National Science Foundation Industry/University Cooperative Research Centers Program

30

YEARS OF PARTNERSHIP

30 Years of Partnership:

Past Successes and

New Challenges

in Cooperative Research

Welcome

I am delighted to welcome you today to this conference celebrating the thirtieth anniversary of the National Science Foundation's Industry/University Cooperative Research Centers (I/UCRC) Program. I note with pride that the I/UCRC Program is the oldest and largest multimember research partnership in the United States.

From Dr. Rita Colwell

Director, National Science Foundation

It is seldom that a federally funded program is a real pioneer and yet remains vigorous and innovative more than a generation later. With 45 current centers, 80 participating universities, and more than 600 industrial and other members, the I/UCRC Program continues to be recognized as a model for collaborative research and development between universities and industry, throughout the United States and around the world.

As a participant in this long-running and successful experiment, your involvement reflects the close cooperation between universities and industries that is at the heart of the program. We at NSF recognize and appreciate your commitment to help shape the Nation's industrial and academic future while providing opportunities to many young scholars, as they in turn acquire the knowledge and experience they will need to excel as practitioners and researchers. It is the enthusiastic integration of people such as yourself with the ideas, technologies, and facilities developed through the Centers that produces the special chemistry which the I/UCRC Program has always generated. The time and energy you contribute are indispensible to its success. Along with the I/UCRC Program staff, I wish to express my appreciation and that of NSF for your support for the Program.

I see no reason that we should not look forward to the fortieth anniversary of this strong partnership. May it continue to serve as a model for engaging the most productive forces of universities and industry in high-quality cooperative research that serves the Nation's needs.

Sincerely,

Rita Colwell

Rita Colwell
Director

I/UCRCs: A Model for Success

Founding Concepts and Principles

The National Science Foundation is a mission agency. In the early1970s, part of its mission became a drive to bring the nation's universities and industries closer together in order to stimulate innovation and spur our technological competitiveness. At that time the Foundation embarked on an innovative venture known as the Experimental R&D Incentives Program (ERDIP). The purpose of ERDIP was to test the viability of different ways to stimulate non-federal support of R&D and speed the transfer of resulting technology to industry.

A World-Class Driver Simulation Facility

The I/UCRC for Virtual Proving Ground Simulation, at the University of Iowa and the University of Texas at Austin, has developed a facility that pushes the envelope in high-speed mechanical system simulation, providing a revolutionary new capability to test vehicle designs using a super-realistic driver interface. The center's National Advanced Driving Simulator (NADS) facility, completed in 2002 at a cost of around $80M, is being used by companies like John Deere for "virtual prototyping" of new vehicle systems before they are built, as well as by agencies like the National Highway Traffic Safety Administration to conduct highway safety studies under precisely controlled and safe experimental conditions. NADS is the only driving simulator in the world in which such activities can be carried out in a full 360° wrap-around virtual environment.

One of these approaches was the Research and Development Incentives Program, under which several models of cooperative research were implemented and carefully evaluated. One model was a university-based research consortium at the Massachusetts Institute of Technology, the MIT-Industry Polymer Processing Center. At the end of the evaluation period, in 1978, only the MIT center had attracted sustained support from industry and allowed industry to have a voice in project selection. Thus, this university-based consortium model with Industrial Advisory Board input became the prototype for future NSF-funded industry-university centers. From it grew the Industry/University Cooperative Research Centers (I/UCRC) Program, which today is the longest-running centers program in the Foundation. Indeed, it is the only surviving element of the original ERDIP – a clear example of "survival of the fittest."

Today the I/UCRC Program is still quite fit, with 45 centers, 80 participating universities, and over 600 industrial and other member organizations. More than 700 faculty researchers, along with over 650 graduate students and about 200 undergraduate students, carry out the research at these centers, which encompass almost the entire spectrum of current technological fields. Over the past 30 years a total of **110** I/UCRCs have been formed. More than half of these have moved beyond their period of NSF support, however, many of these are still in existence as "self-sustaining" centers, a fact that attests to the soundness and strength of the I/UCRC organizational model.

Detecting Deceptive Communications

Working with the U.S. Air Force and two other universities, the Center for the Management of Information (CMI) at the University of Arizona is investigating how to detect deception in various communication modes and identify the types of information processing tools needed to improve homeland protection. A key goal is to develop hardware and software tools to screen electronic communications traffic and automatically flag potentially deceptive methods, using indicators of deceit incorporating text, voice, and visual cues.

