FY 2005 ERC Annual Meeting
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NSF Plenary Session

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Deputy Division Director
Division of Engineering Education and Centers
National Science Foundation

Engineering Research Centers Program Guiding Goals 1984-2004

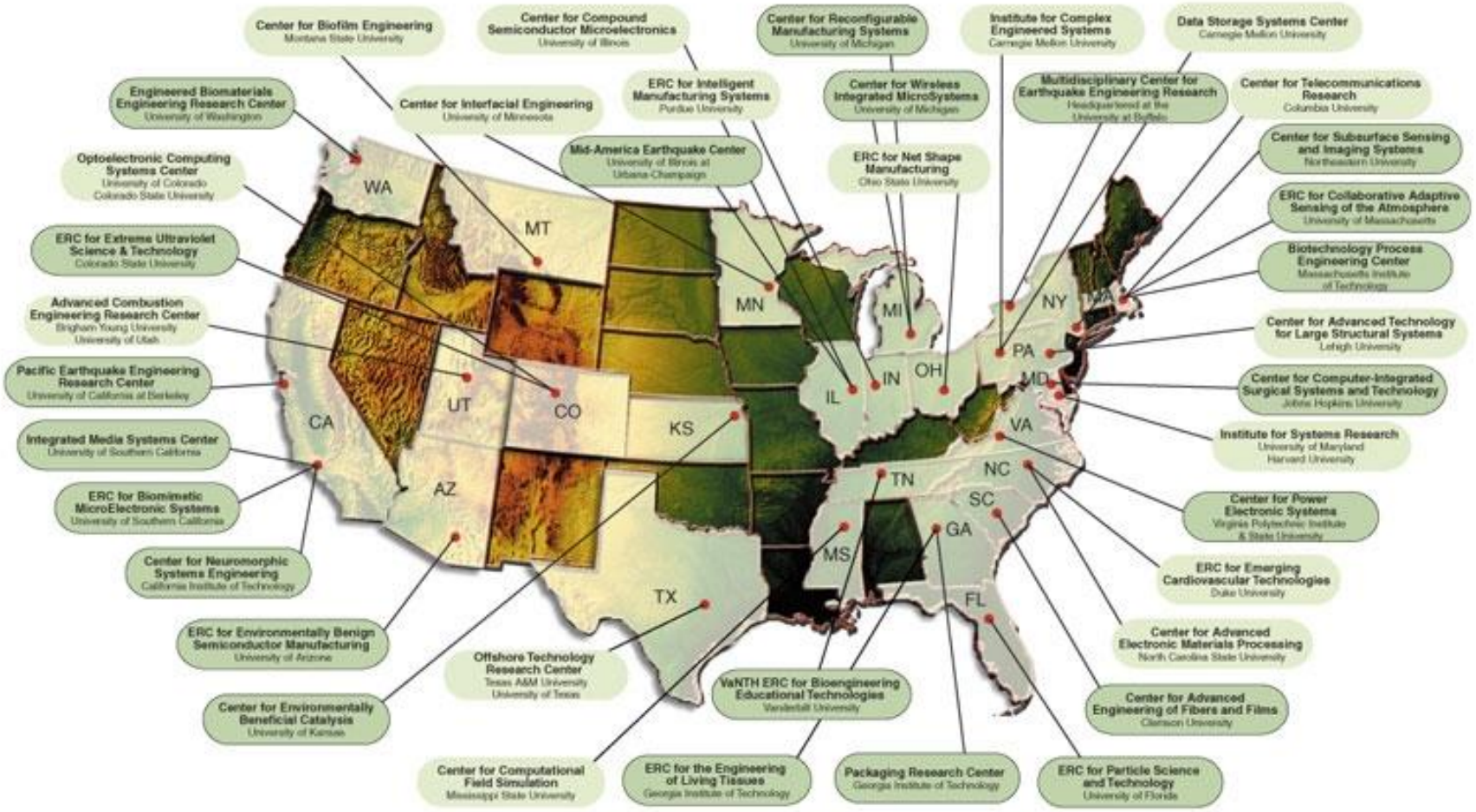
1984 – National Academy of Engineering Guidance ERCs will:

