

Engineering Directorate Report

Pramod Khargonekar
NSF Assistant Director for
Engineering
October 22, 2014



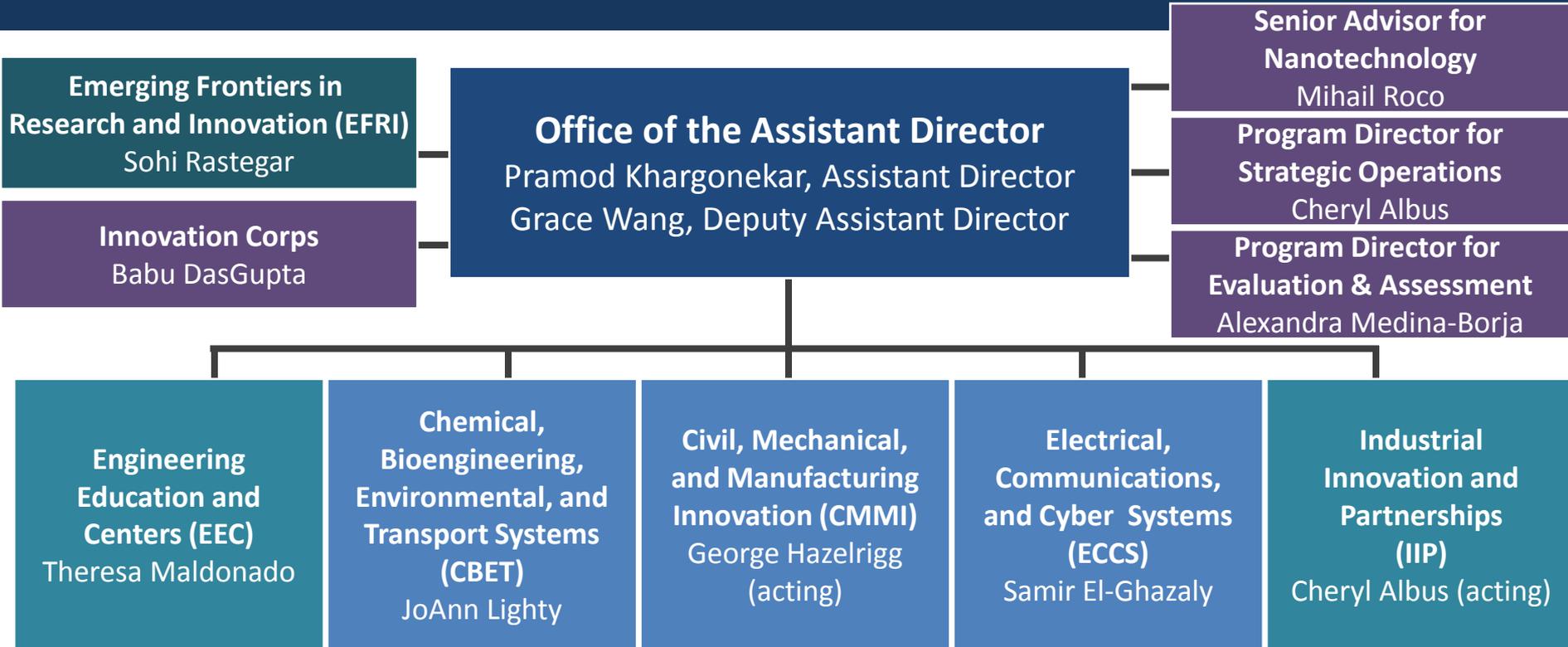
New Advisory Committee Members

Curtis Carlson, SRI International

Louis Martin-Vega, NCSU

S. Shankar Sastry, UC Berkeley

NSF Directorate for Engineering (ENG)



Open Positions

- **Division Director, EEC**
- Division Director, CMMI
- Division Director, IIP
- Deputy Division Directors for ECCS, EEC, and IIP
- CBET program directors
 - Catalysis and Biocatalysis
 - Thermal Transport Processes
- ECCS program directors
 - Communications, Circuits, and Sensing Systems
 - Electronic, Photonic and Magnetic Devices
- EEC program director for Engineering Education
- IIP program director for I/UCRCs

New Staff - OAD and EFRI

- Grace Wang, DAD
- Louise Howe, AAAS Fellow in OAD
- Sarah Naylor, AAAS Fellow in OAD
- Adaora Nwdeoye, AAAS Fellow in EFRI

New Staff - CBET

- Sue Kemnitzer, DDD
- Tamara Battle, Science Analyst
- Elinor Bruno, Program Specialist
- Alex Leonessa, PD, General and Age-Related Disabilities Engineering (Virginia Tech)
- Raj Mutharasan, PD, Nano-Biosensing (Drexel)
- Nora Savage, PD, Environmental Health and Safety of Nanotechnology (EPA)
- Jasmine Spencer

New Staff - CMMI

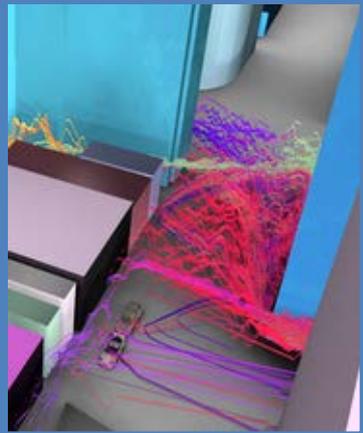
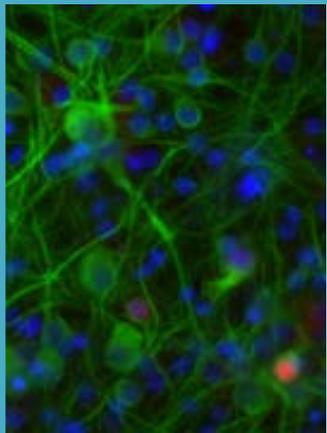
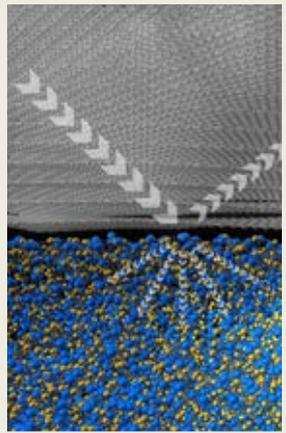
- Larry Bank, PD for Materials Engineering and Processing (City College of NY)
- Jordan Berg, PD, Sensors, Dynamics and Control (Texas Tech)
- Dana Denick, Science Analyst
- Tarneisha Gross, Program Specialist
- Diwakar Gupta, PD, Manufacturing Enterprise Systems (Univ. of Minnesota)
- Elise Miller-Hooks, PD, Civil Infrastructure Systems (Univ. of Maryland)
- Kevin Webster, Program Analyst

New Staff - ECCS

- Mahmoud Fallahi, PD for Electronics, Photonics, and Magnetic Devices (EPMD) in the optics and photonics group (University of Arizona)
- Yuri Podpaly, AAAS Fellow

