Engineering
Past, Present and Future Perspectives



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ASEE Engineering Technology Leaders Institute
Crystal City, Virginia
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Overview

- What is Engineering ?
- Engineering in the 20th Century
- Engineering in the 21st Century
- Impact on Engineering Education at NC State
- Future Perspectives
- Final Thoughts

Scientists study the world as it is; engineers create the world that has never been.

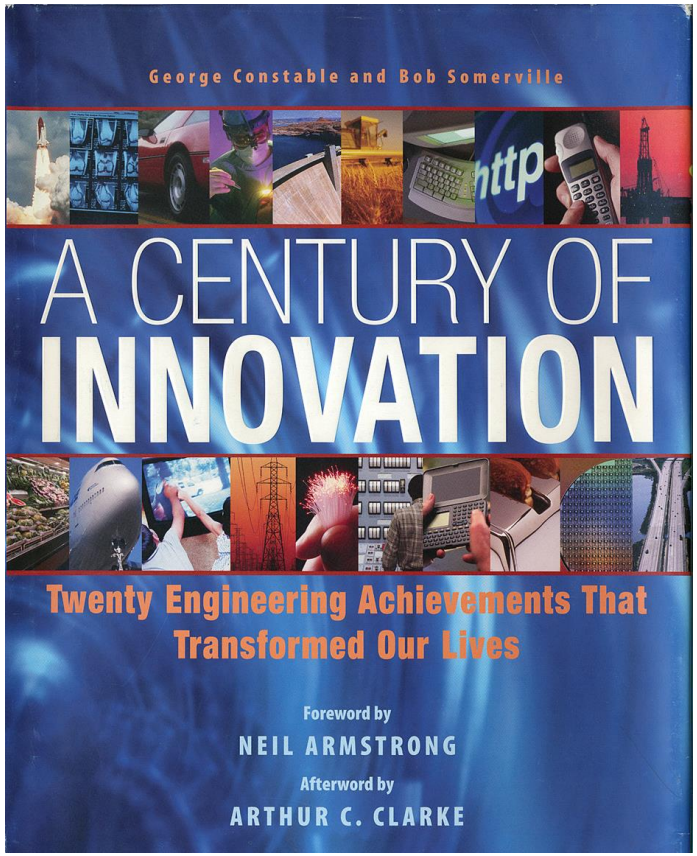
~ Theodore von Kármán

Engineering brings reality to ideas and provides solutions to societal needs.

~ Neil Armstrong

Top 20 Achievements of the 20th Century

National Academy of Engineering



What was the top engineering achievement of the 20th Century?

The Greatest Engineering Achievement of the 20th Century

Electrification

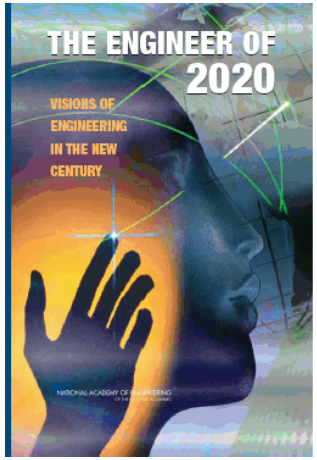
Top 20 Engineering Achievements of the 20th Century

- Electrification
- Automobile
- Airplane
- Water Supply and Distribution
- Electronics
- Radio and Television
- Agricultural Mechanization
- Computers
- Telephony
- Air Conditioning and Refrigeration
- Highways
- Spacecraft
- Internet
- Imaging
- Household Appliances
- Health Technologies
- Petrochemical Technology
- Laser and Fiber Optics
- Nuclear Technologies
- High Performance Materials