- Develop fundamental knowledge critical to US competitiveness in world markets
- Focus on cross-disciplinary technological areas of major national and industrial importance
- Emphasize systems aspects of engineering and educate students in synthesizing, integrating, and managing engineering systems
- Include significant education components for undergraduate and graduate students in research
- Operate in partnership with industry

Engineering Research Centers Program
Guiding Goals 2004

- Focus on engineered systems with the potential to spawn whole new industries or radically transform current industries
- Integrate discovery and learning in an interdisciplinary environment, reflecting the complexities and realities of real-world technology
- Integrate ERC research into the curriculum at all levels, from pre-college to life-long learning
- Increase the diversity of the engineering workforce
- Join academe and industry in partnership as change agents

ERC/EERC System Map



Darker labels denote current centers. Lighter labels denote graduated centers. University shown is lead institution.

ERC Program: Partnerships in Transforming Research, Education and Technology

- Transforming engineering research by mandating engineered systems and cross-disciplinary teams
- Adding culture of strategic formulation and management of research
- Giving undergraduate and graduate students first-hand experience in technological innovation & industry practice
- Advancing technology and increasing the productivity of engineering graduates through active partnership with industry
- Integrating interdisciplinary research findings into the curriculum for all students from K-Grey
- Mandating diversity with a broad impact throughout engineering schools and beyond

ERCs' Major Intellectual Impacts

- **Catalysts for the Spread and Recognition of New Interdisciplinary Fields**
  - **Biological Engineering**
    - MIT - BPEC, Montana St. - Biofilms, GA Tech - Tissue Eng. UWEB-Biomaterials
  - **Neuromorphic Engineering** –
    - Caltech - CNSE & Telluride Summer Workshop
  - **Integration of Design & Manufacturing**
    - Purdue - Intelligent Manufacturing Systems, CMU - Design
  - **Multi-Media Systems**
    - USC - IMSC

ERCs' Major Intellectual Impacts

- **Spawned New Systems Paradigms Generating Vitality for Ongoing Fields**
  - CMU – Data Storage Systems
  - Florida – Nano & Microscale Particle Processing & Delivery Systems
  - Arizona - Environmentally Benign Semiconductor Mfg.
  - Michigan - Reconfigurable Manufacturing Systems
  - GA Tech - Electronic Packaging for System Functionality
  - VT et al – Power Electronic Systems
  - PEER, MCEER, MAE -- Systems Paradigms for Earthquake Engineering and Societal Response

ERCs' Major Educational Impacts

- Integration of Systems/Cross-Disciplinary Research into the Curriculum
  - MIT-BPEC – Broad-based Institutional Impact - Biological Eng
  - VaNTH – Educational Materials, Learning Paradigms, and Learning Technology for Biomedical Engineering
  - USC-IMSC – Suite of degree programs in multi media for engineers and non-engineers
  - GA-Tech - Broad-based impact on electronic packaging education in US & Abroad
  - VA Tech, et al – Suite of 78 courses available across five institutions, cross-university matriculation

ERCs Lead in Pre-College Engineering Education

- **Research Experiences for Teachers (RET) Sites** ,pioneered by JHU and Northeastern, model for NSF RET Program
- CASA (UMass, et al) **partnership with State of MA**, helping to set standards for precollege education in engineering/technology
- UWEB's "Guy Simplant" broad-based impact in pre-college learning about **biomedical engineering design**
- CNSE's pre-college teaching partnerships and student-design teams **revolutionized Caltech's view of its role in pre-college education** in the Los Angeles region