New Staff - EEC

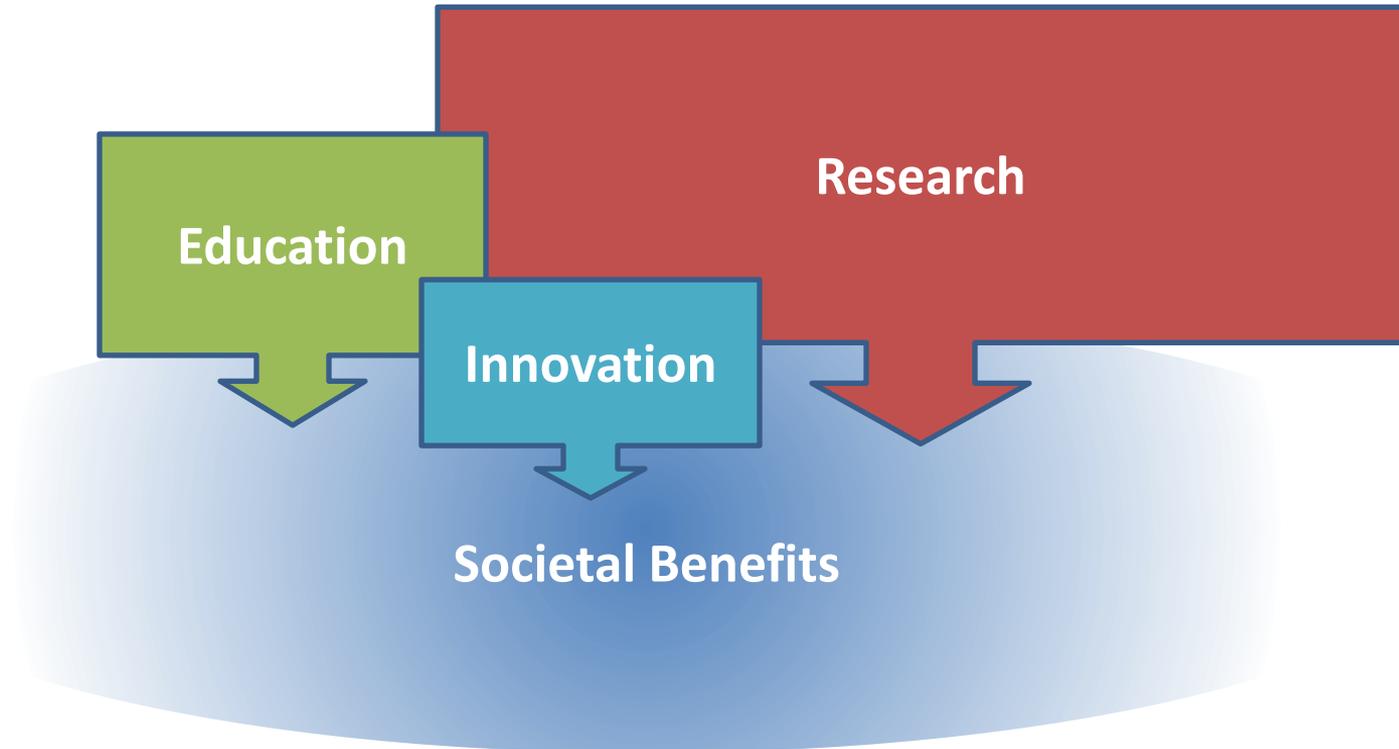
- Don Millard, acting DD
- Daphney Jean, AAAS Fellow
- Ekaette Mbong, AAAS Fellow



Engineering Directorate

FY 2014 REPORT AND FUTURE PERSPECTIVES

NSF ENG: Investing in engineering research and education to foster innovations for benefit to society



ENG prioritizes research critical to the Nation's challenges

- National Initiatives

- Advanced Manufacturing
- Clean Energy
- National Nanotechnology Initiative
- BRAIN

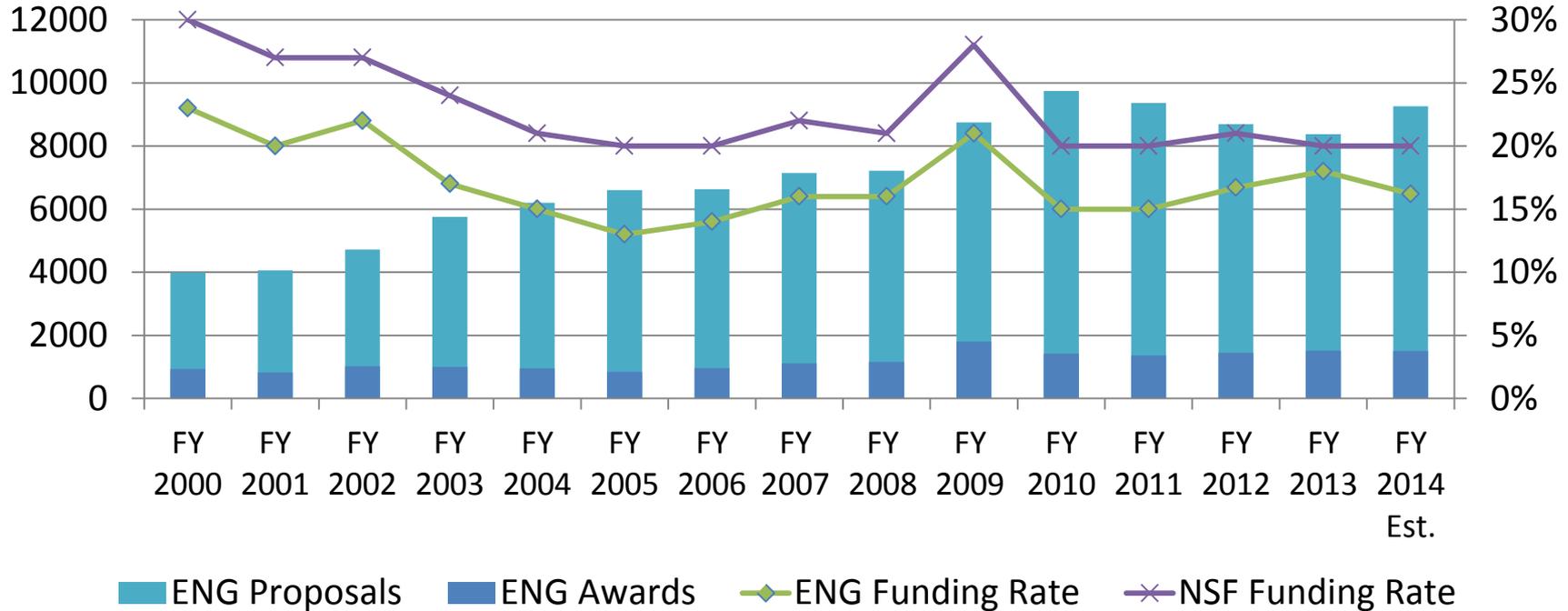
- NSF Cross-cutting Priorities

- Cognitive Science & Neuroscience
- Communications and Cyberinfrastructure
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS)
- Science, Engineering, and Education for Sustainability (SEES)
- Education and Career Development
- Innovation Corps