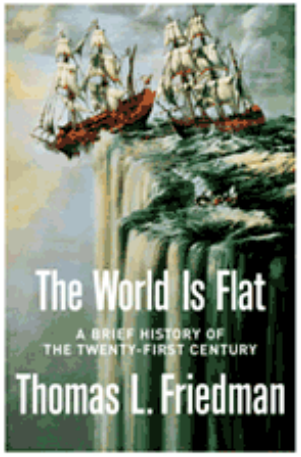
Characteristics

- Very high societal impact, however
  - Primarily “Discipline-based”
  - Many are Electrical and Computer Engineering/Technology Centric
  - Others correlate directly with Mechanical, Aerospace, Civil, Chemical or Nuclear Engineering/Technologies
  - Just one or two cut across areas such as Health and Agriculture

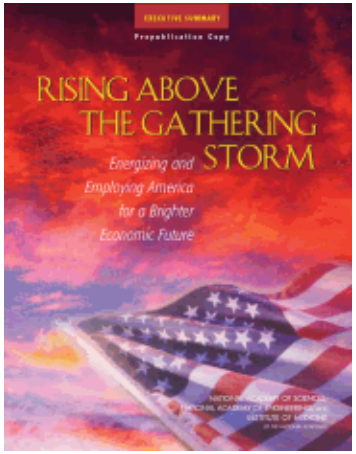
Engineering in the 21st Century



Forecasting the profession, NAE, 2004



NY Times columnist on globalization, 2004



30K-foot-view, plus proposals, National Academies, 2005

White House launches new initiative, 2006

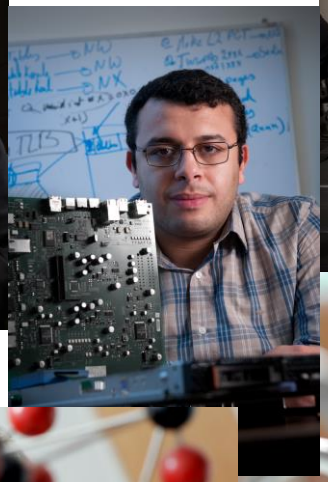
NAE Grand Challenges for the 21st Century

- Sustainability
  - make solar energy more economical
  - provide energy from fusion
  - develop carbon sequestration methods
  - provide access to clean water
  - manage nitrogen cycle
- Health
  - advance health informatics
  - engineer better medicines
  - reverse-engineer the brain
- Security
  - restore and improve urban infrastructure
  - prevent nuclear terror
  - secure cyberspace
- Joy of Living
  - enhance virtual reality
  - advance personalized learning
  - engineer the tools of scientific discovery

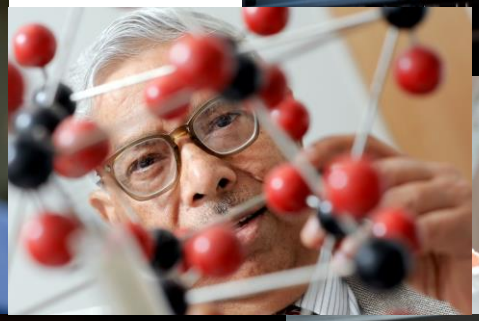
Characteristics

- Motivated by very significant global and societal impact
- Impact Engineering Education at all levels
- Four major cross-cutting, interdisciplinary areas
  - Sustainability
  - Health
  - Security
  - Joy of Living = Engr. Education

