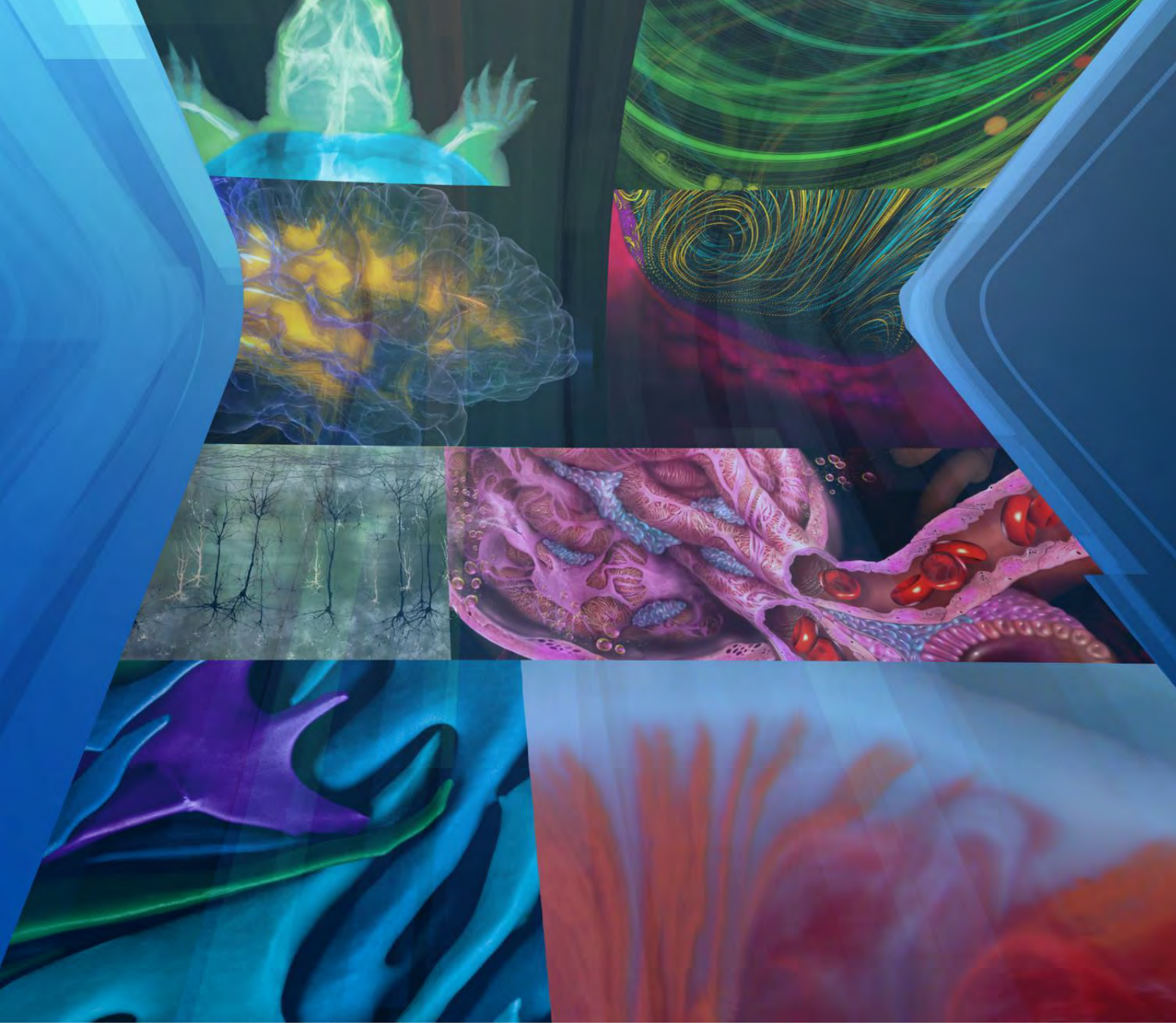
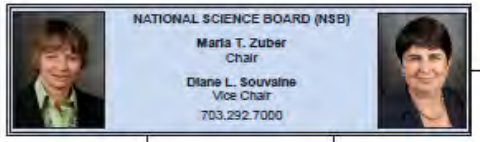


NSF Funding Opportunities at the intersection of Engineering, Computer Science and Social and Behavioral Sciences

Alexandra Medina-Borja, Ph.D.
Office of the Assistant Director
for Engineering &
Industrial Innovation &
Partnerships Division

