research and development process. Indeed, this model has directly influenced several other Centers programs established subsequently by NSF and other Federal agencies. Placed in this context, the I/UCRC program is a distinctive driver of the growing NSF-industry-university partnership.

The I/UCRC Program

There are more than 50 I/UCRCs, all administered by the Engineering Education and Centers Division of NSF's Engineering Directorate. More than 750 faculty researchers, along with some 750 graduate students and 200 undergraduate students, carry out the research at these Centers, which encompass almost the entire spectrum of current technological fields. A primary purpose of the I/UCRC program is providing high-quality interdisciplinary education. Over the past 30 years, the Centers have produced several thousand M.S. and Ph.D. graduates, who can be found throughout American industry and academe.

NSF supports the Centers through a cooperative leveraging mechanism. NSF's financial contribution to the Centers is relatively small—about $5.2 million in FY 2000, as compared to funding from other sources that totaled more than $68 million in FY 2000. Currently, the Centers have over 700 partners. Of these, about 90 percent are industrial firms; the remaining 10 percent include state governments, National Laboratories, and other Federal agencies. In addition, the majority of the universities provide direct and/or indirect support, such as cost sharing, for their Centers. These Centers are truly cooperative.

Switching to a New Technology in Telecommunications

Telephone providers use specialized switches to route calls across town or around the world. An important issue in telecommunications is Quality of Service (QoS) — that is, how do you allocate sufficient bandwidth to handle the ever-increasing volume of traffic without bringing about degradation of service quality? In 1997, a professor at a communications-oriented I/UCRC started a company to design a switch from scratch, applying his algorithms for maximizing QoS. Three years later his company was purchased for $450 million. Today, this center spinoff employs 35 people and is still growing.

How Does It Work?

An I/UCRC often begins with a small planning grant to a university professor who seems to exhibit the scientific, organizational, and entrepreneurial skills necessary to form a team and initiate and run a successful Center. If the prospective Center can obtain commitments of strong support from industry and the affiliated university or universities, it may submit a proposal to NSF describing the progress that has been made and documenting the team's potential to operate successfully as an I/UCRC. Two or more universities may also jointly propose a multi-university Center. Following successful merit review of the proposal, NSF may make an initial five-year I/UCRC award of $70,000 annually to the Center team. When the initial five-year grant expires, NSF funding may be extended at a reduced level of $35,000 annually for an additional five years. In its final year of I/UCRC program support, a Center may compete for a new I/UCRC award based on a proposed research and education program involving significantly new intellectual substance.

NSF's investment in the I/UCRCs is intended to seed partnered approaches to new or emerging research areas, not to sustain the Centers indefinitely. The Foundation intends for I/UCRCs gradually to become fully supported by university, industry, state, and/or other non-NSF sponsors. Each I/UCRC is expected to maintain at least $300,000 of industrial support through membership fees, at least six industrial members, and a plan to work toward self-sufficiency from NSF.

In addition to the basic I/UCRC award, Centers and Center researchers can compete for other NSF support for research and education projects. At any point—even at the end of its life cycle—NSF may provide funding to the Center under special arrangements involving joint participation by other NSF program offices. NSF supplemental support may include collateral programs such as a TIE project, whereby two or

High-Performance Buildings

One I/UCRC has developed award-winning "Guidelines for High-Performance Buildings" that permit significantly reduced energy and environmental impact in building construction and operation (by a factor of five compared to best current-day practices) while at the same time dramatically improving indoor environmental quality (air quality, thermal quality, visual quality, acoustic quality and spatial/ergonomic quality), also by a factor of five or more. These guidelines have been applied, with the active participation of the Center as systems integrator, in many government and commercial building projects around the world, including not only the United States but also buildings in Korea, Germany, France, and China. The work has proved that the supposed dilemma between saving energy on the one hand and improving environmental quality on the other is not an either/or choice.