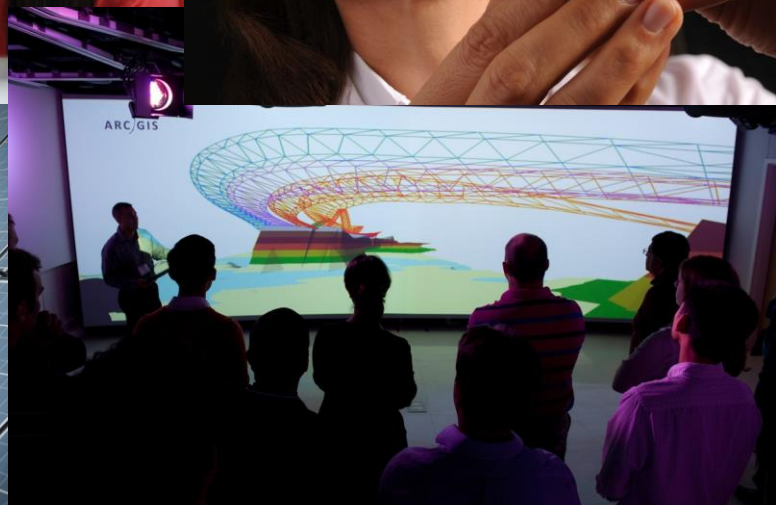
Engineering at NC State University







Students

Fall 2015 Enrollment	
Undergraduate	6,656
Master's	2,145
PhD	1,212
Total	10,013

2014-15 Graduates	
Bachelor's	1,344
Master's	849
PhD	181
Total	2,374

Among all U.S. engineering colleges*

- 9th in BS degrees awarded
- 12th in MS and PhD degrees awarded
- 10th in total degrees awarded
- 10% : transfers from technology program

* ASEE Profiles 2014

COE Mission

- Provide a **premier educational experience** for our students and a **world-class environment** for our faculty that supports and prepares them for **addressing the engineering and computer science challenges and opportunities** that exist and await them in the 21st century.

- We want our students and faculty to be **global leaders in discovery, learning and innovation** across the **broad, exciting and diverse world of engineering and computer science**.

- In so doing, it is our expectation that our faculty and students will **convert ideas to reality, provide solutions to societal needs** and **enhance the economic development and quality of life** of the citizens of North Carolina, our nation and humankind.

Departments & Partners

Biomedical Engineering

Chemical and Biomolecular Engineering

Civil, Construction & Environmental Engineering

Computer Science

Electrical and Computer Engineering

Fitts Dept of Industrial and Systems Engineering

Materials Science and Engineering

Mechanical and Aerospace Engineering

Nuclear Engineering

Biological and Agricultural Engineering

Forest Biomaterials

Textile Engineering, Chemistry and Science

Community College Partners:

Wake Tech, Durham Tech, Guilford Tech,

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COE STRATEGIC VISION

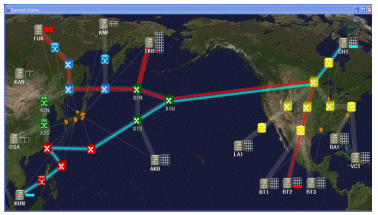
Engineering Health Systems

Bioengineering

Nanotechnology

Robotics & Sensor Technology

Emphasis on the integration of research and education



Information & Communications Technology

Advanced Materials & Manufacturing

Energy & Environmental Systems

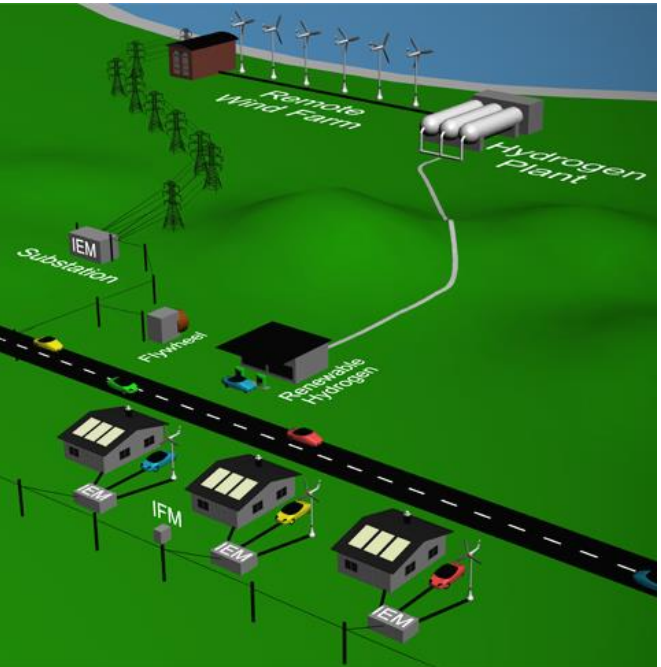
Transportation & Logistics

Security & Critical Infrastructure

Solving Society's Energy Challenges

FREEDM Systems Center

NSF Engineering Research Center for Future Renewable Electric Energy Delivery and Management (FREEDM) Systems



