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

ILO Summit 2016
Seattle, WA
Tues Aug 2 - Thurs Aug 4, 2016

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

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

OUTLINE

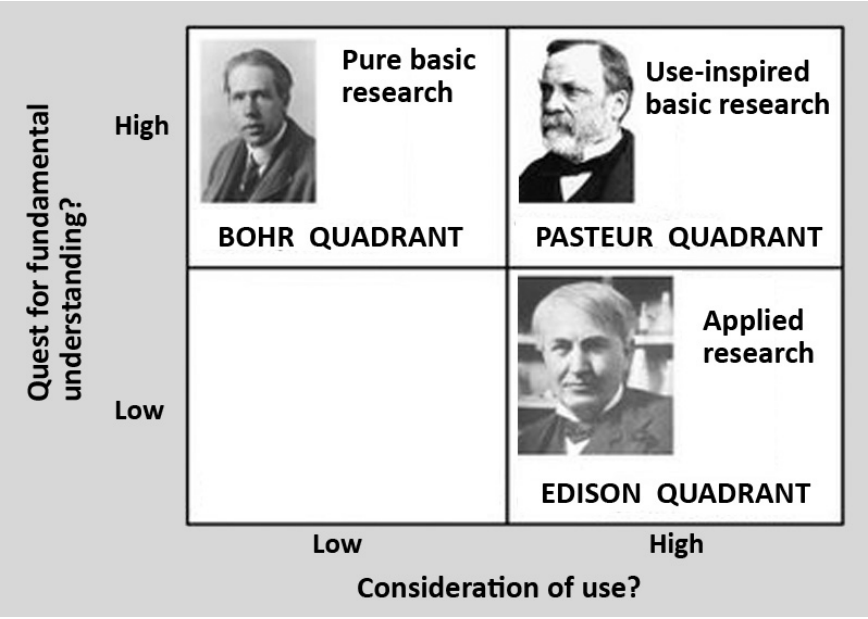
1. ERC vision and framework
2. Status of ERC Program
3. Funding Opportunities – Near Term
4. Funding Opportunities – on the Horizon
5. Future Directions