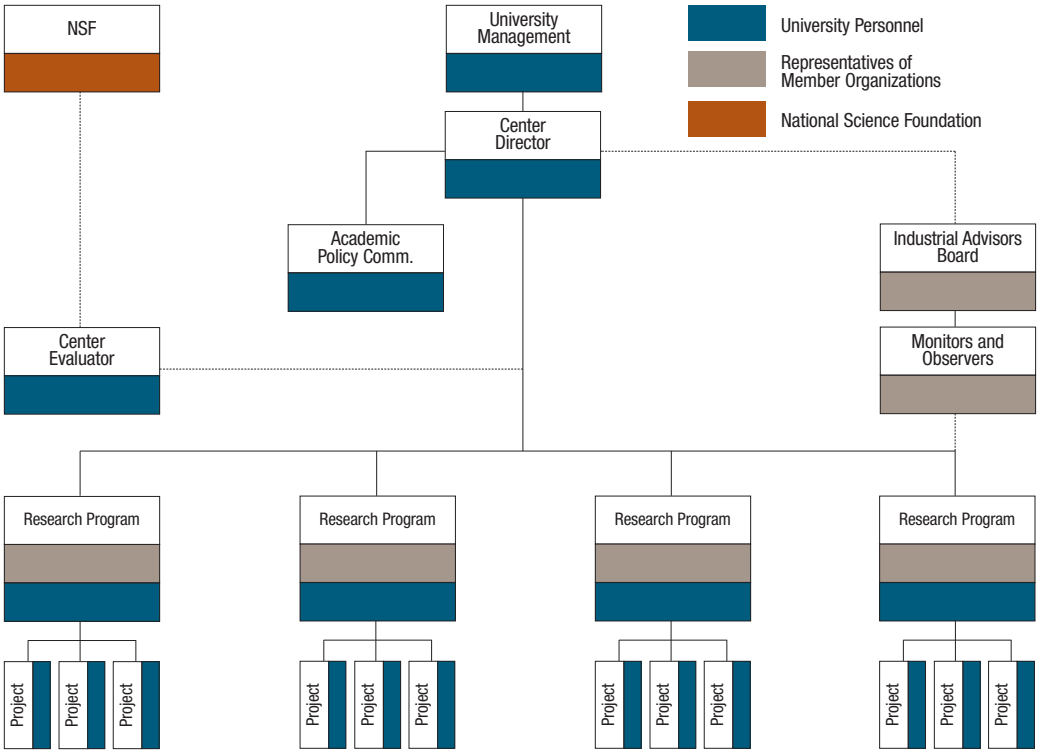


Figure 1. Organizational Chart of a Typical I/UCRC

More Efficient Electric Power Systems

A Center focused on solving problems facing the electric power industry is contributing in many ways to improving the ability of power system operators to more efficiently assess, manage, and control the distribution of electric power. For example, Center researchers are developing improved graphical interfaces for visualization of current power system conditions, that allow operators to better identify, anticipate, and respond to conditions that could affect supply reliability. Researchers have identified key economic and technical issues associated with industry deregulation and have proposed solutions including the pricing of services and detection of market conditions. Using experimental economics, they have provided insights into market behavior under various generation auction and price-setting rules, and have presented the results of these studies to operators and state committees in California, New York, and elsewhere. Center researchers have made recommendations to the Department of Energy about the Federal role in mitigating future power system failures.

more Centers and their industrial members engage in a cooperative research project of interest to all parties (with NSF and industry sharing costs). Through programs such as Grant Opportunities for Academic Liaison with Industry (GOALI), fellowships are offered to Center faculty, whereby the faculty member can spend time in a corporate research lab or factory, again with NSF sharing the cost. Other supplements to I/UCRC awards may be made in the form of joint sponsorship of projects with other federal agencies, Research Experiences for Undergraduates (REU) and other educational activities, workshops, and other purposes consistent with the goals of the program.

The structure of a typical I/UCRC is illustrated in Figure 1. The **Center Director** reports to **university management**—in most cases, directly to the Dean of Engineering. An **Academic Policy Committee** composed of the deans of engineering and science and other top university officials such as the provost and vice president for research is available to address important policy issues such as patents and licensing, promotion, and tenure. The various **research programs** usually consist of several **projects** with a coherent focus on an industrial interest; they are pursued by graduate students under the direction of faculty researchers.

Across the program, these centers have established an extraordinarily effective partnership with industry. This partnership takes full advantage of the strength of each participant. University faculty contribute their skills in research and their understanding of the knowledge base; industrial researchers contribute their knowledge of both the technical needs of industry and the challenges associated with competing successfully in the marketplace. The partnership is formalized in each Center's **Industrial Advisory Board** (IAB), which advises the Center's management on all aspects of the Center, from research project selection and evaluation to strategic planning. It is important to note that all IAB members have common ownership of the *entire* I/UCRC research portfolio; however, individual firms can provide additional support for specific "enhancement" projects.

The partnership is given even greater depth through the direct involvement of industry representatives in research projects. Each project in the Center has a **principal researcher** (typically the project's research professor) and in many cases also has a **monitor** from industry (who may be an IAB representative or an engineer assigned from an IAB member company). The principal researcher maintains close oversight of the progress of the research by the student(s) and briefs the industrial monitor on a regular basis. The monitor can, and often does, have direct input into the direction of the research.

This extensive industrial involvement in research planning and review leads to direct technology transfer, bridging the gap that tradi-

Advanced Driving Simulator

One I/UCRC has created real-time mechanical system simulation methods and software that form the foundation for a National Advanced Driving Simulator (NADS) being developed by the U.S. Department of Transportation. This world-class $55 million facility will be operated by the Center's host university to support initiatives in U.S. highway safety research, carried out by both the Federal Government and industry. The NADS represents a quantum jump in research capability, offering simulation in which the driver interacts with the vehicle's controls, views an ultra-realistic scene, and experiences realistic sounds and feelings of motion. The NADS simulator provides the basis for a new era in highway safety research.

tionally has kept U.S. industry from capitalizing fully and quickly on the fruits of research at American universities. The close involvement of industry in the Centers also eliminates the perennial problem of "Not Invented Here"; in the cooperative research model, all Center-developed research products are owned by all the members.

