The ERC Program in NSF ENG/EEC

D. Keith Roper

Engineering Research Centers Program Leader
Network for Computational Nanotechnology Program Leader

Engineering Education and Centers Division, Engineering Directorate
National Science Foundation

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Disclaimer: The comments in this presentation are of the author, and do not necessarily reflect those of the National Science Foundation (NSF)

Thanks to: R. Gupta, C. Hemingway, P. Kharghonekar for contributions to the presentation
OUTLINE

1. ERC vision and framework
2. Status of ERC Program
3. Funding Opportunities – Near Term
4. Funding Opportunities – on the Horizon
5. Future Directions
NSF Program vision for Engineering Research Centers

• Create a culture to translate scientific discovery to technological *innovation* through transformational engineered systems research and education

• Build partnerships with *industry* to strengthen the innovative capacity of the U.S. in a global context

• Produce diverse engineering *graduates* who are effective in industry and creative innovators in a global economy

http://scielo.isciii.es/img/revistas/im/v8n2/03-Esparza-Fig3.gif
OUTLINE

1. ERC vision and framework
2. Status of ERC Program
3. Funding Opportunities – Near Term
4. Funding Opportunities – on the Horizon
5. Future Directions
NSF FY2016 Engineering Research Centers
Lead Institutions ★ and Core Partners ●

Note: All centers are multi-university partnerships; university shown is lead institution.
ERC Products of Innovation, FY 1985–2015*

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* Does not include centers from the Earthquake Technology Sector
### ERC Industrial/Practitioner Members and Supporting Organizations, FY 2008–2015*

<table>
<thead>
<tr>
<th>Year</th>
<th>Contributing Organizations</th>
<th>Funders of Associated Projects</th>
<th>Funders of Sponsored Projects</th>
<th>Foreign Industrial/Practitioner Members</th>
<th>U.S. Industrial/Practitioner Members</th>
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<td>2015</td>
<td>22</td>
<td>8</td>
<td>67</td>
<td>318</td>
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(Totals) (533) (431) (522) (561) (648) (684) (633)

* Does not include centers from the Earthquake Technology Sector
# ERC Industrial/Practitioner Members and Supporting Organizations, FY 2008–2015*

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<td>Funders of Sponsored Projects</td>
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<td>15</td>
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<td><strong>Total Number of Organizations</strong></td>
<td>533</td>
<td>431</td>
<td>522</td>
<td>561</td>
<td>648</td>
<td>684</td>
<td>633</td>
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<tr>
<td><strong>Total Number of Centers</strong></td>
<td>20</td>
<td>15</td>
<td>14</td>
<td>17</td>
<td>20</td>
<td>20</td>
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<td><strong>Average Number of Organizations per Center</strong></td>
<td>27</td>
<td>29</td>
<td>37</td>
<td>33</td>
<td>32</td>
<td>34</td>
<td>37</td>
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* Does not include centers from the Earthquake Technology Sector
Industrial/Practitioner Member Support by Year, FY 2008–2015*

* Does not include centers from the Earthquake Technology Sector

** Support received by the end of the current reporting year. Includes data for centers that have entered partial data during a no-cost extension (NCE).

*** Data for this line are from the In-Kind Support reported in the Organizations section. There are no data prior to FY 2010 because it was a new field that year.
NOTES:
- Industry sizes are as follows: Small = <500 employees, Medium = 500–1,000 employees, Large = >1,000 employees.
Industrial/Practitioner New Support to ERCs

**FY2014 20 ERCs**
Total value of support: $8.5 million

**FY2015 17 ERCs**
Total value of support: $9.9 million
Industry Support by ERC Technology Sector*,**,***

* Does not include centers from the Earthquake Technology Sector

** Support includes Unrestricted Cash, Restricted Cash, and In-Kind Support.

*** Includes data for centers that have entered partial data during a no-cost extension (NCE)
ERC Graduate Employment

FY2014 20 ERCs

FY2015 17 ERCs
OUTLINE

1. ERC vision and framework
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5. Future Directions
Funding Opportunities: A Recipe :) 

Ingredients

Essentials:
½ cup vegetable oil
½ cup flour
1 small onion, chopped (1 cup)
1 small green bell pepper, chopped (1 cup)
3 stalks celery, chopped (1 cup)
1 28-oz. can diced tomatoes
2 cups fresh or frozen green beans
3 carrots, sliced (2 cups)
1 parsnip, diced (1 cup)
1 Tbs. ground cumin
1 Tbs. paprika
1 Tbs. dried oregano
¼ tsp. cayenne pepper

Optional:
1 cup fresh or frozen sliced okra, optional
2 tablespoons almond butter (randomly delicious)
salt to taste

Directions:
1. Stir together oil and flour in Dutch oven or heavy-bottomed pot until smooth. Cook over high heat 10 minutes, or until roux turns a dark caramel color, stirring constantly.