Microgyroscopes for MEMS Inertial Sensing

The Berkeley Sensors and Actuators Center (BSAC), at UC-Berkeley and UC-Davis, focuses on microelectromechanical systems and devices (MEMS). They have developed microsensors, called microgyroscopes, that can precisely measure changes in the physical orientation and rotation of systems in which they are embedded. Using these research results, one of the industrial members of the center, Analog Devices, recently launched a new low-cost product line that will bring microgyro position and orientation detection and control to a broad spectrum of new applications ranging from vehicular monitoring and navigational systems to industrial control, to consumer devices and toys.

"Networkcentric" Warfare

Working with the U.S. Navy, the Center for the Management of Information (CMI) at the University of Arizona developed CommandNet, a collaborative logging tool designed to shorten the decision-making cycle and to increase situation awareness. Vice Admiral Herb Browne commented that "CMI's development of CommandNet for intelligence, C^4I response and operational situational awareness…showed the way to what the Navy deems 'NetworkCentric Warfare'."

It is a model that has since been emulated in several other NSF programs, such as the Engineering Research Centers, the State I/UCRCs, and the Science and Technology Centers, to name but a few. Other federal agencies, including NIH, NASA, and DoD, have built industry-university centers programs using key elements of I/UCRCs. Over the past 30 years a number of state governments – New Jersey, New York, Pennsylvania, Ohio, and others – have made industry-university centers a major component of their state technology development programs. Even other nations, such as Sweden and France, have studied the I/UCRCs and adopted the model for their own programs.

More Efficient Production Saves Money

The Industry/University Cooperative Research Center for Engineering Logistics and Distribution (CELDi), involving the University of Arkansas, the University of Oklahoma, the University of Louisville, and Oklahoma State University, has made research advances that improve production line performance in processing industries. These results are applicable to many processing industries and in most cases produce significant cost savings. For example, using these advances a food processing company (ConAgra) realized a productivity improvement of greater than 2%, resulting in an increase of 75,000 cases per year on two production lines and generating a savings of over $I million per year. In addition, through operational analysis studies, CELDi identified a significant improvement in sanitation procedures in this company, helping them reduce their environmental impact.

A Formula for Success

Why has the I/UCRC model proven so successful? There are a number of important reasons. One is an organizational form that has been refined over the years to the point where it serves as an effective "bridge" between the diverse cultures of industry and academe – a neutral meeting ground free of many of the restrictive traditions of both sectors, and one where otherwise competing companies can meet in a cooperative atmosphere. In I/UCRCs, faculty pursue large, fundamental problems that are at once scientifically relevant and important to industry. Projects are defined collaboratively and the work is done by multidisciplinary teams, sometimes including researchers from both academe and industry. Knowledge and technology generated by these efforts are transferred directly to the center's industrial partners. Thus, I/UCRCs are "win-win" partnerships that industry, over three decades, has consistently found to be worth the investment.

A second reason for their success is a rigorous screening and selection process, aided by stable NSF program leadership across 30 years. Government programs do not generally last for decades. Changes in priorities, politics, budgets, and administrations tend to limit their life-spans. Even when a program endures, the agency managers responsible for it normally change over time. Those responsible for its early development and growth tend to move on to new challenges (or retire), while new overseers arrive, bringing different perspectives and priorities to the continuing operation of the program.

The I/UCRC program runs counter to both these norms. Not only has the program operated continuously and successfully for 30 years; it has done so under the continuous stewardship of one man, Dr. Alex Schwarzkopf.

Improving Video Transmission Control

Real-time video represents enormous amounts of data that must be compressed for more efficient transmission. Research results from the North Carolina State University/Duke University I/UCRC for Advanced Computing and Communications (CACC) led to the development of breakthrough technology in the area of real-time video transmission recovery as well as in flow control for multimedia streaming, yielding as much as 40 times better data compression. The new technique has the unique capability to recover lost information at the data packet and higher levels, maintaining high picture quality for data transmission, including wireless transmission.