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

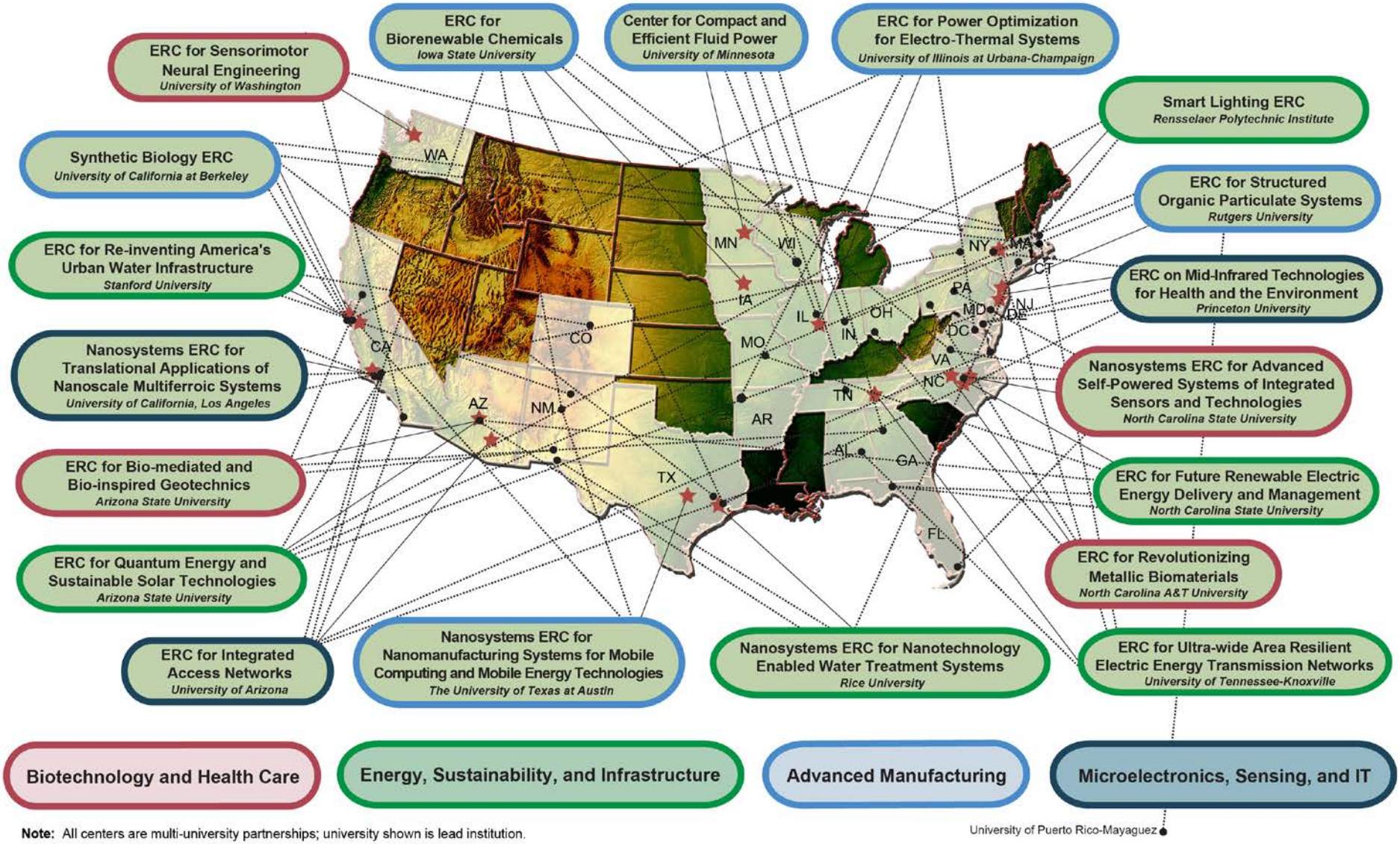


http://scielo.isciii.es/img/revistas/im/v8n2/03-Esparza-Fig3.gif

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 ●



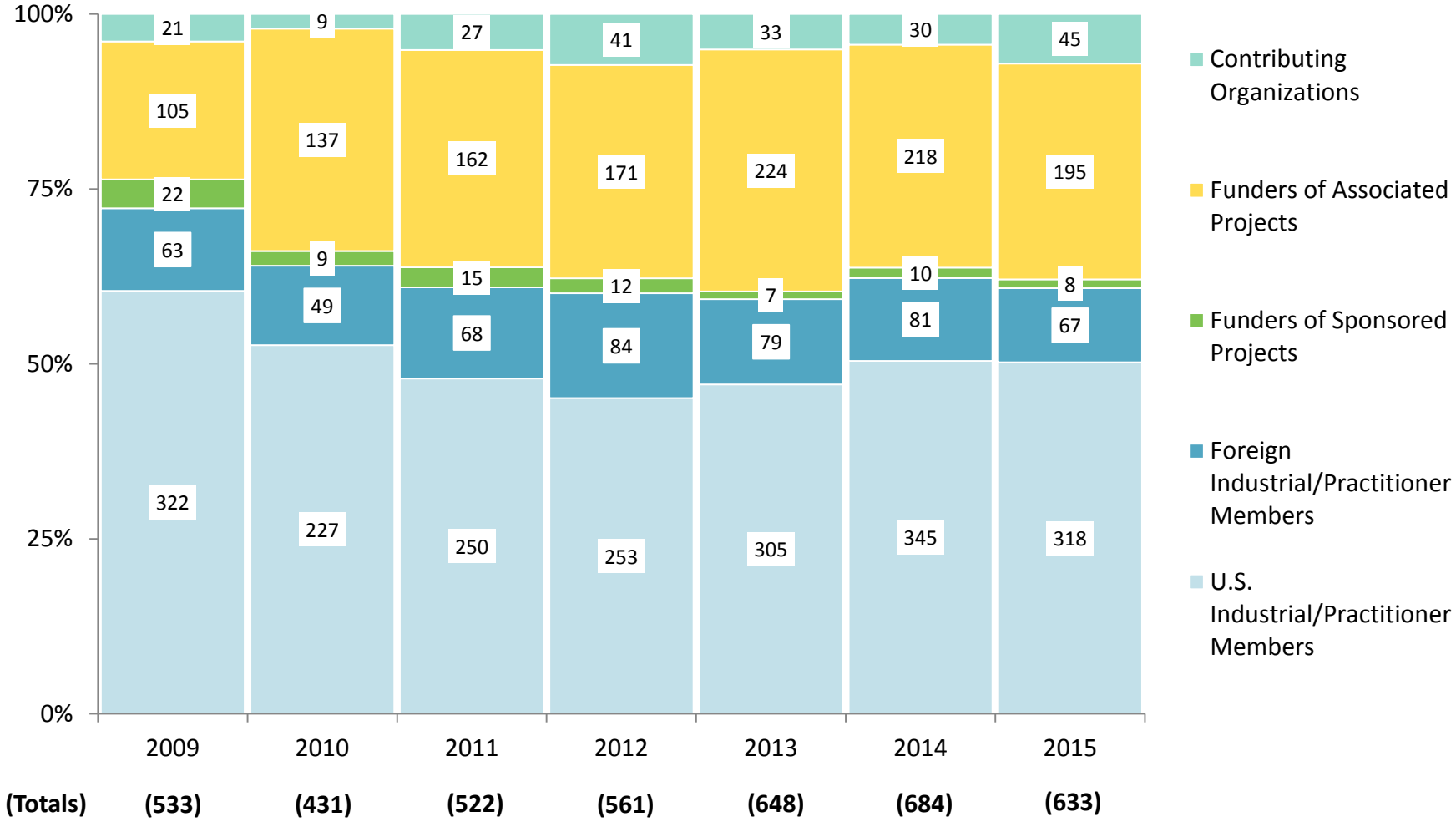
Note: All centers are multi-university partnerships; university shown is lead institution.