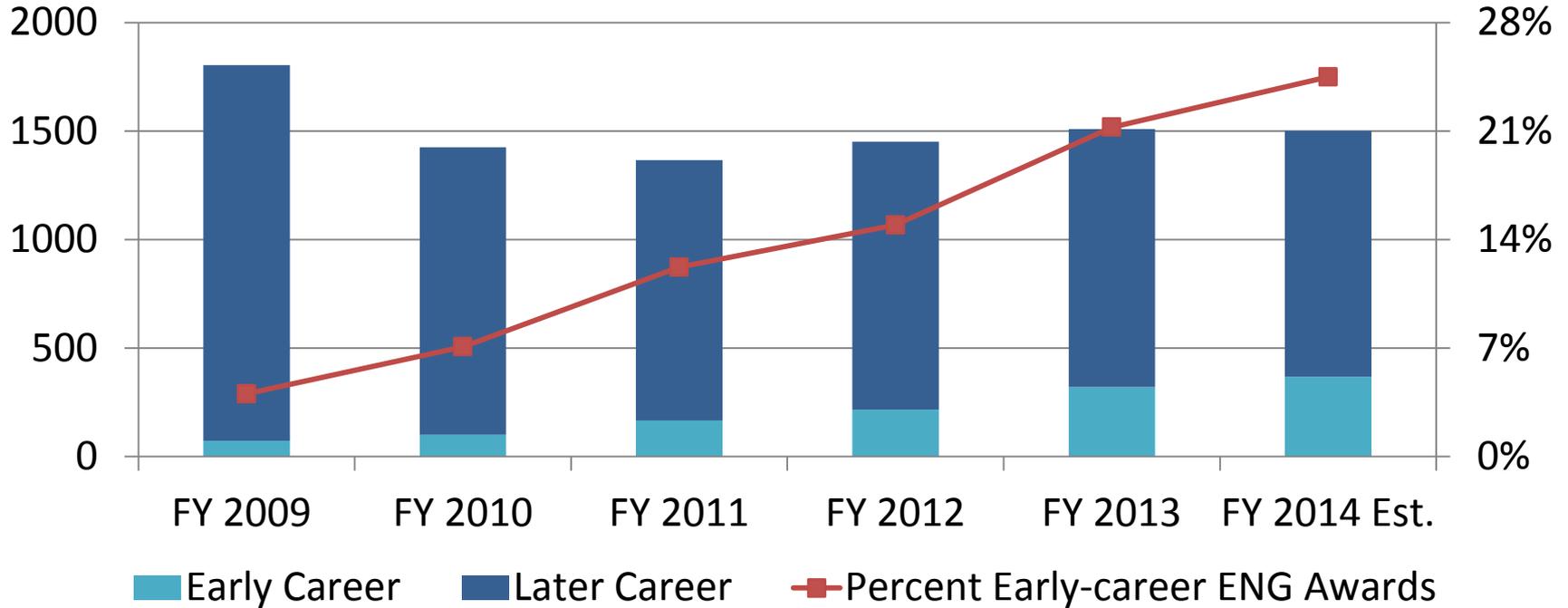
ENG by the Numbers

FY 2014 Est.	
Budget	\$850M
Research Proposals	9,259
New Research Awards	1,502
People, active awards	21,943

ENG Research Proposals and Awards



ENG Research Awards to Early- and Later-career Researchers



What ENG Initiated in FY 2014

Research

- Resilient Interdependent Infrastructure Processes and Systems (RIPS)
- Two-dimensional Atomic-layer Research and Engineering (2-DARE)
- Increase CAREER award size from \$400 k to \$500 k

Education and Workforce

- Broadening Participation in Engineering program (BPE)

Innovation

- PFI: Building Innovation Capacity (BIC) in Smart Service Systems

What ENG is Launching in FY 2015

Research

- Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)
- Understanding the Brain
- Water-Energy-Food nexus via SEES
- Nanotechnology research infrastructure
- Natural hazards engineering research infrastructure
- Ebola-related research

Education and Workforce

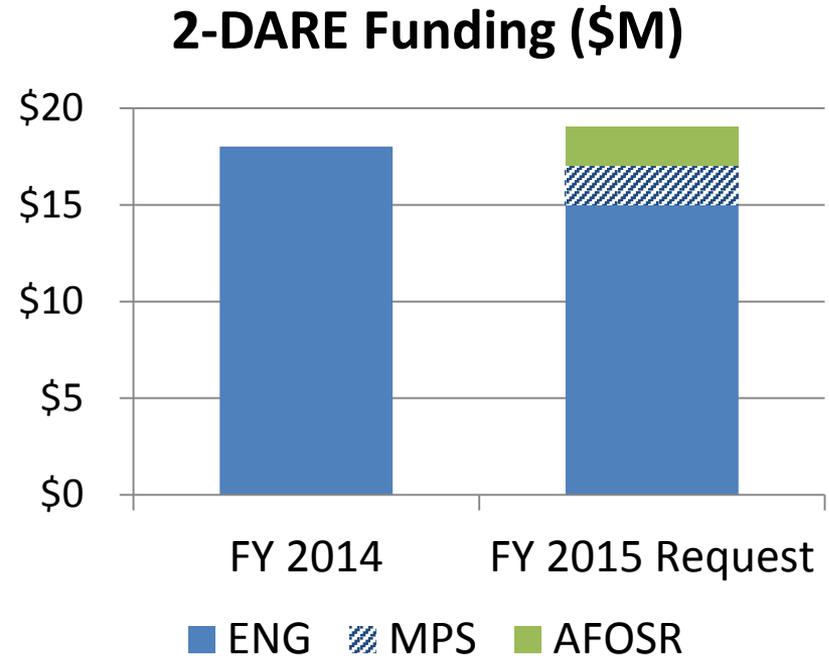
- IUSE / Professional Formation of Engineers: Revolutionizing Engineering Departments (RED)

Innovation

- Scaling up Innovation Corps activities

Emerging Frontiers in Research and Innovation (EFRI)

- Two-dimensional Atomic-layer Research and Engineering (2-DARE)
 - \$18M for 9 projects in FY 2014
 - \$16M for 8 projects planned in FY 2015
- New cross-directorate initiative on risk and resilience in paradigm
 - First Solicitation in 2014 – RIPS
 - New cross-directorate initiative in 2015 – CRISP
- Search for new EFRI Topics for FY 16 is underway



Advanced Manufacturing

- “Advanced manufacturing is a family of activities that
- (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or
 - (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example nanotechnology, chemistry, and biology.

It involves both new ways to manufacture existing products, and the manufacture of new products emerging from new advanced technologies.”

