Division of Engineering Education and Centers (EEC): A Journey

Dr. José L. Zayas-Castro
Division Director
Milestones in US Engineering — Achievements

Steam engine (1775)
Surveyors map breadth of the U.S. (1795)
First national road (1811)
Industrial Age of Manufacturing begins (1820)
Long distance telegraph line (1843)
Internal combustion engine (1860)
Telephone (1876)

Electric light (1879)
Electric power distribution (1886)
Airplane (1903)
First TV broadcast (US) (1930)
Nuclear reactor (1942)
NSF established (1950)
Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.
National Science Foundation Mission (est. 1950)

“To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
What We Support

**Scale**: Single investigator to mid-size teams to centers and networks

**Breadth**: Single discipline through convergence research

**Career stage**: Undergraduate to grad to postdoc to early to middle to later career

**Innovation cycle**: Basic research through translational research
NSF by the Numbers

11K
Number of awards NSF funds each year

$9.9B
FY 2023 Enacted

39K
Proposals evaluated

$1.6B
STEM education

1.8K
NSF-funded institutions

93%
Funds research, education and related activities

352K
People NSF supported

258
NSF-funded Nobel Prize winners
NSF’s MAJOR PRIORITIES

STRENGTHENING ESTABLISHED NSF

INSPIRING MISSING MILLIONS

ACCELERATING TECHNOLOGY AND INNOVATION

 Advance Emerging Industries for National and Economic Security

Build a Resilient Planet

Create Opportunities Everywhere

Strengthen Research Infrastructure
Emerging Industries

- Advanced Manufacturing
- Advanced Wireless
- Biotechnology
- Quantum Information Technology
- Semiconductors and Microelectronics
- Artificial Intelligence
NSF’s Eight Research Directorates

- Computer & Information Science & Engineering CISE
- Biological Sciences BIO
- Mathematical & Physical Sciences MPS
- Geosciences GEO
- Engineering ENG
- Social, Behavioral & Economic Sciences SBE
- STEM Education EDU

TECHNOLOGY, INNOVATION AND PARTNERSHIPS (TIP)
NSF Organizational Chart

Office of the Director (OD)
- Office of the Director (OD)
- Office of the General Counsel (OGC)
- Office of Integrative Activities (OIA)
- Office of Legislative and Public Affairs (OLPA)
- Office of International Science and Engineering (OISE)
- Office of Equity and Civil Rights (OECR)
- Office of the Director (OD)
- Office of Inspector General (OIG)
- National Science Board (NSB)

Directorates
- Biological Sciences (BIO)
- Engineering (ENG)
- Geosciences (GEO)
- Education and Human Resources (EHR)
- Mathematical and Physical Sciences (MPS)
- Social, Behavioral, and Economic Sciences (SBE)
- Budget, Finance, and Award Management (BFA)
- Technology, Innovation, and Partnerships (TIP)
- Information and Resource Management (OIRM)
NSF Directorate for Engineering

Emerging Frontiers and Multidisciplinary Activities
Sohi Rastegar

Senior Advisor for Science and Engineering
Mihail Roco

Assistant Director
Susan Margulies

Deputy Assistant Director
Don Millard

Budget Officer
Darren Dutterer

Operations Officer
Erika Chang

Engineering Education and Centers (EEC)
José Zayas-Castro

Chemical, Bioengineering, Environmental, and Transport Systems (CBET)
Jeanne VanBriesen

Civil, Mechanical, and Manufacturing Innovation (CMMI)
Daniel Linzell

Electrical, Communications, and Cyber Systems (ECCS)
Anthony Maciejewski
ENG by the Numbers: FY 2023

- **$793M** research budget
- **152** ENG staff
- **6,009** proposals
- **444** panels
- **1,506** competitive awards
- **25%** competitive award funding rate
- **22,644** people
- **312** institutions
- **8,962** senior researchers
- **7,736** graduate students
- **653** other professionals
- **4,916** undergraduate students
- **377** postdoctoral associates

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NSF Engineering will be a global leader in identifying and catalyzing fundamental engineering research, innovation, and education.

MISSION

To transform our world for a better tomorrow by driving discovery, inspiring innovation, enriching education, and accelerating access.

VISION

NSF Engineering will be a global leader in identifying and catalyzing fundamental engineering research, innovation, and education.