ERCs Provide Significant Benefit to their Member Firms

Performance Dimension	Quite to Extremely Important
Obtained Access to New Ideas and Know How	92%
Focus of ERC Matched Firm's Interests	91
Access to ERC Technology	78
Access to ERC Faculty and Students	76
Opportunity for Joint Projects	76
Impacted Competitiveness	75
R&D Agenda Influenced	67
Engineered Systems Goals	65

Comparison by Member Firms of Performance of ERC Grads with non-ERC Hires

Performance Dimension	Somewhat Better or Much Better
Overall Preparedness to Work in Industry . . .	87%
Breadth of Technical Knowledge.	83
Ability to Work in Interdisciplinary Teams . .	83
Contribution to Firm's Technical Work	80
Depth of Technical Knowledge	79
Ability to Integrate Knowledge and Technology to Solve Problems	78
Ability to Develop Technology	74

Impact of ERCs on their Home Institutions

Study 17 ERCs operating for at least ten years in 2000, Class of 1985 – Class of 1990

- Systems was embraced by these ERCs but had little broader impact on their Colleges of Engineering
- ERC contributed significantly to the development of interdisciplinary research and education at 16 of the 17 host institutions
- ERCs demonstrated the feasibility of large-scale collaborative, interdisciplinary research and education
- Stimulated host institutions to promote interdisciplinary research
- Few ERC participants failed to attain tenure and in many cases, ERC participation was perceived as an advantage

ERC Program's Diversity Policy Leads NSF

- ERC program's proactive diversity policy applauded as a model for all of NSF by the NSF Committee on Equal Opportunity in Science and Engineering
- National Science Board applauds ERC Diversity policy and recognizes new ERC partnerships with Louis Stokes Alliances for Minority Participation
- ERCs lead national engineering-wide averages for involvement of women and underrepresented minorities

ERC Committee of Visitors Findings (March 2004)

Chair, Linda Katehi, Dean of Engineering, Purdue University

- ERC program is a program of excellence for the Directorate for Engineering and all of NSF
- The ERC program and the ERCs have demonstrated outstanding performance, leadership, and impact
- The pre-award and post-award review processes are outstanding and models for all
- ERC program's diversity policy should be emulated in ENG and NSF

COV Recommendations for the Future

- Work with a Blue Ribbon Panel to assess the effectiveness of the current model for the next 20 years
- Develop a vision for ERCs that will be as effective in the next 15 to 20 years as in the last 20 years
- Consider variable scales of effort to broaden the scope of technologies funded and support both large & small ERC teams
- Analyze the positive and negative impacts on universities and NSF of the emerging trend toward multi-university centers
- Continue the new ERC diversity policy with its explicit motivation for goals and performance targets.

Trends between 1984 and 2004

- Interdisciplinary research is increasingly common in academe
- Rewarding young faculty for participation in interdisciplinary teams is on the increase but practices vary widely across institutions
- Centers are not the only way to engage in interdisciplinary research (institutes, cross-dept. clusters, groups, etc)
- The primary engine for innovation is small firms
- Role of large firms in the support of research has shifted away from internal R&D labs to:
  - "outsourcing" to academic centers in the US and abroad, and
  - "gleaning" the fruits of small firms that take the initial risk to prove new, high-risk technology

Plan of Action

Examine Assumptions underlying the ERC Program, Trends for the Future, and Optimal Configuration of Program for the Future

- Gary Gabriel (EEC/DD) will form a strategic "Blue Ribbon" committee to examine the programs of EEC:
  - Membership drawn from academe and industry
  - Focus across all EEC programs
  - Gain input from ERCs and their industrial partners
  - Assess findings from ERC studies/evaluations
  - Recommend needed reconfiguration