Scalable Nanomanufacturing

- Identifies and supports nanomanufacturing research with high potential to become industrially relevant
- Begun in FY 2011, SNM aligns with NNI Signature Initiative on Sustainable Nanomanufacturing
- ENG contributed nearly \$12M in FY 2014

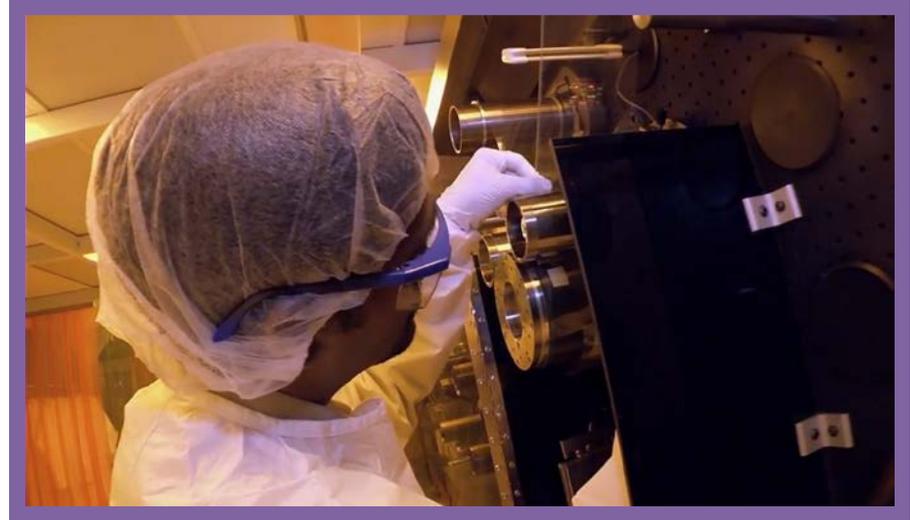


Image credit: NSF

Nanotechnology Infrastructure

- NSF support will bridge NNIN to successor
- Community input on the design of the successor program
 - Community input period, May 2 through June 2
 - Workshop held August 19-20
 - Workshop report published October 1
 - <https://www.src.org/newsroom/src-in-the-news/2014/656/>
- New opportunity for nanotechnology infrastructure support in FY 2015

Manufacturing Institutes

- National Network for Manufacturing Innovation vision for 45 across the country
- NSF will supplement our awardees to collaborate with Institutes
- NSF to set up a strong interface to education (including university-based research)
ENG contributing \$1M to each DOD-led Institute
 - Additive Manufacturing (2012)
 - Digital Manufacturing and Design Innovation (2014)
 - Lightweight and Modern Metals Manufacturing (2014)
- NSF FREEDM Systems ERC is centerpiece of DOE-led institute
 - Wide Bandgap Semiconductors (2014)
- Competitions announced for Clean Energy Manufacturing Innovation Institute for Composites (led by DOE)
- Integrated Photonics Manufacturing Institute (led by DOD): announced on Oct. 3

Understanding the Brain

- FY 2014 groundwork:
 - NSF Steering Committees and Working Groups
 - Exploratory projects
 - www.nsf.gov/brain
 - 2 workshops
- FY 2015
 - NCS - Integrative Strategies for Understanding Neural and Cognitive Systems (CISE, ENG, SBE)
 - I/UCRCs: \$1.5M/year

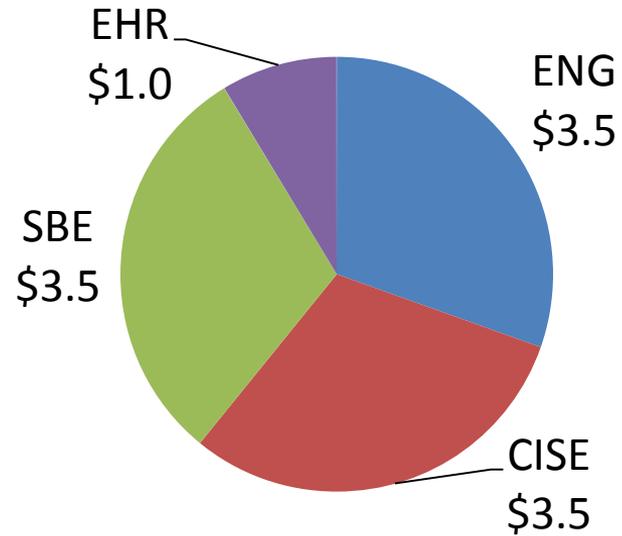
BRAIN Initiative

- Multi-scale integration of brain dynamic activity and structure
- Neurotechnology and research infrastructure
- Quantitative theory and modeling of brain function
- Brain-inspired concepts and designs
- BRAIN workforce development

Integrative Strategies for Understanding Neural and Cognitive Systems (NCS)

- Explaining functionally important **Individuality and Variation**, as well as the role of noise
- Merging insights from neuroscience and cognitive science with those from rapidly changing technologies for **Neuroengineering and Brain-inspired Concepts and Designs**
- ~\$10-12M for 15-25 awards

NCS Funding (\$M), FY 2015 Plan



Cyber-Physical Systems

- Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components
- NSF aims to develop the core system science needed to engineer complex cyber-physical systems upon which people can depend with high confidence.
- ENG, MPS, DHS, DoT contributed \$35M in FY 2014



Image credit: NSF

National Robotics Initiative

- The realization of co-robots: robotic systems that serve as co-workers, co-inhabitants, co-explorers, and co-defenders
- Initiated in FY 2013
- Collaboration among ENG, CISE, EHR, SBE, NASA, NIH, USDA in FY 2014, plus DOD and DARPA in FY 2015



Image courtesy Georgia Tech

Enhancing Access to the Radio Spectrum (EARS)

- Seeks to improve the efficiency of radio spectrum use and the ability for all Americans to benefit from wireless-enabled goods and services
- Multi-year collaboration between ENG, CISE, and MPS



Image courtesy Dept. of Commerce

Big Data: Dynamic Data Systems

- Collaboration between ENG/ECCS and AFOSR
- Big data and computing issues arising from dynamic sensing and control in engineered and natural systems
- DCL dated July 29, 2014
- Thematic areas
 - Dynamic data from ubiquitous sensors and controllers
 - Large scale distributed computing for dynamic data
 - Interactions between data and computing in this context
- Received 80+ EAGER proposals by Sept. 2014 deadline

FY14: Resilient Interdependent Infrastructure Systems (RIPS)

- Paradigm change – Infrastructure as Cyber-Enabled Service
- To enhance understanding and design of interdependent critical infrastructure systems and processes resilient in the face of disruptions and failures from any cause
- ENG, CISE, and SBE funded 10 projects for \$17M in FY 2014