2. Add onion, bell pepper, and celery, and cook 5 minutes, or until vegetables are softened. Stir in all remaining ingredients and 4 cups water. Reduce heat to medium-low, cover, and cook 40 minutes, or until carrots are tender. Serve over rice.

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Research to Commercialization NSF Programs

- NSF overall
- ST
- GOAL
- ERC
- PFI: BIC/AIR
- I/UCRC
- I-Corps
- STTR
- SBIR
- Industry
- Investors
- Foundations
- Universities
- Small Businesses
- Valley of Death
- Translational Research
- Discovery
- Development
- Commercialization
### Large Scale NSF Programs

<table>
<thead>
<tr>
<th>NSF Program</th>
<th>Awards/Proposals</th>
<th>Ann. Budget ($ millions)</th>
<th>Duration (years)</th>
<th>Cycle (years)</th>
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<td>5</td>
<td>5+5</td>
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<td>OIA: D. Brzakovic, <a href="mailto:dbrzakov@nsf.gov">dbrzakov@nsf.gov</a></td>
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<td><strong>Total</strong></td>
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<td><strong>5.25</strong></td>
<td><strong>16</strong></td>
<td><strong>2-3</strong></td>
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Three Overarching Questions

- What is the compelling new idea and how does it relate to national needs?
- Why is a center necessary to tackle the idea?
- How will the ERC's infrastructure integrate and implement research, workforce development, and innovation ecosystem development efforts to achieve its vision?

Specific Review Criteria

- Are there integrated Strategic Plans for Research, Workforce Development, Innovation?
- Leadership: Is there expertise in research, workforce development, and innovation?
  - Diversity Director: experienced in activities proven to create culture of inclusion
- Research: What are the impact, benchmarking, partnerships, and system-at-scale?
- Workforce Development: Is it literature-based and inclusive with assessment?
- Innovation: Is there a scale-able, sustainable community?
- Infrastructure: What are plans for a community of inclusion?
NRT Specific Review Criteria

• Develop innovative approaches to graduate education for MS and/or PhD students
• Expand/enhance professional development
• Encourage strategic collaborations with stakeholders (e.g., university-industry partnerships)
• Rely on existing evidence of effective practices in STEM education (evidence-based approaches)
• Generate new knowledge that promotes transformative improvements in graduate education
• C2C Collaboration: Memorandum of Understanding Sept. 2014
• Trilateral Research Partnership: NSF, SFI, and DEL NI
• Vision
  – Augment existing capabilities of centers in each jurisdiction, e.g., ERC
  – Accelerate achievement of milestones at fundamental, enabling technology and/or testbed levels
  – Facilitate achieving the ERC vision in scope, scale, and/or impact
• Thematic areas: Nano, Sensors, Energy/Sustainability, Telecom
• Funding decision: Merit Review conducted by NSF and advance Funding Commitment review by SF and DEL NI
INTELLECTUAL MERIT:

1. **Significance:** What transformative progress envisioned by the Proposal derives from C2C interactions?

2. **Complementarity:** What interaction/activities of the Proposal align with/go beyond current TANMS Center activities?

3. **Relevance/Quality:** What support enduring results in knowledge, workforce, and technology transfer?

BROADER IMPACTS:

1. **Society:** What sustains interaction/exchanges between faculty/students during/beyond the Proposed Plan?

2. **Innovation:** What real, tangible outcomes will result from interactions with industry/society?

3. **Infrastructure:** What resources support realization of Project interactions within the projected timelines?
C2C Submission Steps

NSF is the **lead agency** for the C2C mechanism hence they manage the peer review.

1. Submit 2-page EoI to NSF/DEL NI/SFI
2. Invite to full proposal/decline EoI
3. Submission of close-to-final full proposal to SFI/DEL NI
4. Submission of C2C proposal with ERC annual report
5. ERC annual site visit

- At least 12 weeks in advance of NSF deadline
- 6 weeks in advance of NSF deadline
- 5 weeks in advance of NSF annual site visit
Competitive Proposal Ingredients

Innovative Concept

- Unique, potentially transformative
- Interdisciplinary, hypothesis driven
- Significant impact to a real problem
- Bold advance of discovery, understanding
- Synergistic: whole > sum of parts