Evaluations and Studies of ERC Program and Trends in Industrial R&D Underway

- **Impact of 3-Plane Strategic Plan** on ERCs – Steve Currall and Sara Janson, Rice University - Underway
- **Modes of Industrial Collaboration around the World** – Bob Norwood (EEC) - Underway
- Changing Roles of **Industrial Investment in Innovation** – Josephine Yuen, Stevens Institute of Technology - Planned
- **Assessment of ERC Educational "Products"** – Wing Aung (EEC) and ERC Committee - Underway
- **Benefits of ERCs for Industry** - completed evaluations
- **Tenure and Interdisciplinary Research** - Preston with input from ERC Directors – Completed
- Evaluations of the **Impact of ERCs on their home institutions** - Completed

Examine Underlying ERC Program Assumptions and Changes Needed for 2020

Assumption 1. -- To succeed in academe cross-disciplinary, team research needs to be motivated by a vision, strategically planned, and organized by a center construct, with sustained large-scale funding.

- Can cross-disciplinary research and its impact on education flourish in academe without centers?
- Should the ERC model be expanded to encompass smaller groups with shorter funding horizons?
- Should there be variability in the time-scale of funding depending upon the complexity and challenge of the vision?
- What's the impact of the multi-university model on academe and NSF?

Examine Underlying ERC Assumptions and Changes Needed for 2020

Assumption 2: ERCs should be focused on engineered systems of major national and industrial importance.

- Is focus on engineered systems still relevant to industrial needs?
- Should ERCs focus solely on transforming technologies?
- Or, should there be a combination of incremental and transforming foci within an ERC and among the ERCs?

Examine Underlying ERC Assumptions and Changes Needed for 2020

Assumption 3: ERCs are needed to provide a platform for undergraduate and graduate students to integrate fundamentals across disciplines, engage in the design and proof-of-concept of new technologies, and integrate technologies into systems

- Is there a significant different between the typical ERC and non-ERC graduates in terms of their productivity in industry?
- If there is still a need for ERC funding to generate this type of graduate?
- What additional characteristics will be needed for the future, especially in a global economy with a open labor market?
- Should there be more emphasis on education for innovation?
- How can the ERC model for education be further extended to undergraduate engineering education for all?

Examine Underlying ERC Assumptions and Changes Needed for 2020

Assumption 4: Partnership with industry based on memberships enables ERCs to meet industry's needs, define new opportunities, and speed technology transfer

- Centralized R&D in large firms in 1985 to evolved to distributed innovation by small firms in 2005….how does this impact the ERC model for industrial collaboration?
- What is the most effective way to speed technology transfer, especially in emerging fields?
- Have other nations developed more effective modes of industrial partnerships that ERCs should explore?
- Does industry still need ERCs to be focused by systems goals?

The ERC Team

Good Leaders and Managers at all Levels Yield Successful ERCs

- **Directors and Deputies lead ERC teams** to fulfill its vision integrating research, education, and industrial partnership
- **Faculty leaders focus and facilitate individual and collective efforts** to integrate research and education across disciplines and campuses
- **Education Program leaders facilitate curriculum development** across departments and campuses and **lead precollege outreach**
- **Industrial Liaison Officers** lead the ERCs to **integrate academic and industrial views,** build and maintain a partnership with industry, and speed technology transfer
- **Administrative Directors/Chief Operating Officers integrate functional groups** across department/school lines for delivery
- **Student Leadership Councils** organize students across laboratories to strengthen the role of students in fulfilling ERC goals
- NSF ERC **Program Staff** provides leadership, oversight, review, guidance, evaluation, and continuous improvement