ERC Products of Innovation, FY 1985–2015*

	FY (2014) 2015 (17 ERCs)		FY (2009-13)2010–14 Annualized		FY 1985–20(14)15 (61 ERCs)
Intellectual Property Transaction	***Total***	***Per Center***	***Total***	***Per Center***	***Total***
Inventions Disclosed	(117) 118	(6) 7	(95) 102	(6) 6	(2,105) 2,223
Patent Applications Filed (Provisional and Full)	(122) 113	(6) 7	(85) 95	(5) 6	(1,695) 1,808
Patents Awarded	(16) 44	(1) 3	(22) 17	(1) 1	(704) 748
Licenses Issued	(22) 13	(1) 1	(21) 13	(1) 1	(1,326) 1,339
Economic Development	***Total***	***Per Center***	***Total***	***Per Center***	***Total***
Spinoff Companies	(9) 14	(<1) 1	(12) 12	1	(180) 194
Spinoff Employees	(42) 40	(2) 2	(29) 31	2	(1,087) 1,127

** Does not include centers from the Earthquake Technology Sector*

ERC Industrial/Practitioner Members and Supporting Organizations, FY 2008–2015*



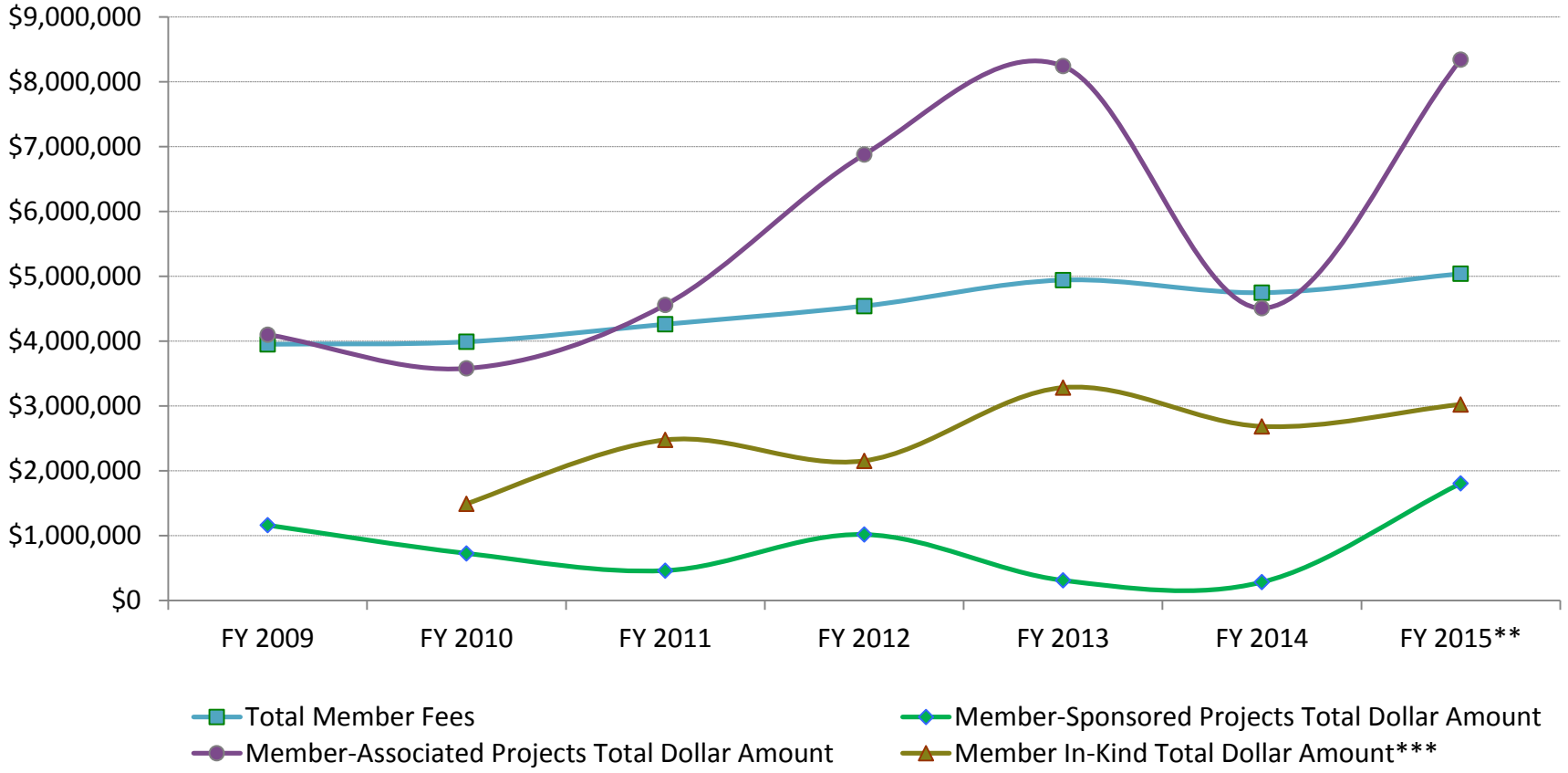
** Does not include centers from the Earthquake Technology Sector*

ERC Industrial/Practitioner Members and Supporting Organizations, FY 2008–2015*

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Organization Type							
Contributing Organizations	21	9	27	41	33	30	45
Funders of Associated Projects	105	137	162	171	224	218	195
Funders of Sponsored Projects	22	9	15	12	7	10	8
Foreign Industrial/Practitioner Members	63	49	68	84	79	81	67
U.S. Industrial/Practitioner Members	322	227	250	253	305	345	318
Total Number of Organizations	***533***	***431***	***522***	***561***	***648***	***684***	***633***
Total Number of Centers	***20***	***15***	***14***	***17***	***20***	***20***	***17***
Average Number of Organizations per Center	***27***	***29***	***37***	***33***	***32***	***34***	***37***