Well-Conceived Research Plan

- Demonstrate knowledge of field (> 50 refs)
- Demonstrate competence (prior work)
- Preliminary data (to overcome skepticism)
- Balanced detail in proposed work plan
- Critical approach with contingency plans
- Reasonable scope & budget

Compelling Broader Impacts

- Activities: aligned with research area
- SMART, leverage institutional resources
- Assessment: summative, formative, external
- Engage under-represented groups scalably
- Include K-12 & undergraduate education & outreach, public outreach, letters of collabor.
- Get all of this done in the last two pages
1. ERC vision and framework
2. Status of ERC Program
3. Funding Opportunities – Near Term
4. Funding Opportunities – on the Horizon
5. Future Directions
ENG Initiatives and Priorities

• Innovations at the Nexus of Food, Energy, and Water Systems
• Risk and Resilience
• Clean Energy Technology
• Cyber-Enabled Materials, Manufacturing, and Smart Systems
  – Advanced Manufacturing
• Smart and Connected Communities
• National Nanotechnology Initiative
ENG Initiatives and Priorities

• Understanding the Brain
  – BRAIN Initiative

• Broadening Participation
  – NSF INCLUDES: Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science

• National Strategic Computing Initiative

• Innovation Corps
ENG Special Emphases under Mandatory Funding

- Early-career investigators
- Transformative use of data and cyberinfrastructure to stimulate data-intensive engineering research
- Disruptive technologies to enable post-Moore’s law computing devices and systems
OUTLINE

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Challenges/Opportunities: R&D Landscape

**National R&D Intensity**
Gross R&D investment as a percent of GDP

- South Korea
- Finland
- Japan
- Taiwan
- Germany
- U.S.
- France
- EU-28
- China
- UK

Internationally, US R&D lagging

Source: OECD, Main Science and Technology Indicators, Feb 2015. © 2015 AAAS

**University R&D Funding by Source**
Expenditures in billions, FY 2013 dollars

Federal support for R&D is flat


**Regionally: Significant demand & competition**

- NSF: 24% of federal support for basic research in U.S. universities
Future NSF Investments: 10 Big Ideas

Enhance Diversity: collective impact of various collaborators with common problem
- 30% in S&E are minorities vs. 53% of population in 2050
- INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

Process Ideas

Grow Convergent Research at NSF
- Cross-directorate, interdisciplinary approaches to grand challenges
- Creative partnerships and thinking

Midscale Research Infrastructure $20 million < mid-scale <$100 million

Integrative Foundational Fund: NSF 2050
- Community / stakeholder input into long-term program development

Research Ideas

Predicting Phenotype: Understand Rules of Life: genes + env $\rightarrow$ phenotype
- disease risk, therapeutic response, crop yield, environment remediation
- Converge biology, computer science, math, behavioral science, engineering via data integration, analysis, modeling, informatics e.g., iPlant collaborative
Future NSF Investments: 10 Big Ideas

Shaping the Human-Technology Frontier
- Living labs, community-scale testbeds
- Work/productivity, system design, human behavior, social organization, learning

Multimessenger Astrophysics: nature of matter, energy, accelerating universe
- Ground-based astronomy, particle astrophysics, gravitational physics

Navigating the New Arctic
- Observing network of mobile and fixed platforms
- Document biological, physical, social changes from 2X warming rate vs. earth

Harness data for Science and Engineering 21st Century
- National research data infrastructure
- Data-driven discovery: visualization, data mining, machine learning

Lead the Quantum Revolution: quantum mechanics, behavior, systems
- Sensing, computing, communication, modeling
- Lasers, computers, LEDs
Ingredients

**Essentials:**
- ½ cup transformative vision
- ⅓ cup interdisciplinary expertise
- 1 small core facility
- 1 small website (1 cup)
- 3 stalks foundational knowledge, chopped (1 cup)
- 1 28-oz. can diced innovation
- 2 cups fresh collaborators
- 1 inclusive culture (2 cups)
- 1 database server, diced (1 cup)
- 1 Tbs. ground intuition
- 1 Tbs. visual resources
- 1 Tbs. engagement
- ¼ tsp. legal infrastructure

**Optional:**
- 1 cup fresh or frozen sliced humor
- 2 tablespoons enthusiasm (randomly delicious)
- salt to taste

**Directions:**

1. Stir together vision and expertise in Dutch oven or heavy-bottomed pot until smooth. Cook over high heat several weeks to months, or until collaboration turns a vigorous color, stirring constantly.

2. Add core facility, website, and knowledge and cook 5 weeks, or until disciplinary perspectives are softened. Stir in all remaining ingredients and 4 cups communication. Reduce heat to medium-low, cover, and cook several weeks, or until team is aligned.

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