GOALS

Propel
U.S. leadership in transformational engineering approaches to problems with societal impact

Expand
opportunities for people

Catalyze
purposeful partnerships
Investing in Cross-ENG Strategic Priorities

- Broadening Participation in Engineering
- Equity, Justice, and Access
- Sustainable and Resilient Solutions
- Pathways to Partners for Translation

- Clean energy technology and integrated power systems
- Climate change adaptation and mitigation
- Bioeconomy and biomanufacturing
- Next-gen microelectronics and wireless

Coordinate  Collaborate  Co-fund
Engineering Research Visioning Alliance

Transforming Women's Health Outcomes through Engineering

Visioning Event
June 5-6, 2024
Columbus, OH

www.ervacommunity.org
Engineering Education and Centers (EEC): Four Intertwined and Interdependent Clusters

Centers and Networks (ERC & IUCRC)

Engineering Education (EE)

Broadening Participation in Engineering (BPE)

Workforce Development* (WFD)

* Includes INTERN
We invest in the creation of 21st century engineers and discovery of technologies through transformational center-based research, research in education and broadening participation and workforce development in engineering.

For more info about EEC, visit: [https://www.nsf.gov/eng/eec/about.jsp](https://www.nsf.gov/eng/eec/about.jsp)
Division of Engineering Education and Centers

LEGEND
- Centers & Networks (Centers)
- Engineering Education (EngEd)
- Workforce Development (WD)
- Broadening Participation (BP)

José Zayas-Castro
Division Director

J. Kemi Ladeji-Osias
Deputy Division Director

Jesus Soriano Molla
Program Director

Alisha Williams
Program Support Manager

Marshall Horner
Operations Specialist

Dorian Davis
Science Analyst (on detail to EDU/DUE)

Sarah Yang
Expert

Turquoise Bowen
Program Analyst

Tammy Jennings
Program Analyst

Kevin Nguyen
Program Analyst

Susan Watson
Program Specialist

LaTanya Sanders-Peak
Program Specialist

Shalika Walton
Program Specialist
Originally launched in 1984 based largely on guidelines proposed by the NAE (1983), and updated to Gen-4 in 2019 (NSF 19-503)

Goals:

- Perform transformative research
- Prepare the next generation of leaders
- Strengthen the competitiveness of the U.S.
Four interconnected **foundational components:**

- Convergent Research
- Workforce Development
- Culture of Inclusion
- Innovation Ecosystem
Current Gen-4 ERCs

FY 2020

• Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE) - Create sustainable, equitable and widespread electrification of vehicles by creating low-cost, ubiquitous, and worry-free charging infrastructure.

• Advanced Technologies for Preservation of Biological Systems (ATP-Bio) - Stop biological time - cryogenically cool, hold and re-warm living materials (cells, tissues, organs and whole organisms), extend ability to bank and transport

• Center for Quantum Networks (CQN) - Create foundations for the future quantum internet by developing key quantum technologies and new functional building blocks connecting quantum processors over local and global scales.

• Internet of Things for Precision Agriculture (IoT4Ag) - Ensure food, energy and water security with new systems to increase crop production while minimizing energy and water use and environmental impacts of agricultural practices.
New Gen-4 ERCs

FY 2022

- **Center for Advancing Sustainable and Distributed Fertilizer Production (CASFER)** – Enabling resilient and sustainable food production by developing next generation, modular, distributed, and efficient technology for capturing, recycling, and producing decarbonized nitrogen-based fertilizers (NBFs).

- **Center for Smart Streetscapes (CS3)** - Advance livable, safe, and inclusive communities through real-time, hyperlocal streetscape applications

- **Hybrid Autonomous Manufacturing Moving from Evolution to Revolution (HAMMER)** - Accelerating the development and deployment of intelligent, autonomous manufacturing systems, enabling mass customization in local production facilities.