** Does not include centers from the Earthquake Technology Sector*

Industrial/Practitioner Member Support by Year, FY 2008–2015*

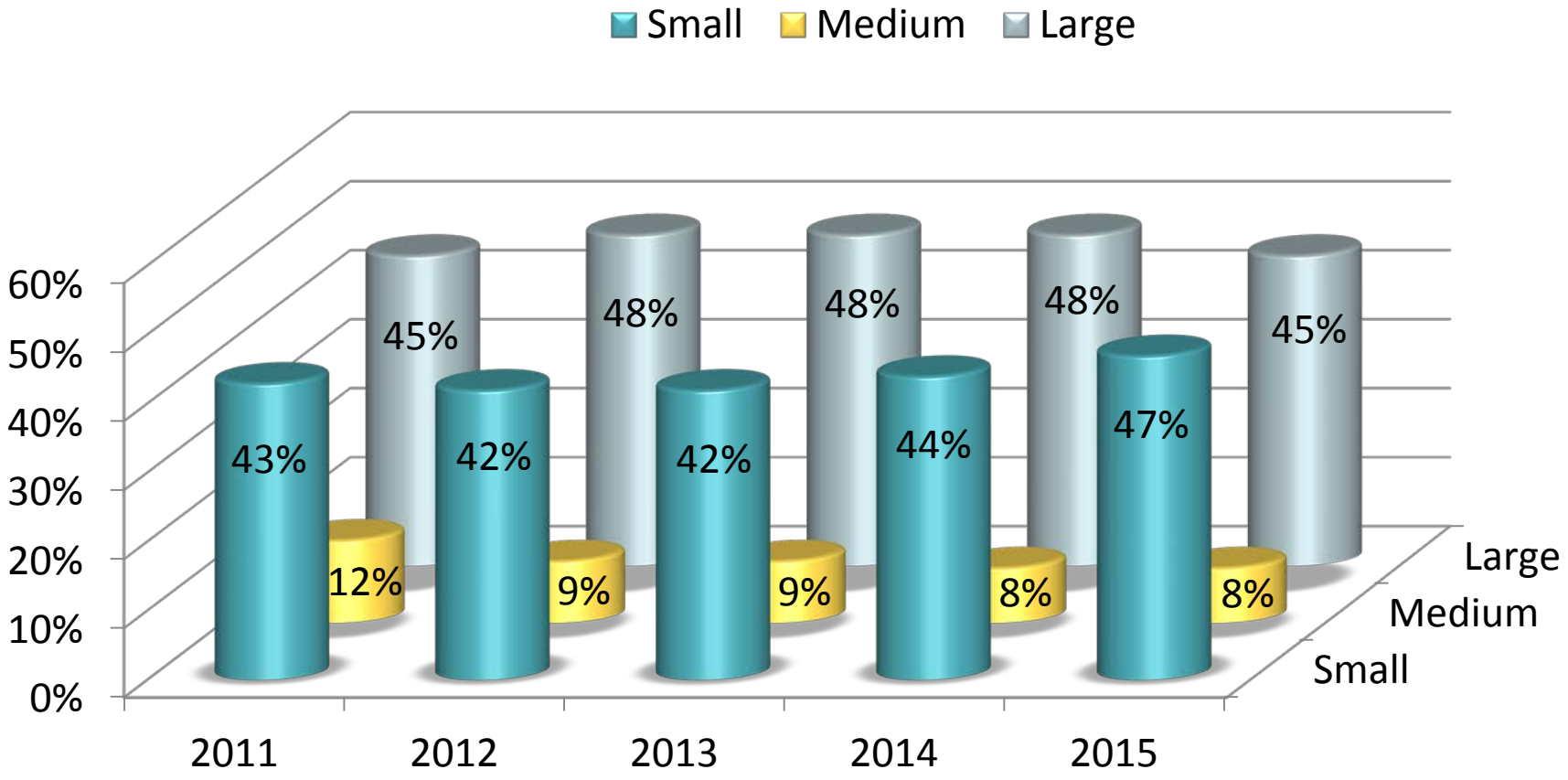


** Does not include centers from the Earthquake Technology Sector*

*** 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.*

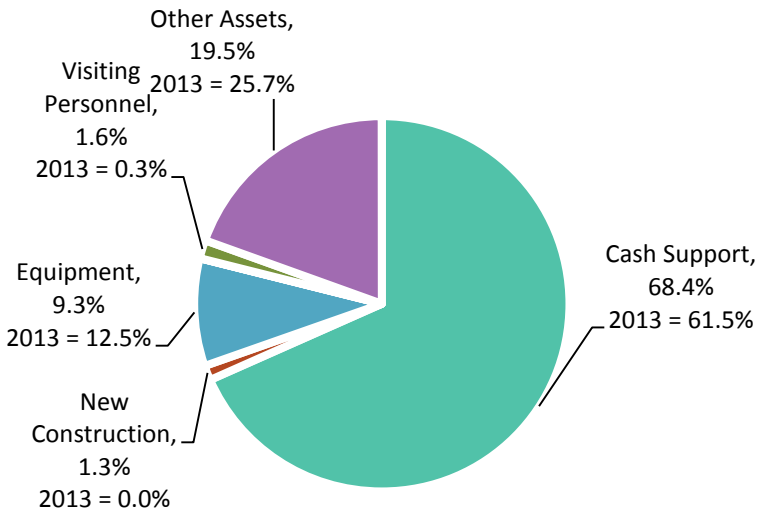
Distribution of Industrial/Practitioner Members by Industry Size