April 28, 2017

NATIONAL SCIENCE FOUNDATION



NATIONAL SCIENCE BOARD (NSB)
Maria T. Zuber
Chair
Diane L. Souvaine
Vice Chair
703.292.7000

NATIONAL SCIENCE BOARD OFFICE
Michael Van Woert
Executive Officer
703.292.7000

OFFICE OF INSPECTOR GENERAL (OIG)
Allison C. Lerner, Inspector General
703.292.7100

OFFICE OF THE DIRECTOR
703.292.8000

France A. Córdova
Director

Richard Buckius
Acting Deputy Director/
Chief Operating Officer

OFFICE OF DIVERSITY & INCLUSION (ODI)
Rhonda Davis, Head
703.292.8020

OFFICE OF THE GENERAL COUNSEL (OGC)
Lawrence Rudolph, General Counsel
Peggy Hoyle, Deputy GC
703.292.8060

OFFICE OF INTEGRATIVE ACTIVITIES (OIA)
Suzanne Iacono, Head
703.292.8040

OFFICE OF INTERNATIONAL SCIENCE & ENGINEERING (OISE)
Rebecca Keiser, Head
703.292.8710

OFFICE OF LEGISLATIVE & PUBLIC AFFAIRS (OLPA)
Amanda Greenwell, Head
703.292.8070

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)

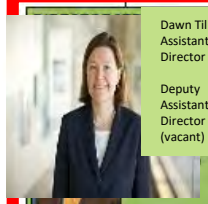
- DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI)
- DIVISION OF ENVIRONMENTAL BIOLOGY (DEB)
- DIVISION OF INTEGRATIVE ORGANISMAL SYSTEMS (IOS)
- DIVISION OF MOLECULAR & CELLULAR BIOSCIENCES (MCB)
- OFFICE OF EMERGING FRONTIERS (EF)

DIRECTORATE FOR COMPUTER & INFORMATION SCIENCE & ENGINEERING (CISE)

- DIVISION OF COMPUTER & NETWORK SYSTEMS (CNS)
- DIVISION OF COMPUTING & COMMUNICATION FOUNDATIONS (CCF)
- DIVISION OF ADVANCED CYBERINFRASTRUCTURE (ACI)
- DIVISION OF INFORMATION & INTELLIGENT SYSTEMS (IIS)

DIRECTORATE FOR EDUCATION & HUMAN RESOURCES (EHR)

- DIVISION OF GRADUATE EDUCATION (DGE)
- DIVISION OF HUMAN RESOURCE DEVELOPMENT (HRD)
- DIVISION OF RESEARCH ON LEARNING IN FORMAL & INFORMAL SETTINGS (DRL)
- DIVISION OF UNDERGRADUATE EDUCATION (DUE)



Dawn Tilburi
Assistant Director

Deputy Assistant Director (vacant)

- DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL & TRANSPORT SYSTEMS (CBET)
- DIVISION OF CIVIL, MECHANICAL & MANUFACTURING INNOVATION (CMMI)
- DIVISION OF ELECTRICAL, COMMUNICATIONS & CYBER SYSTEMS (ECCS)
- DIVISION OF ENGINEERING EDUCATION & CENTERS (EEC)
- DIVISION OF INDUSTRIAL INNOVATION & PARTNERSHIPS (IIP)
- OFFICE OF EMERGING FRONTIERS IN RESEARCH & INNOVATION (EFRI)

DIRECTORATE FOR GEOSCIENCES (GEO)

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- DIVISION OF EARTH SCIENCES (EAR)
- DIVISION OF OCEAN SCIENCES (OCE)
- DIVISION OF POLAR PROGRAMS (PLR)

DIRECTORATE FOR MATHEMATICAL & PHYSICAL SCIENCES (MPS)

- DIVISION OF ASTRONOMICAL SCIENCES (AST)
- DIVISION OF CHEMISTRY (CHE)
- DIVISION OF MATERIALS RESEARCH (DMR)
- DIVISION OF MATHEMATICAL SCIENCES (DMS)
- DIVISION OF PHYSICS (PHY)
- OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA)

DIRECTORATE FOR SOCIAL, BEHAVIORAL, & ECONOMIC SCIENCES (SBE)

- DIVISION OF BEHAVIORAL & COGNITIVE SCIENCES (BCS)
- DIVISION OF SOCIAL & ECONOMIC SCIENCES (SES)
- NATIONAL CENTER FOR SCIENCE AND ENGINEERING STATISTICS (NCSES)