If the I/UCRC program has been a success, it is unarguably the success of Dr. Schwarzkopf. "Alex," as he is universally known, is at once the mentor and manager, friend and critic, sponsor and disciplinarian of all the many centers in the I/UCRC network and their leaders. His constant devotion to the success and vitality of the centers, individually and collectively, is legendary. His hands-on, straight-talking, positive style has won the respect and appreciation of two or even three generations of highly regarded academic researchers and administrators who have been influenced by their experience as I/UCRC directors and, in turn, have influenced the nation's technological strength through the work of their centers. It is an example of government service at its best.

This excellence is recognized by the National Science Foundation's top management, which in 2003 bestowed upon Dr. Schwarzkopf its Distinguished Service Award, one of only four such awards given throughout NSF that year.

WHO Guidelines on Water Quality

The University of Arizona's Water Quality Center developed a data set that is being used by the World Health Organization as the basis for national and international guidelines on heterotrophic plate count bacteria in utility and household delivery water lines.

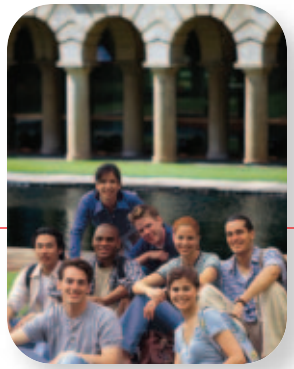
Simulation Tools for Nondestructive Evaluation

The Center for Nondestructive Evaluation, at Iowa State University, has developed novel tools for simulating the results of nondestructive evaluation (NDE) measurements. These simulation tools provide a basis for designing and evaluating improved NDE techniques without having to conduct expensive and time-consuming experiments and tests. One aerospace company has estimated that a particular ultrasonic application saved them $1 million in the first year alone. A consortium of three aircraft engine companies are using similar tools to design the ultrasonic probes used to inspect billet and forging material for defects. A fourth aircraft engine company is using an x-ray simulator in the screening of proposed inspection procedures. Eddy current simulators are being used by companies in a number of industries to evaluate the capabilities of a wide range of NDE techniques. A major oil company plans to use the simulators to ensure the integrity of welds in an offshore application.

Responding to the Blackout of 2003

Researchers from the thirteen-university Power Systems Engineering Research Center (PSERC) are supporting analysis of the Blackout of 2003. PSERC's Director at Cornell University is on leave to the U.S. Department of Energy's new Office of Electric Transmission and Distribution, where he is providing technical briefings and materials to investigators and helping establish priorities for the office, including research priorities. PSERC researchers, working through the Consortium for Electric Reliability Technology Solutions, are developing solutions to transmission reliability concerns and are assisting the U.S. DOE in the blackout investigation. Interviews with PSERC researchers have appeared in news media around the world. The center is providing resources to help people understand the blackout. For example, PSERC has created the "Blackout of 2003" web page, which has become a recognized portal to information about the blackout, ongoing investigations, and power systems in general.

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. Also important is the technical and financial support provided through a multi-year grant and a network of professional evaluators, one of whom is assigned to each center. The financial support by NSF is not large, but it conveys an "NSF Seal of Approval" that helps to catalyze the support by industry. The key is that NSF's investment aims to seed partnered approaches to new or emerging areas, not to sustain ongoing efforts through large-scale government expenditures. With industrial and other support totaling 10 to 15 times the NSF investment, I/UCRCs are a premier example of "leveraged" funding for government programs.



Rotary Internal Combustion Engine on a Chip

Researchers at the Berkeley Sensors and Actuators Center (BSAC), at UC-Berkeley, designed and microfabricated engine components with features on the scale of 10s of microns and an overall scale of millimeters. These MEMS engines, much like conventional-sized gasoline-powered generators, will be used to convert the stored chemical energy of liquid fuels into usable electric power in the 10-1000 mW range. Several BSAC member companies, such as ChevronTexaco and Textron Systems, participated in the research and testing of this device.

Finally, a variety of intangibles have contributed to the program's success including: a reputation for being a good R&D investment for industry, the Program's long history, and management tools developed out of that experience – such as a handbook for center managers* and periodic evaluation studies that bring into focus issues that facilitate improved management of the Program and its centers. From the standpoint of member companies, certainly one of the outstanding benefits of participation in an I/UCRC is the opportunity to work with – and ultimately employ – graduate students who are being exposed to industrial needs and practices in an environment that integrates research and education.

* Gray, D.O. & Walters, G.W. (1998). Managing the Industry/University Cooperative Research Center: A Guide for Directors and Other Stakeholders. Columbus, OH: Battelle Press.