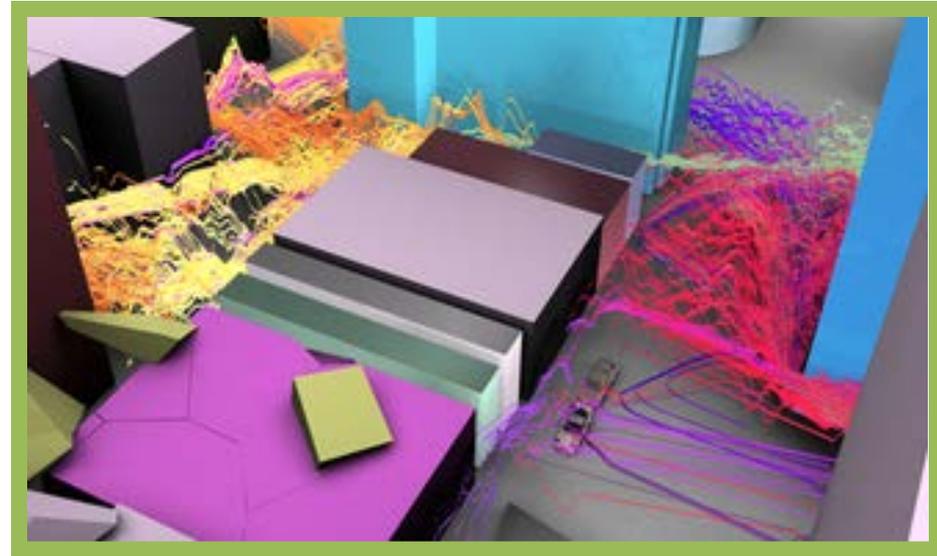


Image credit: Paul M. Torrens, Geography and UMIACS, University of Maryland, College Park

Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)

- Emphasize the understanding and design of interdependent infrastructures as processes delivering services
- Integrate across the cyber-physical, engineering and social, behavioral and economic sciences
- ENG, CISE, and SBE will contribute ~\$20M in FY 2015



Image credit: City of Scottsdale

Natural Hazards Engineering Research Infrastructure (NHERI)

- Successor to NEES
- Supports multi-hazard engineering research and education, focusing on wind and earthquake engineering
- Envisions sustainable civil infrastructure for multi-hazard resilience
- CMMI to contribute up to \$62M for 5 years, starting in FY 2015



Image courtesy FEMA

Engineering Degrees by Gender

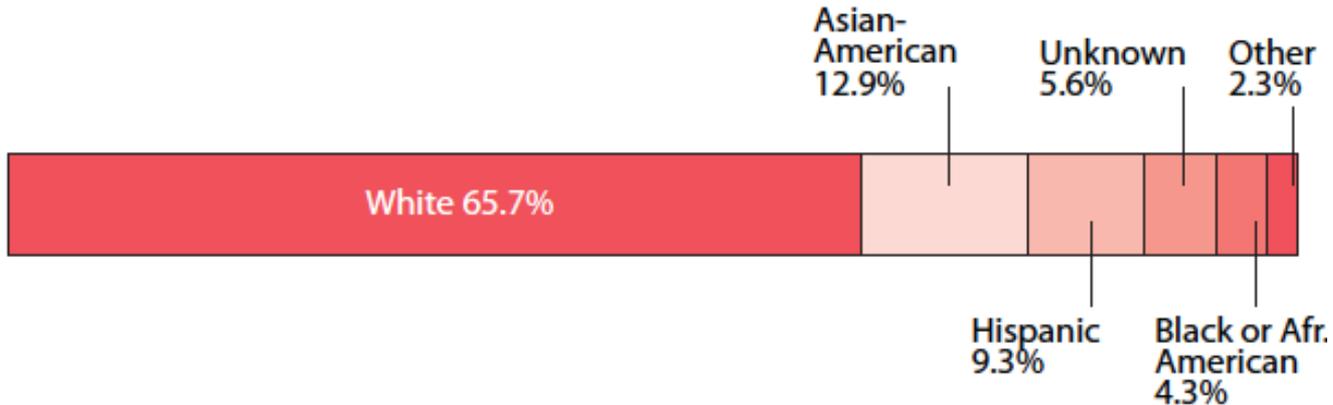
BACHELOR'S DEGREES BY GENDER, 2013



	2004	2005	2006	2007	2008	2009	2010	2011	2012
Female	20.3%	19.5%	19.3%	18.1%	18.0%	17.8%	18.1%	18.4%	18.9%
Male	79.7%	80.5%	80.7%	81.9%	82.0%	82.2%	81.9%	81.6%	81.1%

Engineering Degrees by Ethnicity

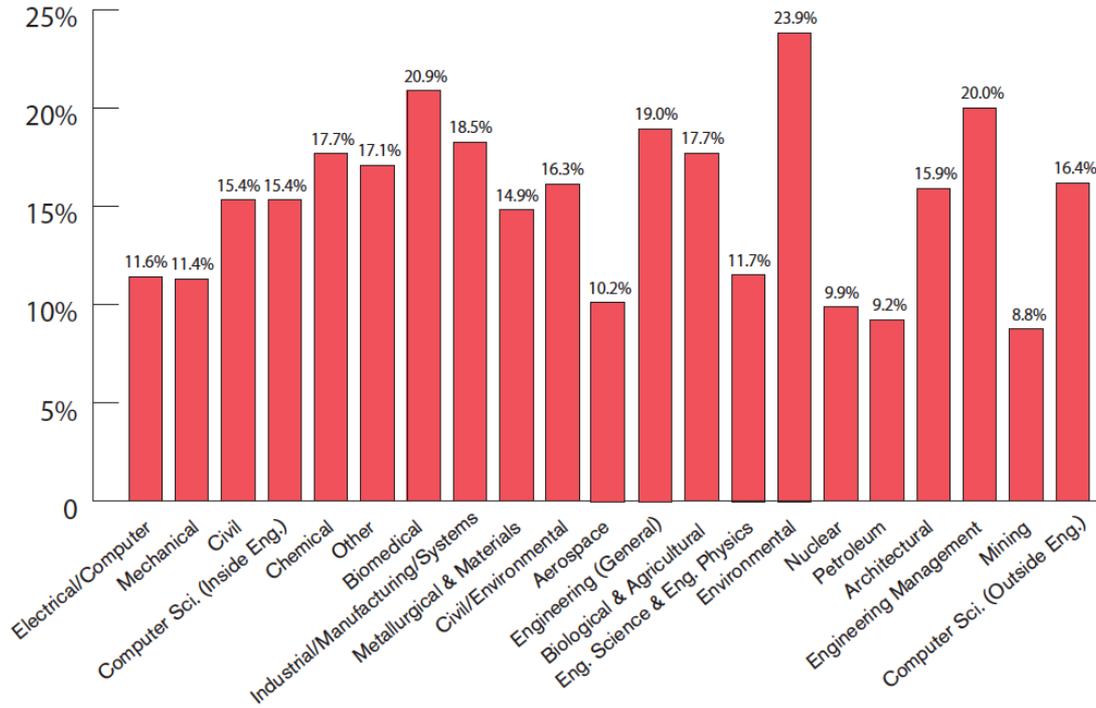
BACHELOR'S DEGREES BY ETHNICITY, 2013*



	2004	2005	2006	2007	2008	2009	2010	2011	2012
Black or African American	5.1%	5.3%	5.0%	4.9%	4.7%	4.6%	4.5%	4.2%	4.2%
Hispanic	5.6%	5.8%	6.0%	6.2%	6.5%	6.6%	7.0%	8.5%	9.0%
Other	8.0%	8.6%	8.5%	8.3%	8.9%	11.0%	1.2%	1.6%	2.0%
Asian American	14.2%	14.1%	13.8%	13.3%	13.0%	12.4%	12.2%	12.2%	12.2%
White	67.1%	66.2%	66.7%	67.3%	66.9%	65.4%	69.8%	66.6%	66.2%
Unknown							5.3%	6.9%	6.5%