OFFICE OF BUDGET, FINANCE, & AWARD MANAGEMENT (BFA)

- BUDGET DIVISION (BUD)
- DIVISION OF ACQUISITION AND COOPERATIVE SUPPORT (DACS)
- DIVISION OF FINANCIAL MANAGEMENT (DFM)
- DIVISION OF GRANTS & AGREEMENTS (DGA)
- DIVISION OF INSTITUTION & AWARD SUPPORT (DIAS)
- LARGE FACILITIES OFFICE

OFFICE OF INFORMATION & RESOURCE MANAGEMENT (OIRM)

- DIVISION OF ADMINISTRATIVE SERVICES (DAS)
- DIVISION OF INFORMATION SYSTEMS (DIS)
- DIVISION OF HUMAN RESOURCE MANAGEMENT (HRM)

National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230
TEL: 703.292.5111 | FIRS: 800.877.8339 | TDD: 800.281.8749

September 2016

NSF by the numbers

$7.5 billion FY 2016 estimation

95% funds research, education and related activities

49,600 proposals

12,000 awards funded

1,859 NSF-funded Institutions

350,000 NSF-supported researchers

All S&E disciplines funded

Funds research into STEM education

217 Nobel Prize winners

Other than the FY 2016 estimation, numbers shown are based on FY 2015 activities.

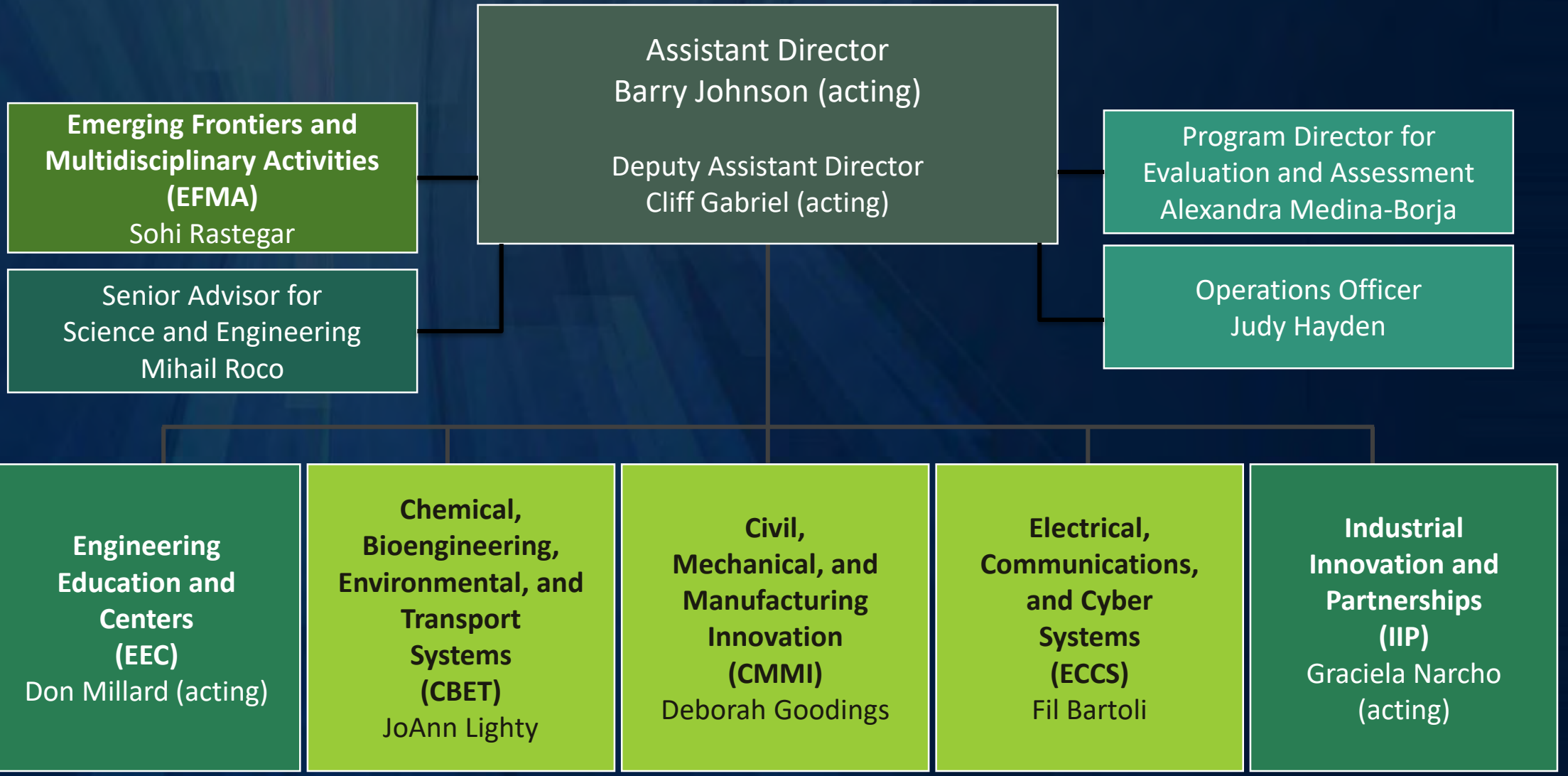
NSF Engineering (ENG) Directorate MISSION