- Center Director: Dr. Iqbal Husain
- "Top 10 Emerging 21st Century Technologies"
  ~MIT *Technology Review*
- $40 million,10-year grant from NSF
- Creating the "Internet for Energy" for renewable energy generation and storage
- Over 40 industry partners and catalyst for numerous "clean-tech" companies
- **Renewed through 2018**

FREEDM Industry Members

Utilities

- Duke Energy
- Dominion
- Southern California Edison (An Edison International Company)
- FPL
- PJM
- North Carolina's Electric Cooperatives

Vendors

Integrated Solutions

- ABB
- Siemens
- GE

Equipment

- Samsung
- AEG
- Fuji Electric
- Eaton
- Total

IT/ Communications

- Itron
- Cisco
- Green Energy Corp
- Huawei
- Elster
- SAS

Technology Providers

- Infineon Technologies
- Powerex
- RFMD
- Cree
- Hexatech
- Peregrine Power LLC
- TE Connectivity
- Vacon
- Petra Solar
- Vestas
- Toshiba
- IOR
- Delta
- Fairchild Semiconductor
- Ford
- Newport News Shipbuilding

Services/ Consultancies

- McKim & Creed
- Advanced Energy
- M.C. Dean
- Oak Ridge National Laboratory
- KEMA DNV
- Quanta Technology
- EPRI
- digital grid

Start Ups/ Innovators

- Bing Energy
- GridBridge
- Microcell
- Triangle Technology Ventures, LLC
- ARDA
- Earl Energy