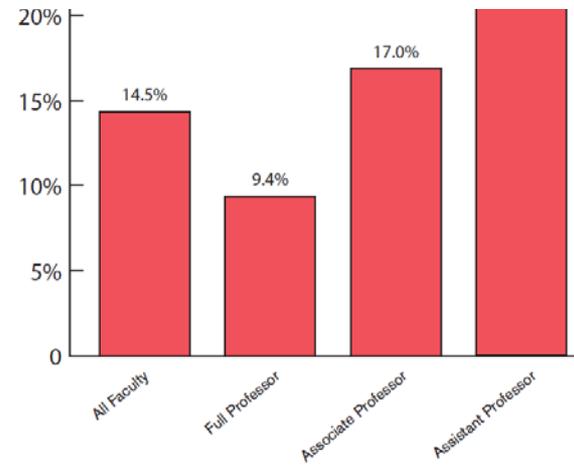
Faculty Diversity

PERCENTAGE OF WOMEN TENURED/TENURE-TRACK FACULTY BY DISCIPLINE: 14.5%



	Women	African-American	Asian	Hispanic
2004	10.4%	2.3%	20.2%	3.2%
2005	10.6%	2.4%	20.9%	3.2%
2006	11.3%	2.4%	22.0%	3.3%
2007	11.8%	2.5%	22.6%	3.4%
2008	12.3%	2.5%	22.7%	3.5%
2009	12.7%	2.5%	23.3%	3.5%
2010	13.2%	2.5%	23.9%	3.6%
2011	13.8%	2.5%	24.1%	3.7%
2012	14.0%	2.7%	24.6%	3.9%
2013	14.5%	2.6%	25.2%	3.6%

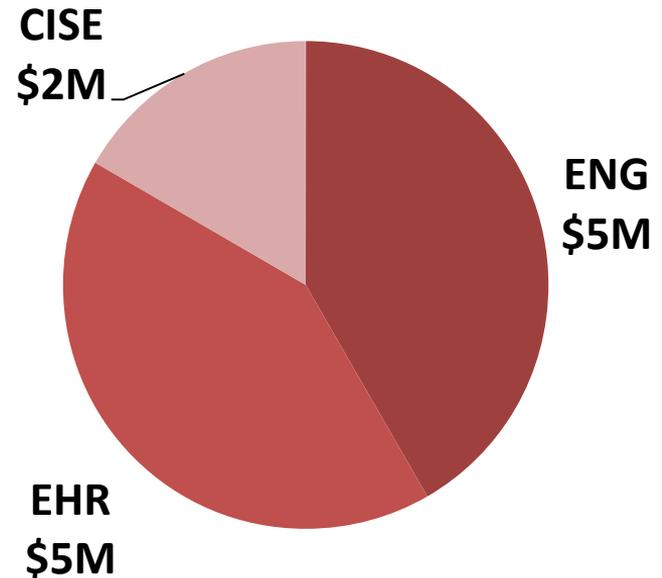
**Note: Includes faculty data from University of Puerto Rico, Mayaguez, Polytechnic University of Puerto Rico and Turabo University*



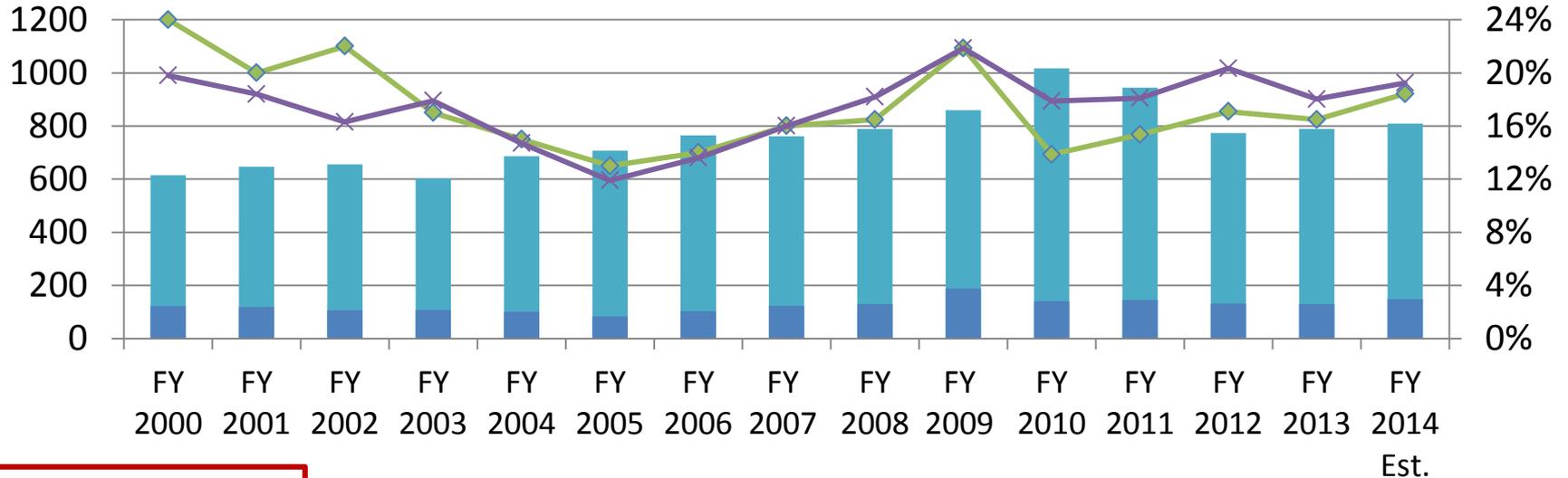
IUSE Professional Formation of Engineers: Revolutionizing Engineering Departments (RED)

- Departments as fulcrum of change
- Department chair as PI
- Aims to create and support an innovative and inclusive engineering profession for the 21st Century
- Scalability and transferability beyond local successes
- Major partnership between ENG, EHR, and CISE.

