Engineering Research Centers: Linking Discovery to Innovation

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Driving the discovery, dissemination, and deployment of transformational knowledge and technologies and a new generation of graduates in service to industry and the Nation

The Engineering Research Centers (ERC) program was created in 1984 to bring technology-based industry and universities together in an effort to strengthen the competitive position of American industry in the global marketplace. These partnerships established cross-disciplinary centers focused on advancing fundamental engineering knowledge and engineered systems technology while exposing students to the integrative aspects of engineered systems and industrial practice. As a result, over the past quarter century this partnership has produced a wide range of engineered systems and other technologies aimed at transforming product lines and industrial practices and processes, along with a new generation of engineering graduates who are highly innovative, diverse, globally engaged, and effective as technology leaders in industry.

In 2006, NSF revisited the originally defined goals and purposes of the program to initiate the third generation (Gen-3) of ERCs to meet the needs of industry in an increasingly global economy where the U.S. competitive advantage lies in its capacity to innovate. The goal of the Gen-3 ERC Program is to build on the proven core goals of Gen-1 and Gen-2 ERCs and add features that will create a culture that more actively stimulates technological innovation through partnerships with small firms involved in translational research, with organizations devoted to entrepreneurship, and with foreign universities. Five Gen-3 centers were established in 2008. These and future Gen-3 ERCs will advance transformational engineered systems and produce graduates who will be creative innovators in the global economy.

To achieve this goal, Gen-3 ERCs have the following key features:

- A guiding **strategic vision** for a transformational engineered system and the development of an innovative, globally competitive engineering workforce
- **Partnerships with foreign universities** to add value in research and education
- A strategically planned discovery-and systems-motivated cross-disciplinary **research program**, including as partners small firms engaged in translational research

The major technological areas upon which current ERCs focus are:

- Biotechnology and Health Care
- Energy, Sustainability, and Infrastructure
- Micro/Optoelectronics, Sensing, and IT

BIOTECHNOLOGY AND HEALTH CARE

Synthetic Biology ERC (Class of 2006)
University of California at Berkeley, CA (lead institution) in partnership with Harvard University, the Massachusetts Institute of Technology, Prairie View A&M University, and the University of California at San Francisco

Quality of Life Technology ERC (Class of 2006)
Carnegie Mellon University, Pittsburgh, PA (lead institution) in partnership with the University of Pittsburgh

ERC for Revolutionizing Metallic Biomaterials (Class of 2008)
North Carolina A&T State University (lead institution) in partnership with the University of Cincinnati and the University of Pittsburgh

Center for Structured Organic Particulate Systems (Class of 2006)
Rutgers University, New Brunswick, NJ (lead institution) in partnership with Purdue University, New Jersey Institute of Technology, and the University of Puerto Rico at Mayagüez

ERC for Biomimetic MicroElectronic Systems (Class of 2003)
University of Southern California - Keck School of Medicine and Viterbi School of Engineering, Los Angeles, CA (lead institution) in partnership with California Institute of Technology and the University of California, Santa Cruz

ENERGY, SUSTAINABILITY, AND INFRASTRUCTURE

ERC for Biorenewable Chemicals (Class of 2008)
Iowa State University (lead institution) in partnership with the University of California, Irvine, the University of New Mexico, Rice University, the University of Virginia, and the University of Wisconsin-Madison

ERC in Compact and Efficient Fluid Power (Class of 2006)
University of Minnesota, Minneapolis, MN (lead institution) in partnership with Georgia Institute of Technology, Purdue University, the University of Illinois at Urbana-Champaign, and Vanderbilt University

ERC for Future Renewable Electric Energy Delivery and Management Systems (Class of 2008)
North Carolina State University (lead institution) in partnership with Arizona State University, Florida A&M University, Florida State University, Missouri University of Science and Technology

Smart Lighting ERC (Class of 2008)
Rensselaer Polytechnic Institute (lead institution) in partnership with Boston University and the University of New Mexico

MICRO/OPTOELECTRONICS, SENSING, AND IT

ERC for Integrated Access Networks (Class of 2008)
University of Arizona (lead institution) in partnership with the California Institute of Technology, Columbia University, Norfolk State University, Stanford University, Tuskegee University, the Universities of California at Berkeley, San Diego, and Los Angeles, and the University of Southern California

ERC for Extreme Ultraviolet Science & Technology (Class of 2003)
Colorado State University, Fort Collins, CO (lead institution) in partnership with the University of Colorado at Boulder and the University of California at Berkeley