ERC PROGRAM TEAM

Program Management


Gary Gabriele


Lynn Preston

Program Professionals and Support


Win Aung


Esther Bolding


Mary Poats


Darlene Suggs


Linda Parker


Torin Edwards


Bob Norwood


Court Lewis

ERC PROGRAM DIRECTORS

Bioengineering Centers

Sohi Rastegar
Cluster Leader

Joy Pauschke

Rajinder Khosla

George Vermont

Manufacturing & Processing Centers

Tap Mukherjee
Cluster Leader

Bruce Kramer

John Hurt

ERC PROGRAM DIRECTORS

Microelectronic Systems & Information Technology Centers

Bruce Kramer
Cluster Leader

Lynn Preston

Steve Nelson

Sohi Rastegar

Fil Bartoli

Earthquake Engineering Centers

Rick Fragaszy
Cluster Leader

Vilas Mujumdar

Joy Pauschke

Renewals, Graduations, & Class of 2006

- **Renewals in FY 2004**
  - Class of 1998 (4) – 6th Year Renewals – All Renewed as Proposed
  - Vanderbilt – 5th Year Renewal – Renewed as Proposed
  - EERC Class of 1997 (3) – 7th Year Renewal – 2 Renewed as Proposed, 1 recommended for renewal based on review of an addendum
- **Phasing Down in CY 2004-2005**
  - MIT-BPEC, Caltech, Florida, GA-Tech, Arizona, Michigan-RMS, USC-IMSC, Washington, Vanderbilt
- **Graduating in CY 2006**
  - MIT-BPEC, Florida, GA Tech-PRC, Caltech, Arizona
- **Class of 2006** -- Competition Underway
  - 136 Letters of Intent, 95 Preproposals, 3-4 Awards

Biotechnology Processing Engineering Center
a graduating NSF ERC

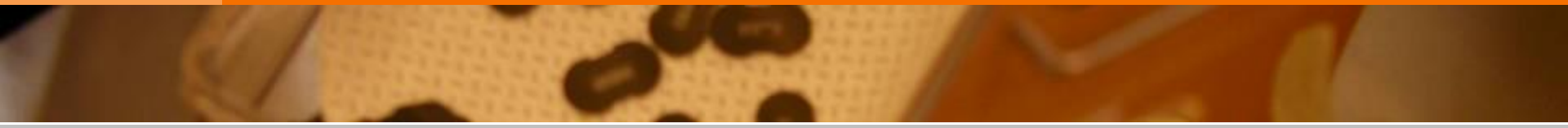
Children's Hospital Boston

Massachusetts Institute of Technology

UNIVERSITY of TORONTO

WHITEHEAD INSTITUTE

BROWN UNIVERSITY



Linda Griffith, Director
Doug Lauffenburger, Executive Director of Development
Harvey Lodish, Executive Director of Research

Biotechnology Process Engineering Center
An Engineering Research Center

Particle Engineering Research Center

PERC

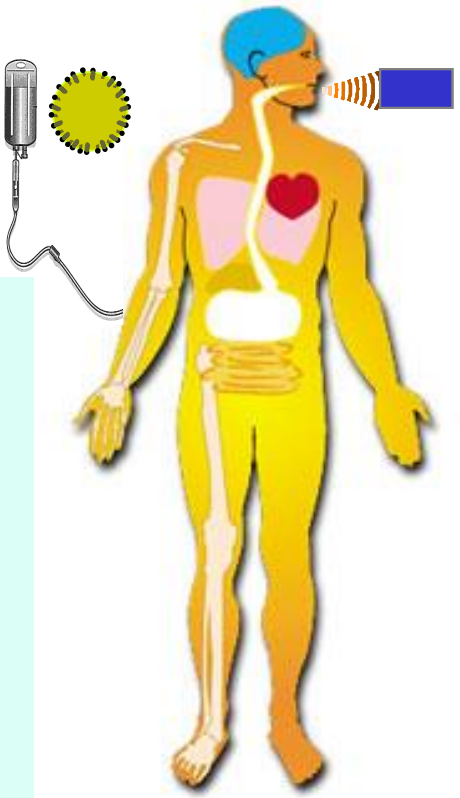
National Science Foundation Engineering Research Center
for Particle Science and Technology at the University of Florida

Brij M. Moudgil, Director

Distinguished Professor, and Alumni
Professor of Materials Science &
Engineering, University of Florida