- **Precision Microbiome Engineering (PreMiEr)** - Creating microbiome technologies that address challenges at the interface of human health and the built environment, promoting the proliferation of beneficial microorganisms and preventing colonization by infectious agents.
ERC Program Achievements since 1985*

- **Spinnoffs**: 250 Spinoff Companies, 1,641 Spinoff Company Employees
- **Graduates**: 5,495 Ph.D., 4,474 M.S., 4,774 B.S.
- **Curricula**: 189 Textbooks, 5,811 Courses
- **Invention Disclosures**: 2,686
- **Licenses**: 1,400
- **Patents**: 929

*as of 2022
Industry-University Research Partnerships (IUCRC) Program

Execute cutting-edge pre-competitive basic research in science and engineering to drive innovation and societal impact (NSF 20-570).

IUCRCs are focused on bridging the gap between early academic research and commercial readiness.

**Government**
- NSF catalyzes partnership
- Other government entities fund research relevant to their needs

**Universities**
- Provide research infrastructure, human capital, and technical expertise

**Industry**
- Provides funding for research and insight for industrially relevant projects

**IUCRC FOCUS**
- Early Stage Research
- Technology Readiness
- Commercial Deployment
Gen-4 ERC Distinguishing Features

- **Engineering systems** focus
- 10-year strategic plan to overcome fundamental technical barriers
- Faculty committed to **convergent research**, multi-institutional/multi-disciplinary team
- Emphasis on **societal impact**
Engineering Education Programs

- Research in the Formation of Engineers (RFE), PD 19-1340
- Research Initiation in Engineering Formation (RIEF), NSF 20-558
- Revolutionizing Engineering Departments (RED), NSF 23-553
- CAREER in Engineering Education
Overview of EEC Engineering Education

- Encourages educational research to create and support an innovative and inclusive technical workforce for the future.
- Supports research that advances our understanding of how people become engineers, explores diverse pathways to and through degree programs, and examines how changes in engineering education spread.
- Funding Mechanisms:
  - Unsolicited Research
  - CAREER
  - Conferences & Workshops
  - EArly-concept Grants for Exploratory Research (EAGER)
  - Rapid Response Research (RAPID)

Professional Formation of Engineers

- Introductions to the profession at any age
- Development of deep technical and professional KSAs in both formal and informal settings
- Development of outlooks, perspectives, ways of thinking, knowing, and doing
- Acculturation to the profession, its standards, and norms

*PFE: the formal and informal processes and value systems by which people become engineers.*
Revolutionizing Engineering Departments (RED)

**Track 1**
RED Innovation projects develop new, revolutionary approaches and change strategies.

**Track 2**
RED Adaptation and Innovation projects adapt and implement evidence-based organizational change strategies.

**Track 3**
RED 2-Year projects develop radically new approaches among multiple two-year institutions to expand pathways to engineering.

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**Developing Changemaking Engineers (1519453)**
- Focused efforts on connecting social to technical by creating 5 new courses and modules to embed social context traditional engineering courses
- Challenges include defining engineering, incorporating sociotechnical, and changing culture

**Innovation Beyond Accommodation: Leveraging Neurodiversity for Engineering Innovation (1920761)**
- Focused efforts on moving beyond limitations of traditional engineering education by creating a radically inclusive department
- Advance personalized learning, increase recruitment and retention of neurodivergent students, improve learning outcomes, and leverage potential for breakthroughs
Common threads across these projects: focus on organizational and cultural change within the departments, involving students, faculty, staff, and industry in rethinking what it means to provide an engineering program.

The RED programs are changing department culture and contributing to literature on organizational change - not simply changing curriculum or pedagogy.

Projects funded in RED history from ENG, EDU, and CISE

Change doesn’t start with the syllabus, change shows up in the syllabus.
Research Experience for Undergraduates Sites (REU)

- Supports participation of undergraduate students in all research areas supported by ENG
- Encourages pursuit of graduate education
- Promotes integration of research and education
- Develops a diverse and competitive workforce

FY23: **143** active sites in **43** states*

*As of May 1, 2023
REU Sites Program

The NSF invests ~$70M per year on the REU sites program across all directorates. About a fourth of REU sites are funded in the Engineering Directorate.

**NSF**

600+ active sites at universities, field stations, observatories, museums, and other research facilities around the United States and abroad

6000+ undergraduate students annually

**ENG**

143 active sites at 106 institutions

1500+ undergraduate students annually
Research Experience for Teachers Sites (RET)

- Supports pre-service, in-service K-12 STEM teachers and community college faculty in ENG research
- Participants translate research experiences into classroom activities
- Facilitates professional development
- Provides instructional opportunities – via grad student mentorship, involvement in K-12 classroom activities

FY23: 44 active sites in 25 states

* As of May 1, 2023
Research Experience for Teachers (RET) (NSF 21-606)

The RET Program Supports pre-service, in-service K-12 STEM teachers and community college faculty in ENG and CISE research.