- **Education programs** strategically designed to produce creative, innovative engineers by engaging students in all phases of the research and innovation process
- Long-term **partnerships with middle and high schools** aimed at bringing engineering concepts to the classroom and increasing enrollment in college-level engineering degree programs
- **Partnerships for technology transfer and innovation** formed with member firms and local-level organizations devoted to stimulating entrepreneurship and speeding technological innovation

From their inception the ERCs have embodied NSF's strategic interests in the integration of research and education, in the integration of science and engineering disciplines, in partnerships between academe and industry, and in the improvement of science and engineering graduates' ability to meet the nation's needs in a global economy. In many ways the program has redefined the concept of an academic research center, serving as a model for the development of other Centers programs in the U.S. and around the world.

Each ERC is established as a three-way partnership involving academe, industry, and NSF (in some cases with the participation of state, local, and/or other Federal government agencies). In FY 2009, total annual funding from all sources provided directly to each Center ranged from $4.1 to $8.8 million, with NSF's contribution ranging from $3.25 to $4.2 million per year.[1]

These centers are funded by NSF for 10 years. Since 1985, a total of 54 ERCs and 3 Earthquake ERCs[2] have been formed across the United States, with 15 ERCs currently in operation and five more planned for initiation in 2010 and 2011. Surveys of industry employers have shown that ERC graduates are viewed by 80% of their supervisors as being more productive than their peers because, through their ERC experience, they know how to integrate knowledge across disciplines and manage teams to advance technology. A 2007 study of the impacts of ERC-generated technologies found that the economic value of products and processes deriving from the ERCs was already in the low tens of billions of dollars, with some centers having had a transformational impact on their field of engineering and technology.

[1]NSF funding ramps down in the last two years of a Center's life as an ERC; that reduced funding is not reflected in these figures.
[2]Three Earthquake Engineering Research Centers were funded in 1997 with funds outside of the ERC Program but were managed by the ERC Program from 1999 through their graduation from NSF support.

ERC for Collaborative Adaptive Sensing of the Atmosphere (Class of 2003)
University of Massachusetts, Amherst, MA (lead institution) in partnership with Colorado State University, University of Oklahoma, and University of Puerto Rico at Mayagüez

Center for Wireless Integrated MicroSystems (Class of 2000)
University of Michigan (lead institution) in partnership with Michigan State University and Michigan Technological University

Center for Subsurface Sensing and Imaging Systems (Class of 2000)
Northeastern University (lead institution) in partnership with Boston University, Rensselaer Polytechnic Institute, University of Puerto Rico at Mayagüez, Brigham and Women's Hospital, Lawrence Livermore National Laboratory, Massachusetts General Hospital, and Woods Hole Oceanographic Institution

ERC on Mid-Infrared Technologies for Health and the Environment (Class of 2006)
Princeton University, Princeton, NJ (lead institution) in partnership with the City University of New York, the Johns Hopkins University, Texas A&M University, the University of Maryland–Baltimore County, and Rice University

At the end of their ten-year life-cycle as NSF-supported Engineering Research Centers, most ERCs graduate from NSF support and become self-sustaining. Currently there are 31 graduated ERCs and 3 graduated Earthquake ERCs:

Bioengineering

ERC for Emerging Cardiovascular Technologies — Duke University & other North Carolina Institutions (established in 1987, graduated in 1998)

ERC for the Engineering of Living Tissues — Georgia Institute of Technology, Atlanta, GA (lead institution) in partnership with Emory University (established in 1998, graduated in 2008)

Center for Computer-Integrated Surgical Systems and Technology — Johns Hopkins University, Baltimore, MD (lead institution) in partnership with the Brigham and Women's Hospital, Carnegie Mellon University, the Johns Hopkins University Hospital, MIT, and Shady Side Hospital (established in 1998, graduated in 2008)

Bioprocess Engineering Research Center — Massachusetts Institute of Technology, Cambridge, MA (established in 1985, graduated in 1994)

Biotechnology Process Engineering Center-Massachusetts Institute of Technology, Cambridge, MA (BPEC recompeted and was reestablished in 1994, graduating in 2005)

Center for Biofilm Engineering — Montana State University, Bozeman, MO (established in 1990, graduated in 2001)