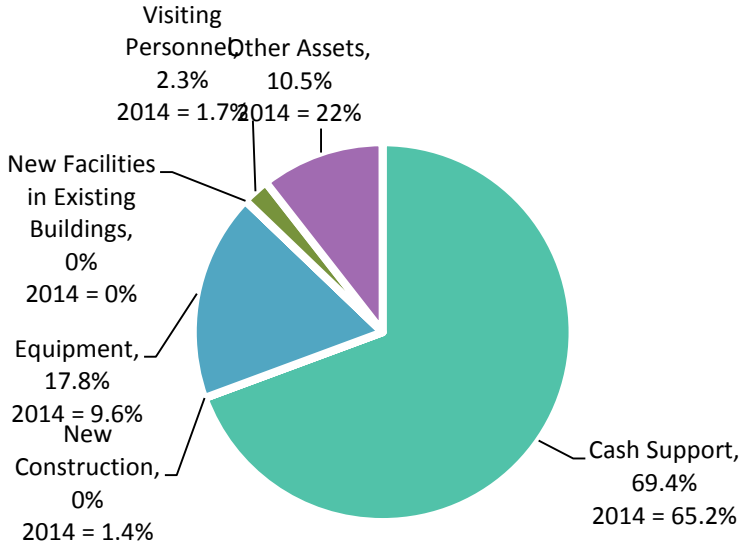
NOTES:

- *The total number of firms is as follows: 2010: 253, 2011: 292, 2012: 306, 2013: 337, 2014: 328.*
- *Industry sizes are as follows: Small = <500 employees, Medium = 500–1,000 employees, Large = >1,000 employees.*