- Translation of research experiences into classroom activities
- Grad student professional development through mentorship and involvement in K-12 classroom activities
- Partnerships with Industry to address workforce needs

40 active ENG sites in 25 states, serving 400+ STEM teachers and community college faculty annually.

Sites

**Deadline** – Mid-October annually
- Max $200,000 / year
- 10+ K12 or Community College Faculty / year
- ~6 weeks per summer, 3 years

Supplements

**No Deadline** – supplements existing awards
- Up to $10,000 per participant / year
- ~ 1-2 participant / year
INTERN: An early investment in graduate student training and professional development

Building the next generation science and engineering workforce

www.nsf.gov/INTERN
Broadening Participation in Engineering

- Understand the barriers
- Increase access to engineering
- Innovate curriculum and teaching approaches
- Aggressively recruit and retain tenure track faculty
- Transform engineering cultures
Broadening Participation in Engineering (NSF 22-514)
Strengthens the future U.S. engineering workforce by enabling and encouraging the participation of all citizens in the engineering enterprise via 4 tracks

**Track 1**
Planning and Conference Grants
*(no submission deadline)*
*(range 50-100K)*

**Track 2**
Research on Broadening Participation in Engineering
*(no submission deadline)*
*(range 300-400K)*

**Track 3**
Inclusive Mentoring Hubs (IMHubs)
*NEW!*
*(range 800K)*

**Track 4**
Centers for Equity in Engineering (CEE)
*NEW!*
*(range 1.2 mil)*
**NSF INCLUDES**: Inclusion Across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

**INCLUSIVE Engineering**
This affinity group brings together individuals from NSF-funded Engineering Research Centers (ERCs) and individuals who work to lead and support NSF-funded INCLUDES initiatives. Members will share best practices that create a robust culture of inclusion and diversity in both programs. The group will address ways to make activities and resources accessible and inclusive; develop collaborations; collect and report data on diversity; and include people with diverse characteristics in leadership roles, research, and activities.

[https://www.includesnetwork.org](https://www.includesnetwork.org)
A “living laboratory” to address societal grand challenges, educate & develop a diverse workforce, and promote innovation
Thank You
Our World is ENGINEERED
IUCRC Program Framework

Industry/Government Members
Industry Advisory Board (IAB)

Pooled Member $

Shared Project Portfolio

✓ Precompetitive
✓ Use-inspired
✓ IAB-driven

Value derived from portfolio

Universities provide infrastructure, intellectual capital and reduced indirect costs

NSF provides funding for administrative and management costs

IAB provides $$ for research (90% industry funds are for research)
Broadening Participation in Engineering

• Broadening Participation in Engineering
• CAREER
• Early-concept Grants for Exploratory Research (EAGER)
• Rapid Response Research (RAPID)
**RED Solicitation Overview (NSF 23-553)**

- Catalyze revolutionary approaches in **engineering & engineering technology** departments
- Multi-institution Partnerships – Two-Year track (required)

**Innovation**
Generate new knowledge  
(focus: middle two-years)  
*PI at 4-year institution*  
$1M - $3M

**Adaptation & Implementation**
Adapt proven change strategies  
*PI at 2-yr or 4-yr institution*  
$1M

**Two Year**
Generate new knowledge  
(focus: students transferring to 4-year)  
*PI at 2-yr institution*  
$1M - $2M

Only Two-Year Track
Workforce Development Initiatives

A digital library of engineering curricula for K-12 educators to make applied science and math come alive through engineering design; 3.3 M unique annual users.

High School Engineering Pilot: Earn College engineering credit; 1400 high school juniors and seniors, 40 high schools across the nation; supported by 100+ Engineering Deans.

Pilot Partnership between e4usa + FIRST Robotics: overcome institutional barriers; broaden K12 engineering participation & exposure at a national scale.

Pilot ECE Consortium of 14 HBCUs and 1 Hispanic Serving Institution; integrated multi-institution site to enhance impact on students & teachers.