Investing in engineering research and education and fostering innovations for benefit to society

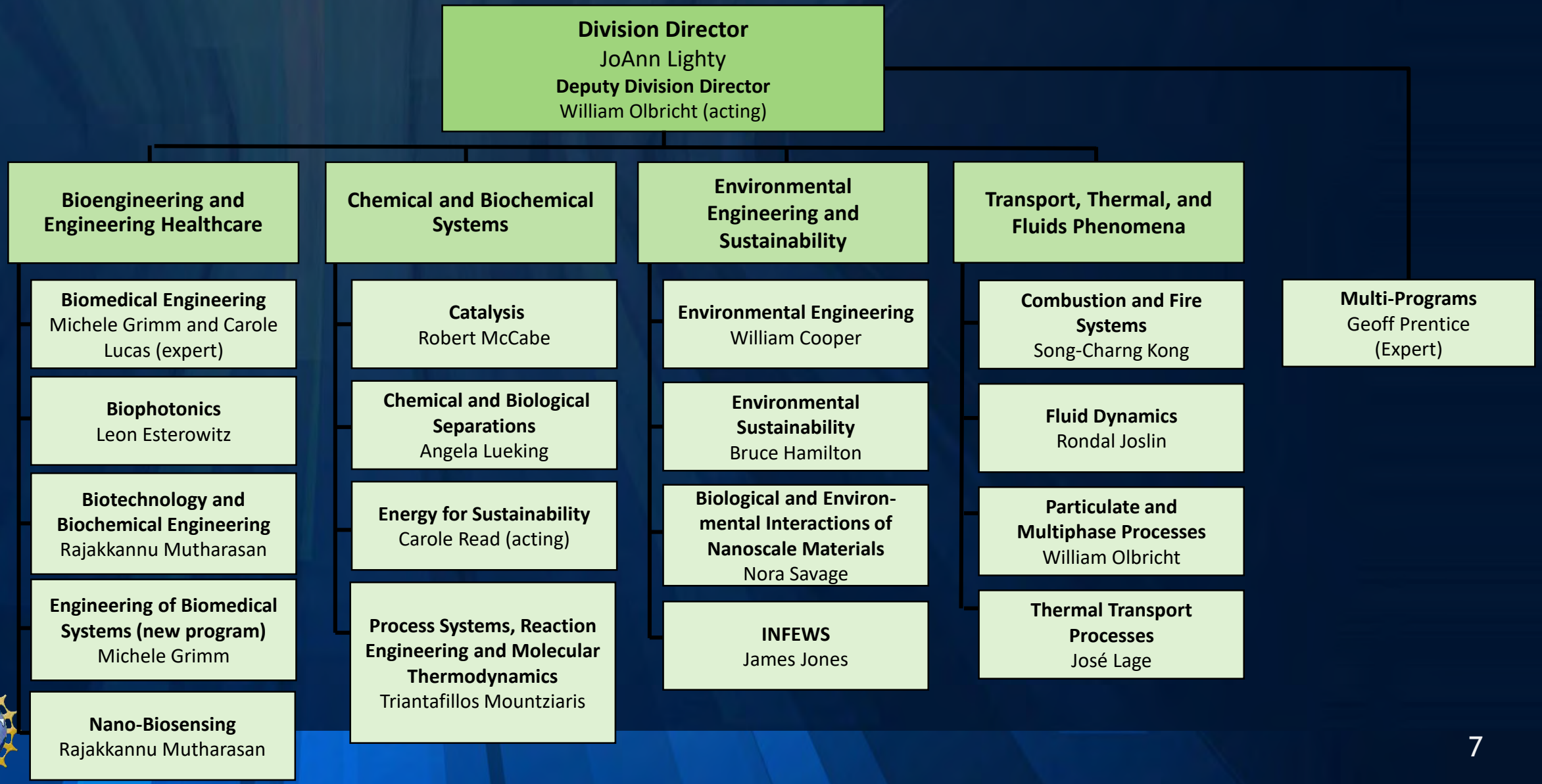
ENG by the Numbers: FY 2016

- FY2017 Budget Request: $1.003 Billion
- Total number of proposals: 12,574
- Total number of new awards: 2,502
- Total number of research proposals (excludes SBIR/STTR and I-Corps Teams): 9,614
- ENG average funding rate (excludes SBIR/STTR and I-Corps Teams): 16%
- Estimated number of researchers and students supported: 23,350
- Supported 19 ERCs, 3 STCs, 75 I/UCRCs, and 3 research facility networks

NSF Directorate for Engineering



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



Civil, Mechanical, and Manufacturing Innovation (CMMI)

Division Director
Deborah Goodings
Deputy Division Director
George Hazelrigg

Senior Advisor
Bruce Kramer

Program Manager for Integrative Activities
Joanne Culbertson

Advanced Manufacturing

- **Cybermanufacturing Systems**
  Bruce Kramer
- **Design of Engineering Material Systems**
  Mary Toney, Kara Peters and Richard Malak
- **Manufacturing Machines and Equipment**
  Steven Schmid
- **Materials Engineering and Processing**
  Alexis Lewis, Mary Toney and Thomas Kuech
- **NanoManufacturing**
  Kershed Cooper

Mechanics & Engineering Materials

- **Biomechanics and Mechanobiology**
  David Fyhrie
- **Design of Engineering Material Systems**
  Mary Toney, Kara Peters and Richard Malak
- **Mechanics of Materials and Structures**
  Kara Peters and Siddiq Qidwai

Operations, Design, & Dynamics Systems

- **Dynamics, Control & Systems Diagnostics**
  Jordan Berg and Irina Dolinskaya
- **Engineering and Systems Design**
  Richard Malak
- **Mind, Machine and Motor Nexus**
  Jordan Berg
- **Operations Engineering**
  Georgia-Ann Klutke and Irina Dolinskaya
- **Systems Science**
  Richard Malak

Resilient and Sustainable Infrastructures

- **Civil Infrastructure Systems**