Industrial/Practitioner New Support to ERCs

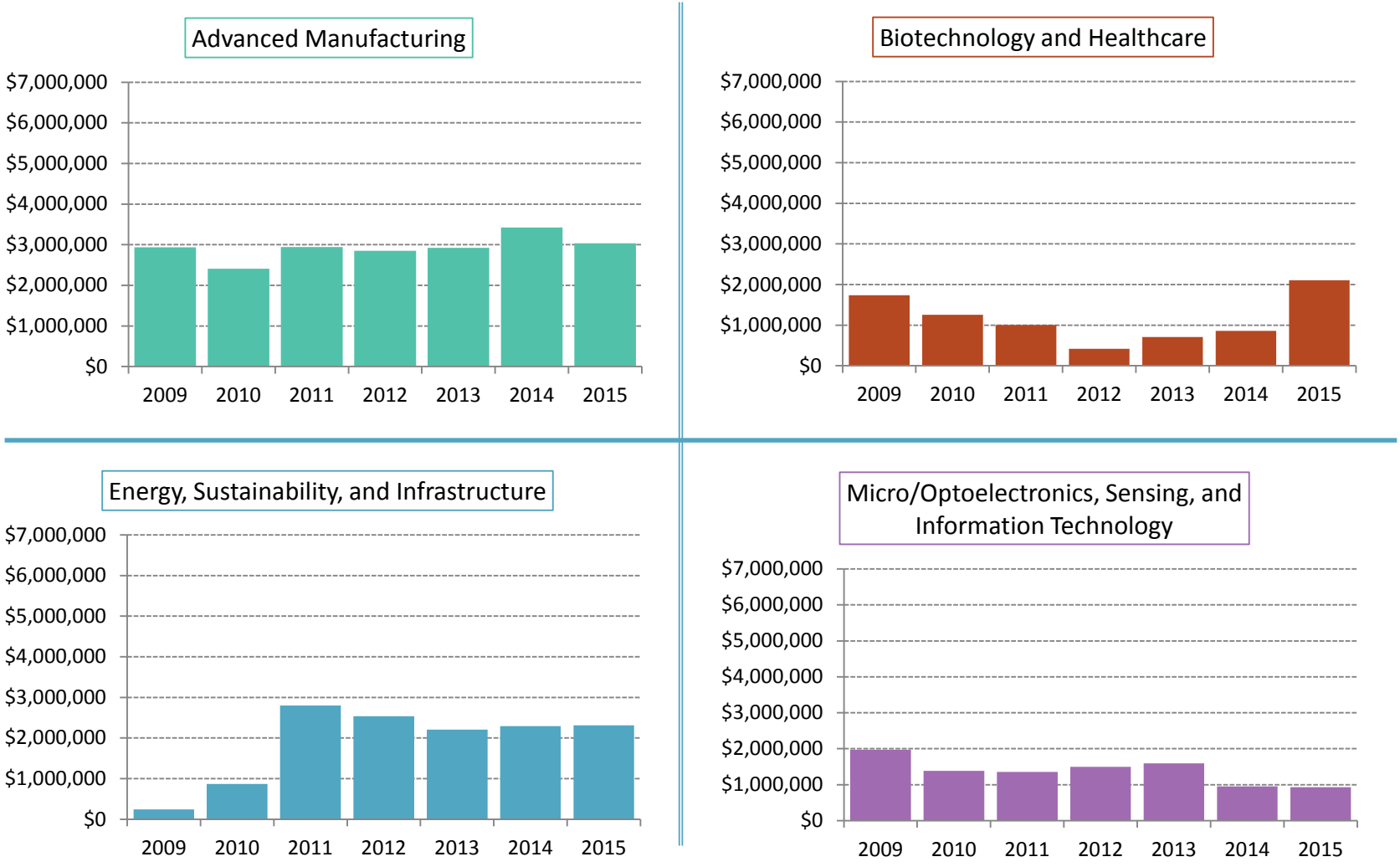


FY2014 20 ERCs
Total value of support:
$8.5 million



FY2015 17 ERCs
Total value of support:
$9.9 million

Industry Support by ERC Technology Sector*,**,***

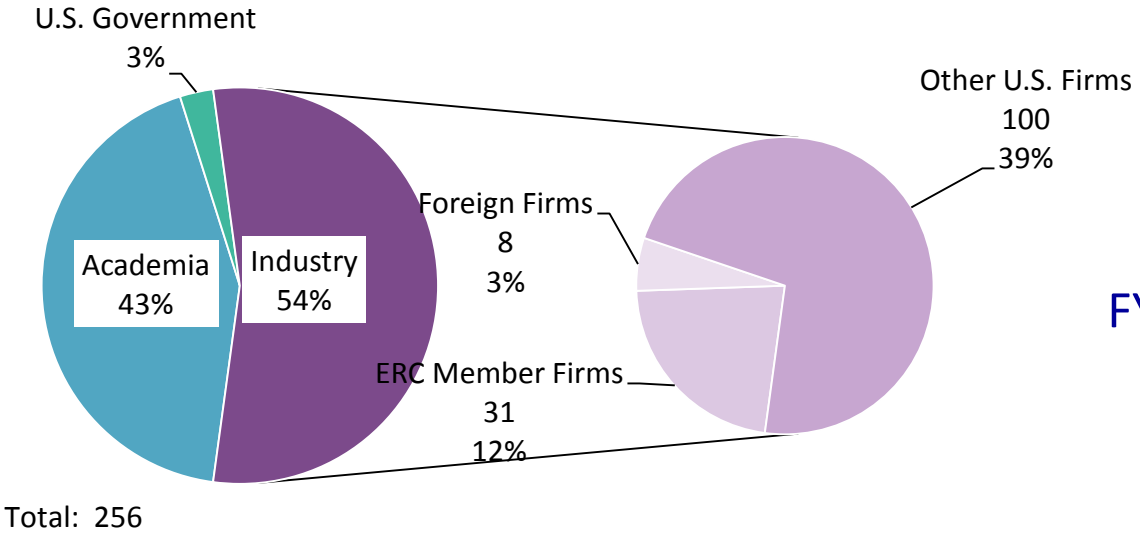


** Does not include centers from the Earthquake Technology Sector*

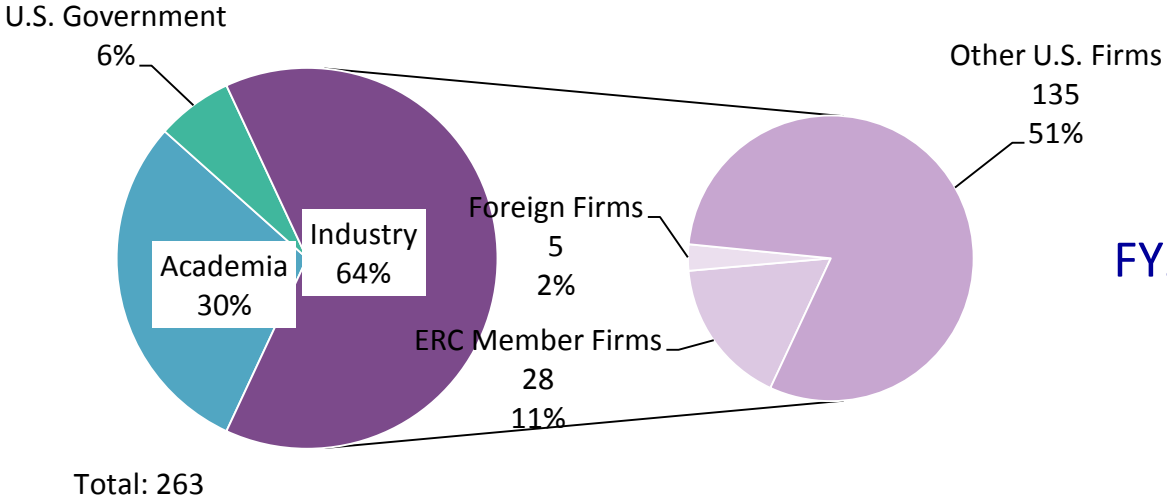
*** Support includes Unrestricted Cash, Restricted Cash, and In-Kind Support.*