Bridge Rehabilitation Underway

The Repair of Buildings and Bridges with Composites (RB2C) is an I/UCRC based at the University of Missouri-Rolla and North Carolina State University. The RB2C center has been contracted by the Missouri Department of Transportation to rehabilitate five aging concrete bridges throughout the state. The bridges will be strengthened using fiber-reinforced polymer (FRP) materials. They will then be instrumented and monitored biennially over five years. The data, information, and understanding gained from this project will be used to draft specifications for future FRP-related bridge-strengthening projects. Alongside these specifications, guidelines will also be written, documenting how bridges should be selected for various FRP-strengthening procedures, providing associated cost estimates of competing schemes, and predicting the life expectancy of strengthened bridges. The center's industrial member consortium will carry out the physical work, in conjunction with RB2C researchers.

"Fouling Meter" Helps Keep Membranes Clean

Research at the I/UCRC for Membrane Applied Science and Technology (MAST), involving the University of Colorado-Boulder and the University of Cincinnati led to the development of an ultrasonic sensor that allows non-invasive, real-time monitoring of membrane fouling and cleaning. A U.S. patent has been issued for this technology. The sensor enables membrane modules used for a wide range of industrial separations to be operated much more efficiently due to reduced cleaning time and less use of cleaning chemicals. Two companies are negotiating with the center to license the fouling meter for use in the food and beverage and municipal water industries.

Measures of Success

Apart from the tangible numbers of centers, industrial partners, students, and like, there are also many intangible indicators of the value of the I/UCRC program, the high level of achievement of its centers, and the esteem in which its participants are held. Here are just a few of many examples by which the success of the program can be measured.

- In 1998, the Technology Transfer Society awarded the I/UCRC program as a whole its coveted *Justin Morrill Award*. This national award is given annually in recognition of excellence in technology transfer. The award is presented to an organization that has an exemplary record in the transfer of technology and also has made outstanding contributions to the theory and practices that are widely used by others.

Machine Vision for Automated Guided Vehicles

The Material Handling Research Center, at the Georgia Institute of Technology, found a way to use low-cost machine vision to track the motion of AGVs (Automated Guided Vehicles) in a factory or warehouse. The research led to a "smart sensor" in which a complete vision system is packaged in a unit that looks like a camera but outputs information about an image rather than the image itself. The principal investigator and his graduate student formed a company, DVT Corporation, to market this sensor. DVT is now the second largest U.S.-based supplier of machine vision systems to industry worldwide.

- I/UCRC research has led to the creation of a number of *successful start-up companies.* Two examples will illustrate:

  - **Dust Inc.** was founded in 2002 to bring the power of pervasive sensor networking to industrial and consumer product markets. The company includes leaders in the field of extreme low-power computing and communications, brought together by the common goal of creating an industrial-grade platform for delivering awareness and communication into everyday objects and environments. With roots in the Sensors and Actuators Center at UC Berkeley, Kris Pister proposed technology to deliver sensing, computing, and networking in a millimeter scale package – essentially an autonomous computer, smaller than a match head but capable of awareness of its environment, simple evaluation of conditions and events, and wireless communication to relay information and raise alerts.

The project was called "Smart Dust" and was funded by DARPA the same year. Since that time, four generations of Smart Dust hardware (called "motes") have been tested and refined. Universities, government research labs, and industrial developers have deployed Smart Dust technology in dozens of laboratory and real-world applications. In 1999, a compact but complete operating system called "TinyOS" was added to the Smart Dust platform, and a wide range of novel applications began sprouting up on campuses across the US. Today there are more than 100 organizations using TinyOS in distributed sensor networks for a host of different applications. The value of pervasive sensor networks is clear and compelling to industry leaders in control systems, logistics, retailing, energy management, and a host of other key markets. Dust Inc. brings together the team that created Smart Dust and has driven its development into a complete computing platform with the potential to revolutionize the way we live and do business.