RED Funding, FY 2015 Plan



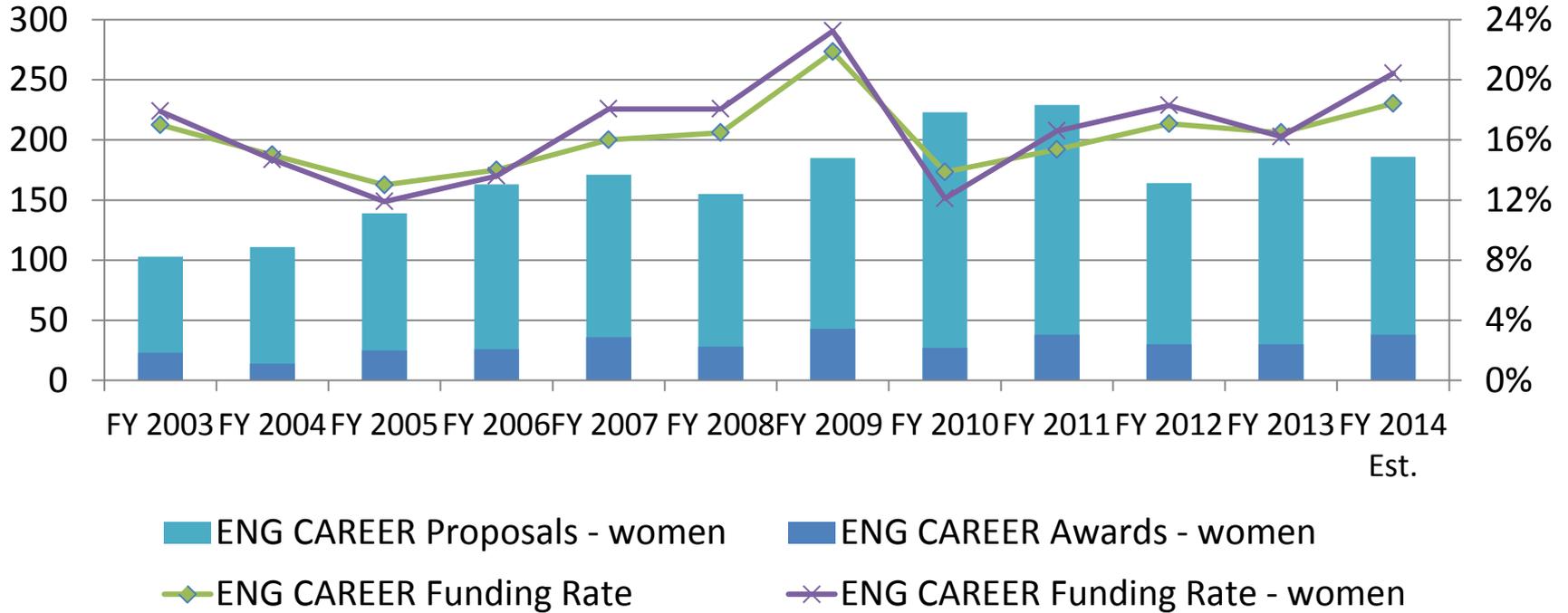
ENG CAREER Proposals and Awards



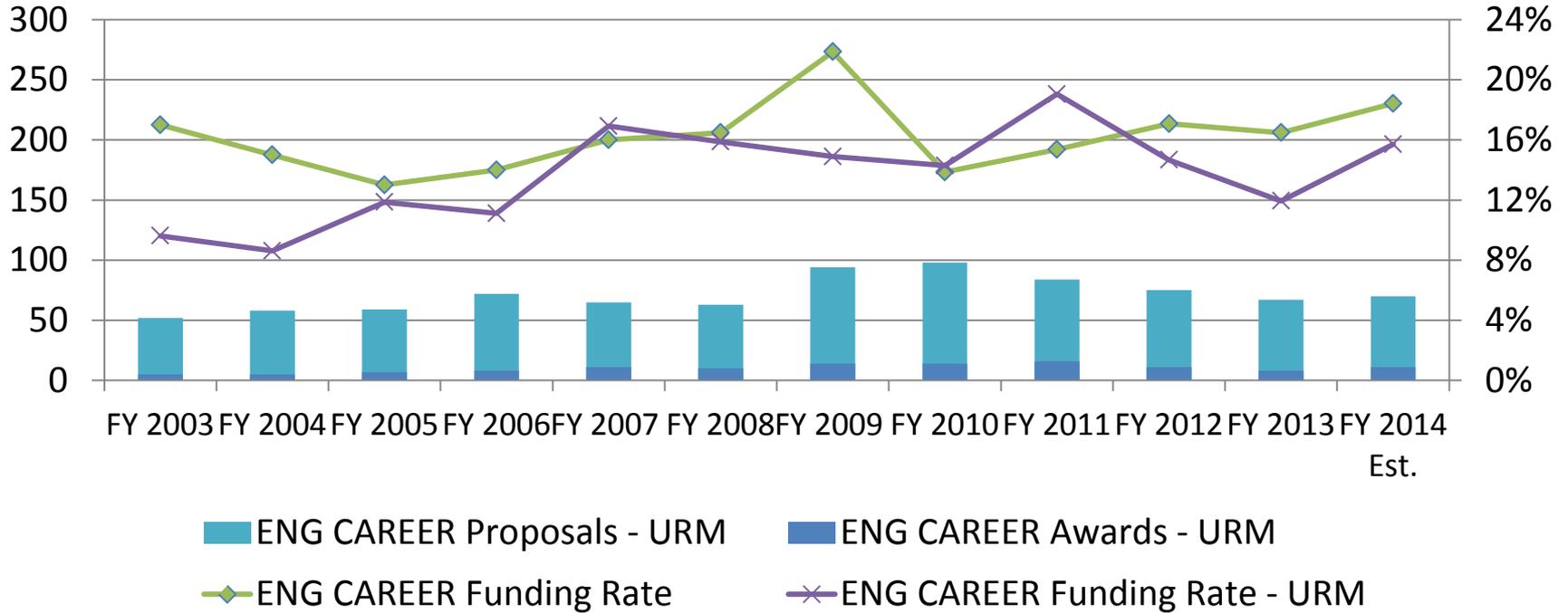
ENG CAREER award size increases to \$500K in FY 2015

■ ENG CAREER Proposals ■ ENG CAREER Awards
◆ ENG CAREER Funding Rate ✕ NSF CAREER Funding Rate

ENG CAREER Proposals and Awards Women



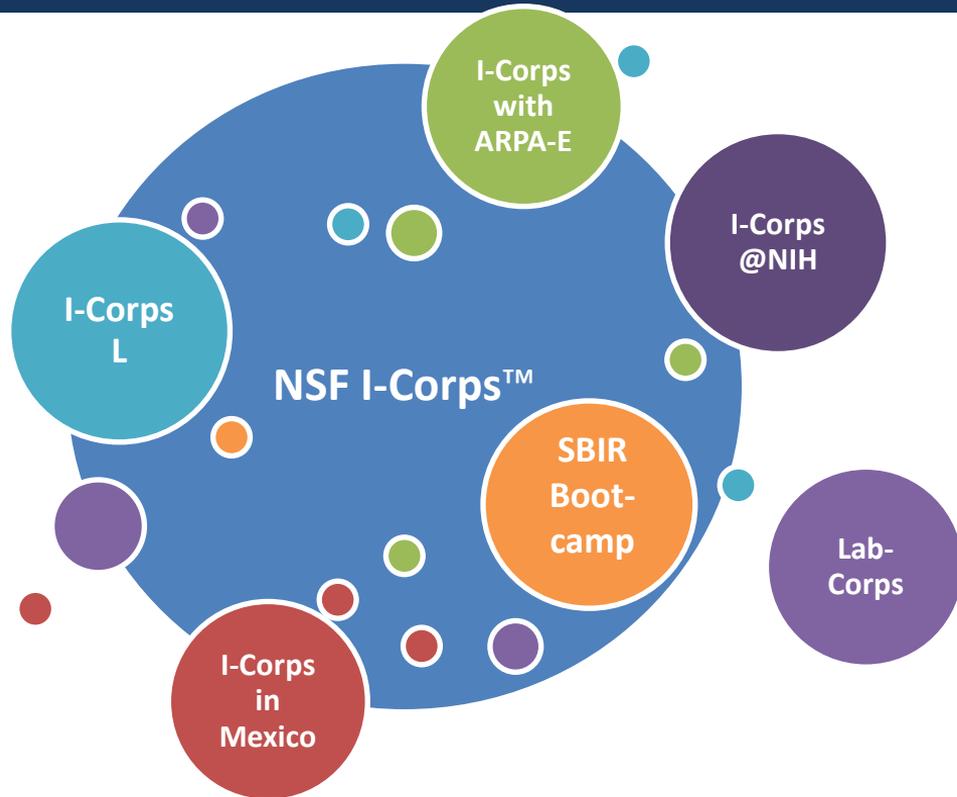
ENG CAREER Proposals and Awards Under-represented Minorities