**** 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
2. Status of ERC Program
3. Funding Opportunities – Near Term
4. Funding Opportunities – on the Horizon
5. Future Directions

Funding Opportunities: A Recipe :)

Ingredients

Essentials:
½ cup vegetable oil
⅓ 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

www.mccormick.com

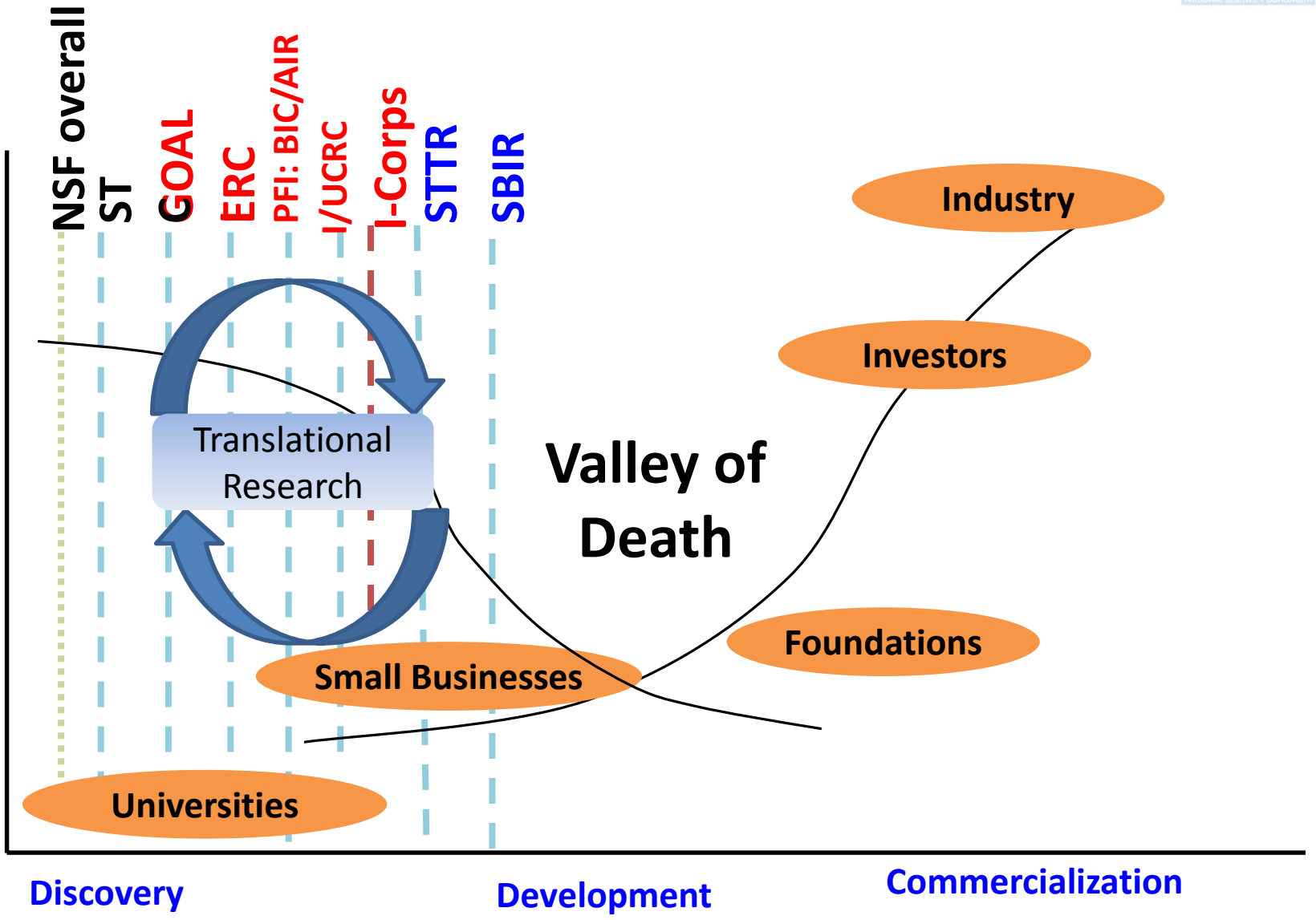
Directions:

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.

Vegetarian tImes

Research to Commercialization NSF Programs



Large Scale NSF Programs

NSF Program	Awards/ Proposals	Ann. Budget ($ millions)	Duration (years)	Cycle (years)
Science and Technology Center (STC) OIA: D. Brzakovic, dbrzakov@nsf.gov	4/259	5	5+5	2-3
Engineering Research Center (ERC) ENG/EEC: K. Roper, kroper@nsf.gov	4/170	4.25	5+5	2
NSF Research Traineeships (NRT) EHR/DGE: R. Tankersley, rtankers@nsf.gov	8/na	0.6	5	1
Emerging Frontiers in Research & Eng. (EFRI) ENG/EFRI: S. Rastegar, srastega@nsf.gov	9/na	0.5	3	1
Science of Learning Collaborative Network (SLC) SBE/BCS: S. Lim, slim@nsf.gov	13/na	0.25	3	1
Neural & Cognitive Systems (NCS) CISE/IIS: K. Whang, kwhang@nsf.gov	16/na	0.27	3	1
Network for Computational Nanotechnol. (NCN) ENG/EEC: K. Roper, kroper@nsf.gov	3/10	0.7	5	5
Industry/Univ. Cooperative Research Ctr (I/UCRC) ENG/IIP: R. Montelli, rmontell@nsf.gov	3/4/5 parners per site	0.15/0.1/0.05 per site	5/5/5	1