Customer

Integrated Solutions

IT/ Communications Infrastructure

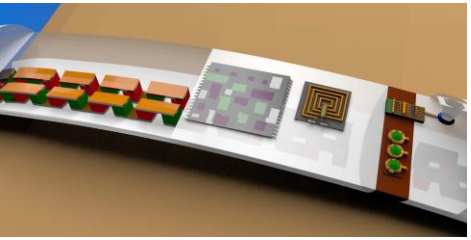
Core Technology

Trusted Experts

New Apps

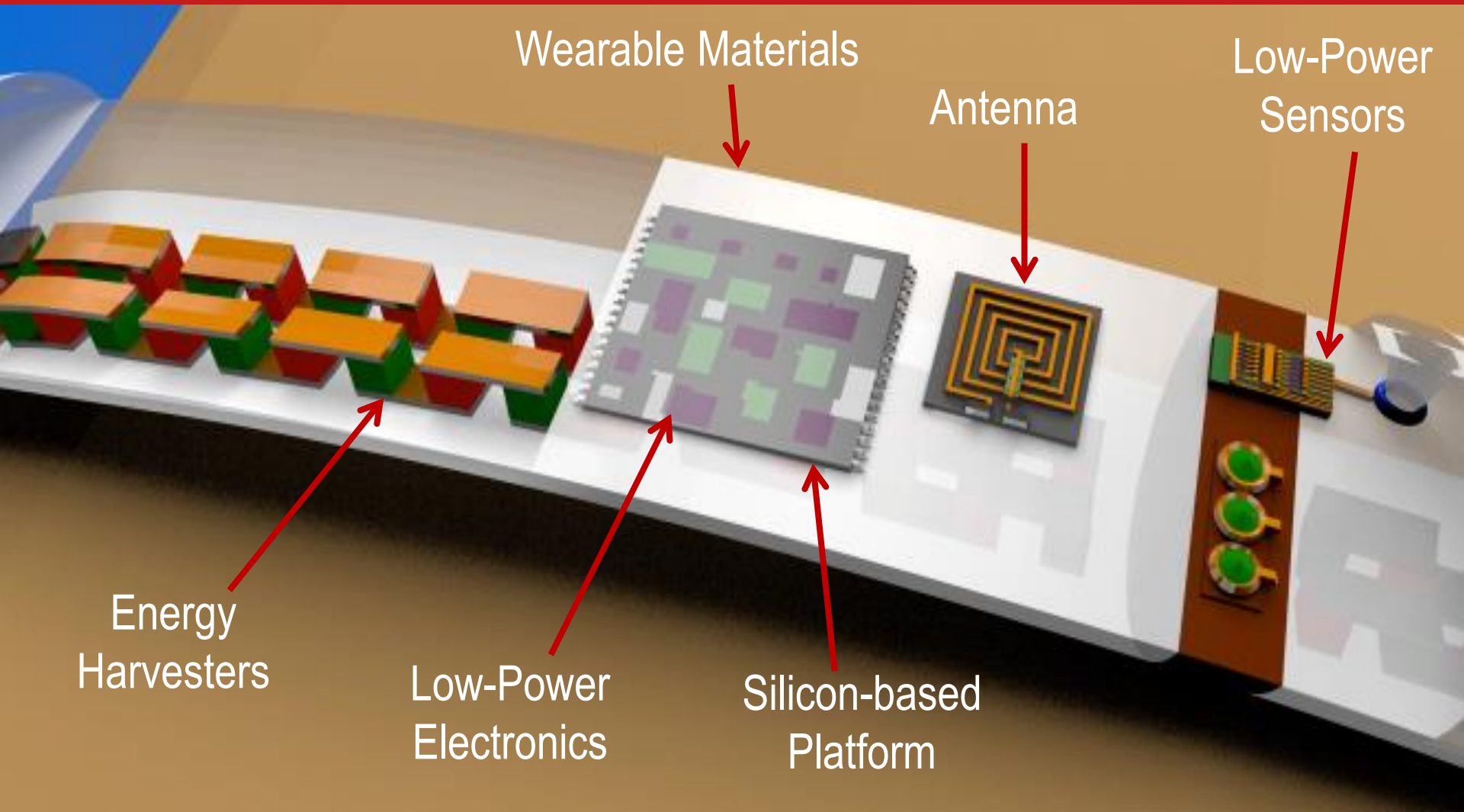
Transforming US and Global Health Informatics

NSF Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)



- Center Director: Dr. Veena Misra
- $40 million ten-year grant from NSF
- Awarded in 2012 and **renewed in 2015 for another five years**
- Developing and employing nano-enabled devices and sensors to create innovative, battery-free, body-powered, and wearable health monitoring systems
- Currently has 33 industry partners

ASSIST Sensor Node for Exposure and Wellness Tracking



Center for Educational Informatics

CEI Center for Educational Informatics

Transforming education with next-generation learning technologies

- NAE Grand Challenge for Engineering: Advanced Personalized Learning
- Director: Dr. James C. Lester (Computer Science)
- Mission: Design, deploy, and evaluate **adaptive learning systems** for national-scale education and training solutions
- Support: **NSF**, **Bill & Melinda Gates Foundation, William & Flora Hewlett Foundation, EDUCAUSE, Army Research Laboratory, USDA, SAS**

Student Success

NAE Grand Challenge Scholars Program

Five Components

1. **Research experience.** Research related to a Grand Challenge.
2. **Engineering + curriculum.** Engineering education that intersects with public policy, business, law, ethics, human behavior, risk as well as medicine and the sciences.
3. **Entrepreneurship.** Preparing students to translate invention to innovation; to develop market ventures that scale to global solutions in the public interest.
4. **Global dimension.** Developing students who are able to address global challenges and lead innovation in a global economy.
5. **Service learning.** Developing and deepening students' social consciousness and their motivation to bring technical expertise to bear on societal problems.