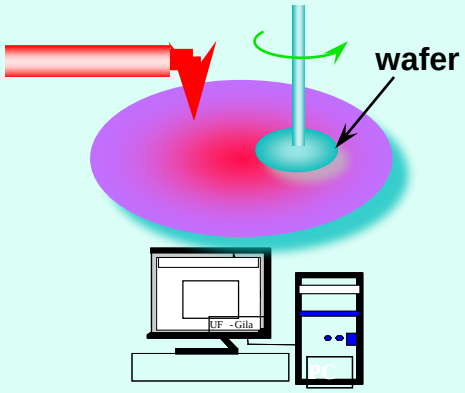
Engineered Particles for Industrial and Medical Applications

Micro Emulsion for Drug Detoxification

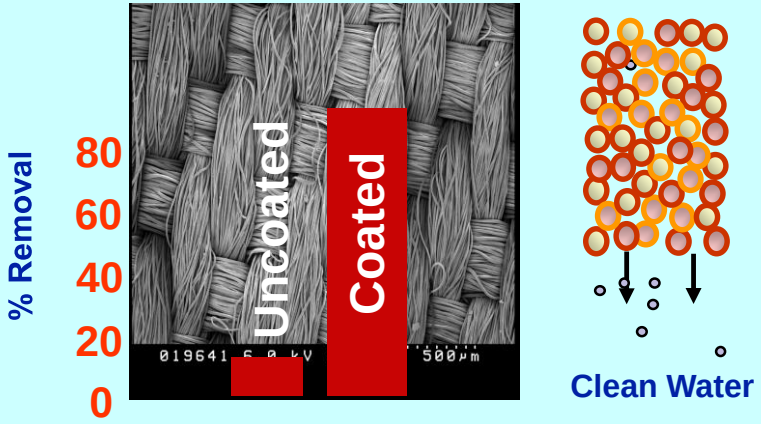


Coatings for Slow Drug Release

Designed Slurry for CMP



Media Coatings to Improve Filtration of Microbes



Thanks to All for Formulating the Meeting and Participating

Extra Thanks to Organizers:

- **Court Lewis** for organizing the meeting and working with all the session organizers and speakers
- **Ann Becker, Kate Ryan, and Louise Robson** for logistics for the meeting
- **Session Organizers:**
  - **Bass Sock**, VPI, Student Retreat
  - **Michael Silevitch**, NE, Center Directors' Meeting
  - **Leigh McGrath**, Mich-RMS, Administrative Directors' Meeting
  - **Phil Cheney**, NE, ILO Mtg
  - **Anne Donnelly**, Florida, Education Directors' Meeting
  - **Ulrich Neumann,** USC-IMSC, International Partnerships
  - **Kathleen Rubin,** UMass & **Michael Maturo**, USC-IMSC, Marketing ERC to Students

Thanks

- **Rao Tummala**, GA Tech-PRC, & **Bill Costerton**, Montana St., ERC Graduation
- **Win Aung**, ERC Program, Education Innovation
- **Yoram Koren**, Mich-RMS, Globalization and membership
- **Leyla Conrad,** GA Tech-PRC, Globalization and Education
- **Linda Parker,** ERC Program, & Chris Bishop, ORC, Reporting
- **Bob Nerem,** GA Tech-Tissue**,** & **Sohi Rastegar,** NSF, Bioengineering
- **Amr Elnashai**, Illinois, & **Joy Pauschke,** NSF, EERCs
- **Bala Subramaniam**, Kansas, & **Tap Mukherjee**, NSF, Mfg/Process
- **David McLaughlin**, Umass, & **Bruce Kramer**, NSF, Microelectronic
- **Bob Norwood**, NSF, Diversity Breakouts with Ralph Etienne-Cummings, JHU, John Kennedy, Clemson, Scott Ashford, UCSD-PEER, Leo McAfee, Michigan-WIMS