VaNTH ERC for Bioengineering Educational Technologies — Vanderbilt University, Nashville, TN (lead institution) in partnership with Northwestern University, the Harvard University-MIT Division of Health Sciences and Technology, and the University of Texas at Austin (established in 1999, graduated in 2007)

Engineered Biomaterials Engineering Research Center — University of Washington, Seattle, WA (established in 1996, graduated in 2007)

Design and Manufacturing

ERC for Environmentally Benign Semiconductor Manufacturing — University of Arizona, Tucson, AZ (lead institution) in partnership with Arizona State University, the University of California at Berkeley, Cornell University, MIT, and Stanford University (this ERC was jointly funded by the Semiconductor Research Corporation) (established in 1996, graduated in 2006)

ERC for Engineering Design (now the Institute for Complex Engineered Systems) — Carnegie Mellon University (established in 1986, graduated in 1997)

Center for Advanced Engineering of Fibers and Films — Clemson University, Clemson, SC (lead institution) in partnership with MIT (established in 1998, graduated in 2008)

ERC for Particle Science and Technology — University of Florida, Gainesville, FL (established in 1995, graduated in 2005)

Systems Research Center — University of Maryland/Harvard University (established in 1985, graduated in 1994)

Institute for Systems Research — University of Maryland/Harvard University (SRC recompeted and was reestablished in 1994, graduating in 1998)

Center for Reconfigurable Machining Systems — University of Michigan, Ann Arbor, MI (established in 1996, graduated in 2007)

Center for Interfacial Engineering (now the Industrial Partnership for Research in Interfacial and Materials Engineering, or iPrime) — University of Minnesota (established in 1988, graduated in 1999)

ERC for Net Shape Manufacturing — Ohio State University (established in 1986, graduated in 1997)

Center for Intelligent Manufactured Systems — Purdue University (established in 1985, graduated in 1994)

Earthquake Engineering

Pacific Earthquake Engineering Research Center — University of California at Berkeley, CA (lead institution) in partnership with California Institute of Technology, Stanford University, University of California at Davis, University of California at Irvine, University of California at Los Angeles, University of California at San Diego, the University of Southern California, the University of Washington, and nine affiliate institutions (established in 1997, graduated in 2007)

Multidisciplinary Center for Earthquake Engineering Research — Headquartered at the University at Buffalo, in partnership with Cornell University, University of Delaware, University of Nevada at Reno, and University of Southern California, as well as other collaborating institutions and private entities throughout the U.S. (established in 1997, graduated in 2007)

Mid-America Earthquake Center — University of Illinois at Urbana-Champaign, IL (lead institution) in partnership with Georgia Institute of Technology, the University of Memphis, MIT, St. Louis University, Texas A&M University, and Washington University (established in 1997, graduated in 2008)

Energy, Environment, and Infrastructure

Advanced Combustion Engineering Research Center — Brigham Young University/University of Utah (established in 1986, graduated in 1997)

Center for Advanced Technology for Large Structural Systems — Lehigh University (established in 1986, graduated in 1997)

Offshore Technology Research Center — Texas A&M University/University of Texas (established in 1988, graduated in 1999)

Microelectronics, Computing, and Communication

Center for Neuromorphic Systems Engineering — California Institute of Technology, Pasadena, CA (established in 1995, graduated in 2005)

Data Storage Systems Center — Carnegie Mellon University, Pittsburgh, PA (established in 1990, graduated in 2001)

Optoelectronic Computing Systems Center — University of Colorado/Colorado State University (established in 1987, graduated in 1998)

Center for Telecommunications Research — Columbia University (established in 1985, graduated in 1996)

Packaging Research Center — Georgia Institute of Technology, Atlanta, GA (established in 1995, graduated in 2005)

Center for Compound Semiconductor Microelectronics — University of Illinois at Urbana-Champaign (established in 1986, graduated in 1997)

Center for Computational Field Simulation — Mississippi State University, Mississippi State, MS (established in 1990, graduated in 2001)

Center for Advanced Electronic Materials Processing — North Carolina State University & other North Carolina Institutions (established in 1988, graduated in 1999)

Integrated Media Systems Center — University of Southern California, Los Angeles, CA (established in 1996, graduated in 2007)

Center for Power Electronics Systems — Virginia Polytechnic Institute & State University, Blacksburg, VA (lead institution) in partnership with North Carolina A&T State University, University of Puerto Rico at Mayagüez, Rensselaer Polytechnic Institute, and University of Wisconsin at Madison (established in 1998, graduated in 2008)

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