Engineering Entrepreneurs Program (EEP)

One of the most innovative programs at NC State, EEP was created in the College of Engineering in 1993 by Dr. Tom Miller to help prepare engineering students for the world of technology entrepreneurship. Many Engineering Entrepreneurs have gone on to create very successful companies.

K-12 Outreach

- **Impacts >17,000 K-12 students and teachers** across the state each year
- **42 summer camps** for elementary through high school located across the state
- Teacher workshops/Research experience for teachers (RET)
- Family Engineering Nights for schools
- Engineering On the Road
- Partnership efforts (Girl Scouts, Marbles Museum, Boys and Girls Club)
- Freshman Engineering Design Day, featuring high school and middle school students

Future Perspectives

- National Science Foundation (NSF)
- Engineering Directorate at NSF
- American Society of Engineering Education

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS)

- By 2050, world population projected at 9 billion and US population 400 million
- Greater demand for energy, water, and food
- Increased variability in precipitation and temperatures
- Goal: To understand, model, design, and manage the interconnected food-energy-water (FEW) system
  - quantitative and computational modeling
  - real-time, cyber-enabled interfaces
  - basic research for innovative system and technological solutions
  - scientific workforce capable of studying and managing the FEW system

Risk and Resilience

Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)

- Goals:
  - To gain new knowledge that will improve resilience, interoperations, performance and readiness in Interdependent, Critical Infrastructures (ICIs);
  - To understand the variety of societal obstacles to improving ICIs; and
  - To identify technologies and strategies for overcoming these obstacles.
- FY 2015: launched CRISP with $20M in 12 projects
  - Collaboration between ENG, CISE, and SBE

Smart and Connected Communities

- To intelligently and effectively design, adapt and manage the smart and connected communities of the future
- To enable more livable, workable, sustainable, and connected communities

- Builds on Cyber-Physical Systems (CPS), CRISP and Smart Service Systems (under PFI:BIC) programs
- Dear Colleague Letter: Supporting Research Advances in Smart and Connected Communities (NSF 15-120)
  - Collaboration between ENG, CISE, EHR, GEO, and SBE

Advanced Manufacturing – Key National Priority

- Strategic directions
  - **Advanced biomanufacturing**
  - **Cybermanufacturing**
  - **Scalable nanomanufacturing**
- PCAST Recommendation from AMP 2.0: mechanism for academic-industry input on future manufacturing technologies
  - Joint solicitation by NSF and NIST in 2015
  - Award to University of Michigan at Ann Arbor: MForesight – Alliance for Manufacturing Foresight
- I/UCRC in manufacturing

Engineering Education
Professional Formation of Engineers

Strategically create and support an innovative and inclusive engineering profession for the 21st Century

- IUSE/REvolutionizing engineering and computer science Departments (RED)
  - Collaboration between ENG, CISE, and EHR
- Research in the Formation of Engineers
  - Evolution from Research in Engineering Education
- Research Initiation in Engineering Formation (RIEF)