NSF 15-589: ERC Specific Review Criteria

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

NSF-SFI-DEL NI C2C Collaboration

- 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

C2C (New) Specific Review Criteria

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

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

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

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**

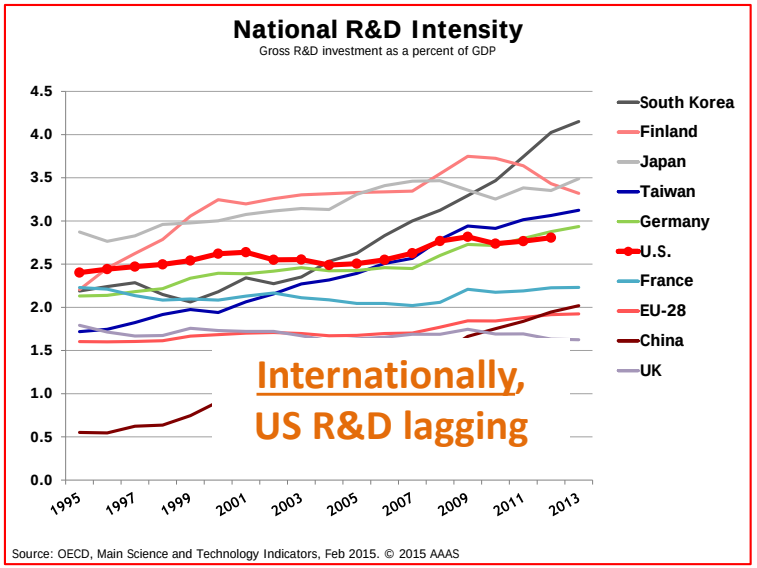
ENG Special Emphases under Mandatory Funding

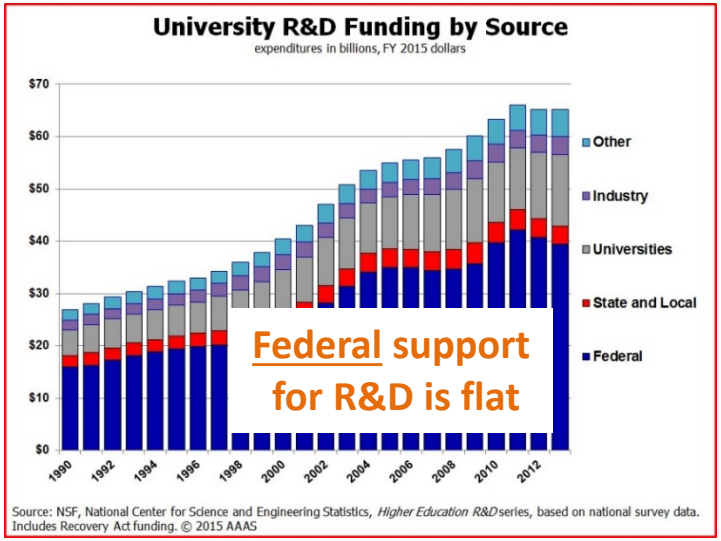
- Early-career investigators
- Transformative use of data and cyberinfrastructure to stimulate data-intensive engineering research
- Disruptive technologies to enable post-Moore's law computing devices and systems

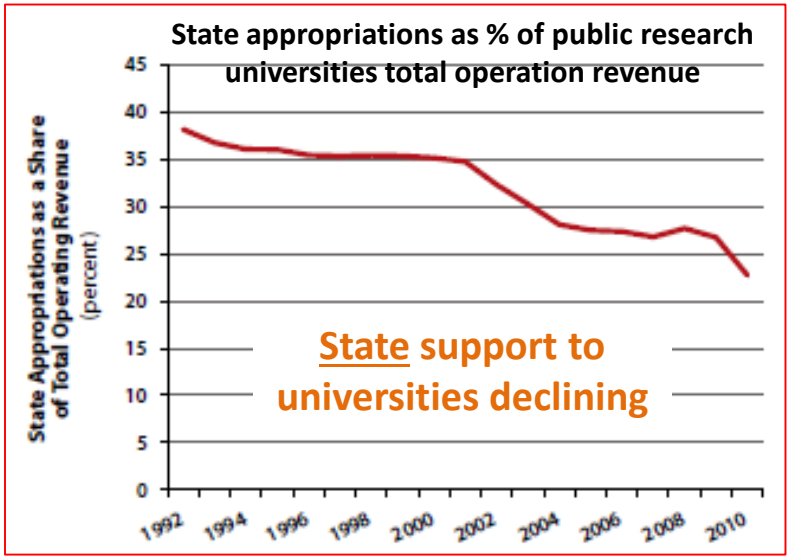
OUTLINE

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

Challenges/Opportunities: R&D Landscape







Regionally: Significant demand & competition

- NSF: 24% of federal support for basic research in U.S. universities

NSF NCSES

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

Bon Appétit!

kroper@nsf.gov

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

www.mccormick.com

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.