Innovation Corps (I-Corps™)

- Immersive experiential entrepreneurial education
- Transformative experience for graduate students and faculty
- Continue to build the I-Corps network
- Next phase:
 - Scaling via partnerships with other federal agencies, universities, state government and non-profit organizations
 - Need to ensure the quality of overall I-Corps experience

Scaling Innovation Corps



What has been done so far:

366 I-Corps™ Teams

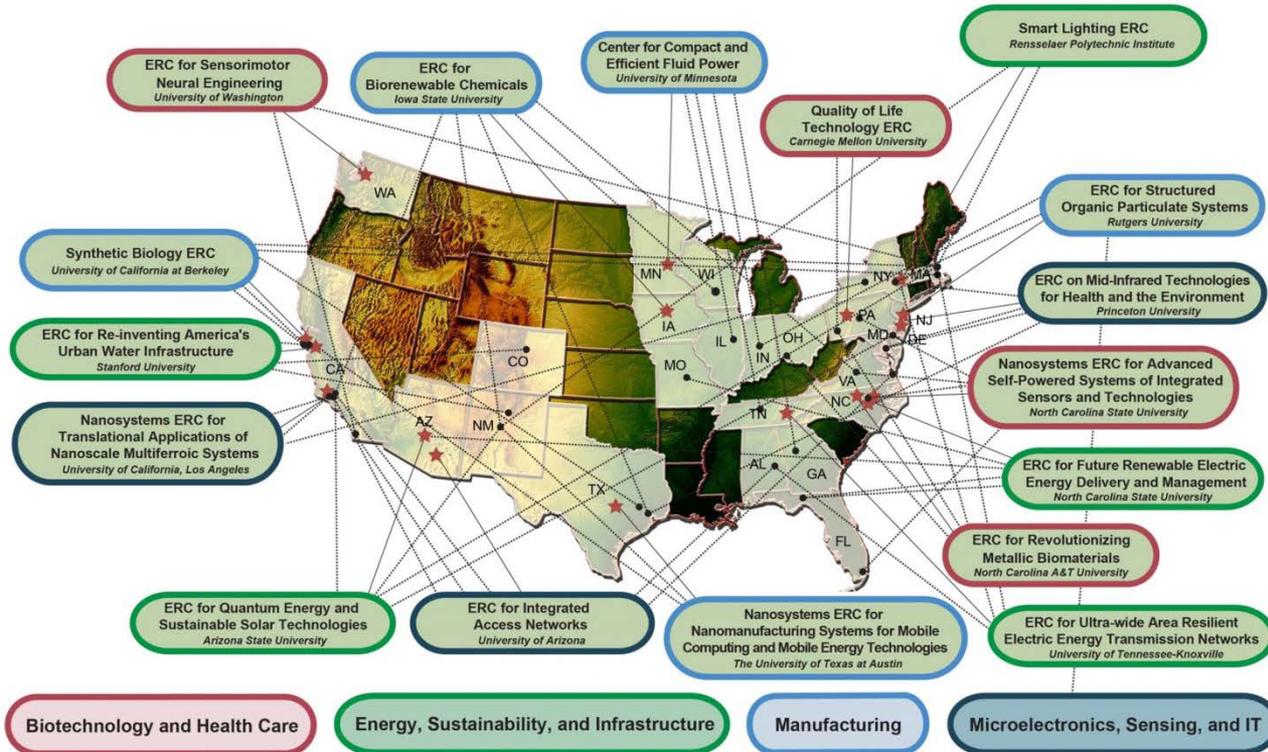
~45% started companies

15 I-Corps Sites

7 I-Corps Nodes

Engineering Research Centers

(Lead institutions ★ and core partners)

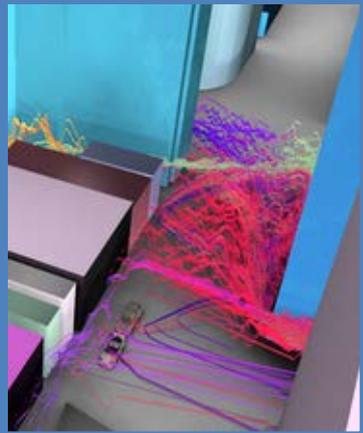
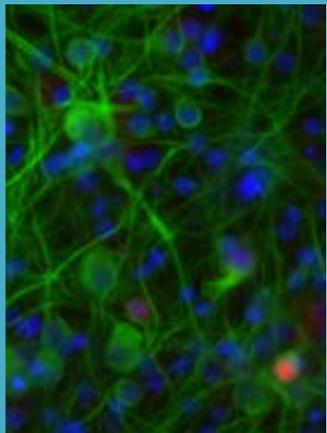
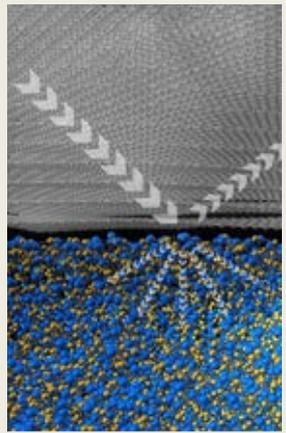


Reproducibility of Research Findings

- Scientific research is claimed to be inherently self correcting
- But there is an increasing concern regarding reproducibility and robustness of published research
- PCAST recommendation to research agencies to address this growing problem
- What is the scale and nature of this problem in engineering research?
- What should NSF ENG do in this regard?

Conclusions

- ENG is very well positioned to contribute to many of the national priorities and goals
- ENG is committed to catalyzing transformative research, educating a diverse engineering workforce, and innovate for society
- ENG is committed to working collaboratively with the academic and industrial community



QUESTIONS, IDEAS, THOUGHTS

Image credits, L to R: ; Jo Wozniak, Texas Advanced Computing Center; Silvia Ferrari, Mechanical Engineering and Materials Science, Duke University; NSF; Paul M. Torrens, Geography and UMIACS, University of Maryland, College Park; West Virginia University.