The participation of **NSF**, although small financially, nevertheless sets the tone for the I/UCRCs. Strong program management ensures that each of the Centers continues to follow the I/UCRC model—each in its individual fashion—and that each remains strong. With such extensive industrial support and participation, NSF's role is crucial in influencing industry to take a longer-term view of its needs, with appropriate attention to research quality. This ensures that the fundamental research conducted in the Centers continues to add to the knowledge base that will be vital for solving the problems and meeting the needs of the future. NSF also helps to ensure high standards among the I/UCRCs through a mechanism that is unique to this program: Independent professional **Evaluators** are engaged to study the industry-university interaction onsite, both qualitatively and quantitatively, to determine the quality and impact of Center research, the satisfaction level of faculty who participate in the program, and the degree of satisfaction of industrial participants. A historical profile of each Center is maintained; and annual assessments are conducted of Center processes and results, finances, and structural issues. One indication of the high quality of I/UCRC research is that faculty publish their work in the most prestigious journals. I/UCRC faculty as well as students regularly win awards from the professional societies for their innovative research.

Better Materials for Micromechanical Structures

First developed at an I/UCRC in the 1980s, surface micromachining has been adopted worldwide as a way to produce micromechanical structures for integrated electrical and mechanical systems (MEMS). Before now, polycrystalline silicon has been the material most frequently used to build mechanical parts. But recent research at the I/UCRC has shown the advantages of using chemical vapor-deposited films made with both silicon and germanium, to produce poly Si/Ge. One advantage is that the structures can be fabricated at lower temperatures, after the conventional electronic processing of integrated circuits is completed. Using this "electronics-first" approach to building fully integrated MEMS permits the use of integrated-circuit foundries to produce microelectronics with high performance at low cost. This development is expected to have far-reaching significance in the MEMS arena.

Measures of Success

Perhaps the strongest indication of the value of these Centers to industry is the continued and growing participation of industry, even during periods of economic fluctuation. While industrial in-house research and development (R&D) continues to decline nationally, another indicator of the positive impact the I/UCRCs are having is the R&D activity they spark among their members. In FY 2000, I/UCRC research resulted in at least $75 million in "follow-on" R&D funding investments by member firms. The total industrial R&D investment attributable to the I/UCRCs in FY 2000 came to almost $100 million. This "new money" investment by I/UCRC members may be the most tangible evidence that successful transfer of knowledge and ideas is occurring. The follow-on investment by companies demonstrates that they derive something from the I/UCRCs that they believe merits further development and commercialization.

The program's long record of success in this arena is recognized not only by its members. In 1998 the Technology Transfer Society of America, a national organization of public and private-sector technology transfer professionals, bestowed on NSF's I/UCRC program its Justin Morrill award. This award is given annually to an organization that has an "exemplary record of transfer of technology and also has made outstanding contributions to the theory and practices of technology transfer that are widely used by others."

From the standpoint of member companies, one of the outstanding benefits of participation in an I/UCRC is the opportunity to work with graduate students who are being exposed to industrial needs and practices and who have learned to pursue their research with a view toward improving the competitiveness of U.S. industry. Graduates of I/UCRCs represent for their employers an effective and long-lasting form of knowledge transfer.

To industry, it is *results* that count. Evaluator surveys show that industry is satisfied with the results of I/UCRC membership—not just in terms of new products and processes (as described in the accompanying fact sheets), but also in terms of access to the best new ideas and first-rate prospective employees. Their enthusiastic participation and support are the proof of their satisfaction.

Reliable Electronics for Hot Cars

As automobiles have become dependent on ever more complex electronics, reliable operation in the harsh under-the-hood environment has become a more pressing issue. One Center explores advanced materials and processes for the manufacture of reliable automotive electronics to meet this need. For example, investigators are seeking ways to improve the thermal-cycle reliability of Ball Grid Array (BGA) packages for engine controllers. The use of smaller BGA packages will decrease packaging costs while reducing the size of the controller. However, solder balls near the silicon die in small BGAs are prone to fatigue failure in thermal cycling. Center research has demonstrated a cost-effective solution: underfilling the BGAs with a silica-filled epoxy. This approach doubles BGA reliability with minimal additional manufacturing cost and cycle time. An automotive controller with small BGAs is planned for volume production in 2004.

Engineering Education and Centers Division
Directorate for Engineering
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230
(703) 292-8380 Phone
(703) 292-9051 Fax
(703) 292-5090 TDD
E-mail: eng-eec@nsf.gov