- The Ceramic and Composite Materials Center, a joint center of the University of New Mexico and Rutgers University, in 1993 spun off **NanoPore, Incorporated**. NanoPore was founded with the aim of commercializing high porosity/high surface area materials for a wide range of applications including adsorbtion, gas separation, advanced thermal insulation, low-K dielectrics, and optics. The company has developed several product lines including the NANOGLASS© family of porous silica interlevel and intermetal dielectrics thin films for use in advanced semiconductors, NanoPore™ superinsulation vacuum insulation panels and inserts, and NanoCool absorption cooling systems. In 1996, NanoPore (along with the University of New Mexico and Sandia National Laboratories) received R&D Magazine's "R&D 100 Award" for their work on ambient pressure aerogel process technology.

Remote Monitoring of Postal Service Equipment

The Center for Intelligent Maintenance Systems (IMS), an I/UCRC at the University of Wisconsin-Milwaukee, has developed a Remote Monitoring and Prognostic System prototype for the United States Postal Services (a center member since 2001). The prototype enables USPS personnel to remotely monitor the material handling system, located in Kansas City, from the USPS Maintenance Technical Support Center in Norman, Oklahoma. IMS researchers also can remotely interact with the system from the IMS headquarters in Milwaukee, Wisconsin. When the on-board prognostic software, or Watchdog Agent (TM), has detected substantial system degradation, a threshold trigger point is met and an alarming/notification module is engaged. First responders (such as the on-site maintenance manager) are notified via alphanumeric pager messaging, while secondary personnel (support people in the Norman facility and IMS researchers in Milwaukee) are notified via email. The goal of the research project is to introduce IMS enabling technologies into USPS operations in order to achieve near-zero downtime in the critical path equipment chain.

"Green" Foam

Researchers affiliated with the Center for Advanced Polymer and Composites Engineering (CAPCE), at Ohio State University, recently won a $1.9 million award from the National Institute of Standards and Technology (NIST) to establish an Advanced Technology Project, or ATP. The ATP represents a collaboration between an industry scientist from Owens Corning (a center industrial partner) and three CAPCE-affiliated faculty members. The researchers will pursue studies of micro-cellular nanocomposites, aimed at the development of an environmentally benign foam for use in construction and insulation of buildings.

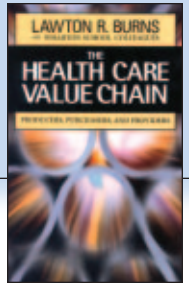
- A number of I/UCRC *directors and faculty have gone on to attain eminent positions in academe.* For example, Dr. John White, founder and former director of the Material Handling Research Center at the Georgia Institute of Technology, later became NSF Assistant Director for Engineering, then Dean of Engineering at Georgia Tech, and is now Chancellor of the University of Arkansas at Fayetteville and a member of the National Science Board. Dr. David C. Chang, founder and former director of the Microwave and Millimeter Wave Computer-Aided Manufacturing, is currently President of Polytechnic University of New York, the nation's second oldest private technology university.

- I/UCRCs have had a substantial *impact on other organizations nationwide,* far beyond their immediate center partners.

  - The Center for Welding Research was founded at Ohio State University in 1979. Today it is known as the Edison Welding Institute, one of six "centers of excellence" supported by the state of Ohio. It is the largest nonprofit, industrially driven engineering organization in North America dedicated to materials joining technology. It has a staff of 160 and provides services to member companies representing 3,300 plant locations nationwide.

The Health Care Value Chain

A three-year study of the University of Washington/University of California Berkeley Industry/University Cooperative Research Center for Health Management Research resulted in a book, "The Health Care Value Chain." The book addresses the supply chain, which represents the trading relationship between producers of health care products, the purchasers of those products (purchasing organizations, wholesalers or distributors) and the health care providers (hospitals). This book has become an important tool in helping hospitals to establish extended trading alliances to lower their operating costs. Lowering these costs will significantly impact both the hospitals profitability and the cost of health care to the public. At least nine large, integrated health care systems representing hundreds of hospitals are now implementing many of the recommendations noted in the book. In particular, the specific findings on pharmaceutical supply management have been reported through conferences and the media throughout the industry and to the U.S. Senate Subcommittee on Antitrust.



- In 2003, the NIH's National Cancer Institute (NCI) formed an Academic Public-Private Partnership Program (AP4), which for the first time in NCI's history establishes long-term relationships between academia, industry and nonprofit organizations. *AP4 is explicitly modeled after the NSF I/UCRC program,* allowing multiple industrial partners along with nonprofits to fund academic science. The NIH program originates from recommendations by several NCI progress review groups stressing the "need for a new drug discovery and development assistance mechanism."