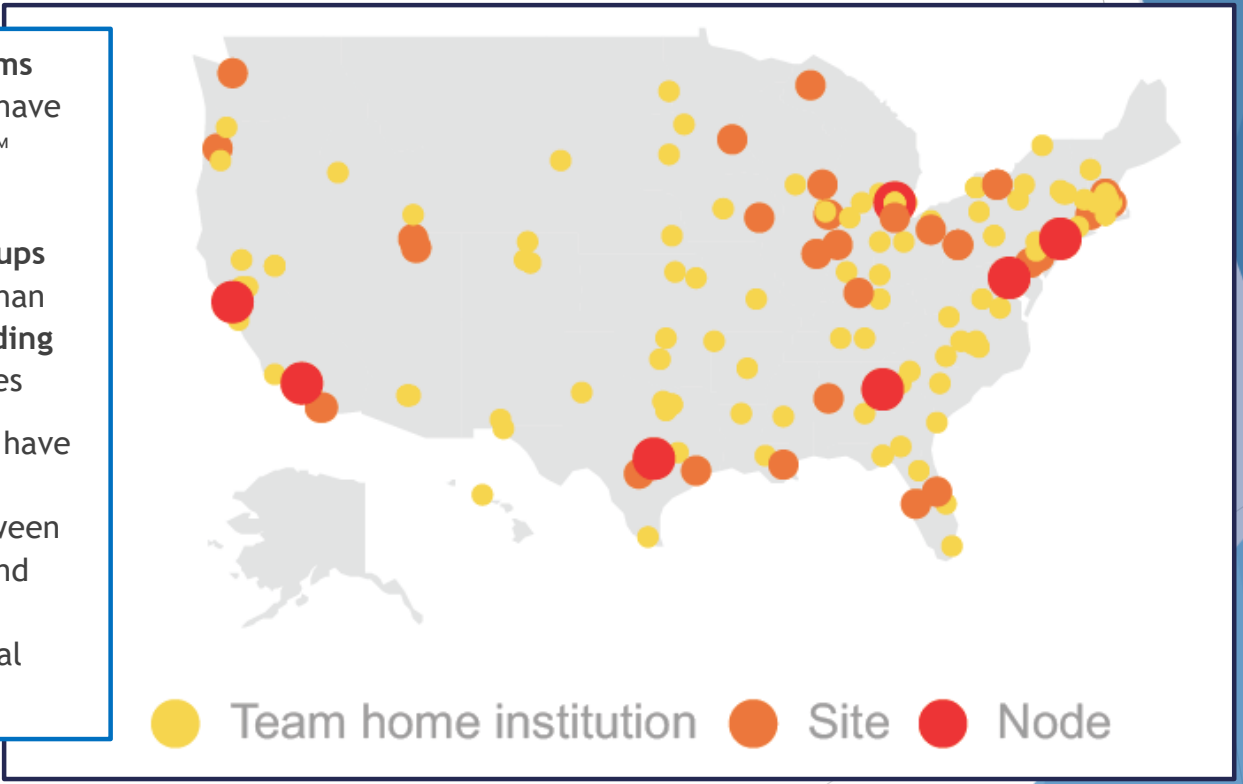
A student works on circuit board project at the University of San Diego, chosen as one of six engineering departments chosen for a RED award. *Credit: University of San Diego*

I-CORPS NSF Innovation Corps

7 Nodes provide entrepreneurial learning environments and curriculum development

36 Sites leverage existing entrepreneurial activities

- More than **500 teams** and **1,600 people** have completed I-Corps™ training
- **261 I-Corps™ startups** have raised more than **$49 million in funding** from outside sources
- **176 teams** to date have reported new collaborations between their universities and industry, investors, and/or state or local governments



Final Thoughts

- The conversion of “ideas into reality” and the solution of societal needs has always been a primary focus of Engineering
- Engineering education has moved from a primarily discipline centric effort in the 20th century….
- To a much more cross-cutting interdisciplinary effort
  - We are now seeing the confluence of engineering, the sciences, medicine and the social sciences as the norm

Final Thoughts

- Benefit from lessons learned and directions of engineering education…without changing “who you are” and “what is important to you”
- Use what “makes sense and is relevant to you”
- Define grand challenges and educational directions in ways that best serve the needs and future of your students and constituencies
- Always strive to be globally competitive to bring out the very best in your faculty, students and those you are privileged to serve

Final Thoughts

Our responsibility:

As engineering and engineering technology educators, is to assure that our students graduate with both the breadth and depth needed to be major players in addressing and solving the societal grand challenges facing our nation and the world

Our daily commitment to our students is to ensure that the “E” in Engineering and Engineering Technology truly stands for *Excitement.*