  Cynthia Chen
- **Decision Frameworks for Multi-Hazard Resilient & Sustainable Buildings (RSB)**
  Joy Pauschke and Richard Fragaszy
- **Engineering for Natural Hazards**
  Richard Fragaszy and Joy Pauschke
- **Natural Hazards Engineering Research Infrastructure**
  Joy Pauschke, William Miller and Erica Stein
- **Geotechnical Engineering & Materials**
  Richard Fragaszy
- **Infrastructure Management & Extreme Events**
  David Mendonça
- **Structural & Architectural Engineering & Materials**
  Yick Hsuan

Electrical, Communications, and Cyber Systems (ECCS)

Senior Engineering Advisor
Lawrence Goldberg

Division Director
Fil Bartoli
Deputy Division Director
Dominique Dagenais (acting)

Communications, Circuits, and Sensing Systems (CCSS)

RF, analog & mixed signal integrated circuits & systems; RF, microwave, millimeter-wave & THz technology; Energy-efficient, low-noise, reconfigurable electronics; Antennas & wave propagation for communications & sensing
Jenshan Lin

Integrated sensing, communication & computational systems; RF/wireless, optical & hybrid communications & networking; Signal processing & compressive sampling; Spectrum access & sharing, cognitive radio; Cyber-physical systems & security
Chengshan Xiao

Micro, nano & bio systems; Chemical, biological & physical sensors, sensors & actuators & electronic interfaces; ultra-low power wearable & implantable sensing & imaging systems; Real-time monitoring & stimulation of the brain & other body functions in natural environments
Shubhra Gangopadhyay

Electronics, Photonics, and Magnetic Devices (EPMD)

Flexible, printed & organic electronics & photonics; Carbon-based electronics; Beyond graphene 2D materials & devices; Nano-electronics & energy-efficient electronics; Solar cells & photovoltaic components
Nadia El-Masry

Nanophotonics, metamaterials & plasmonics; Advanced optical sources & photo-detectors; Nonlinear & Ultrafast Photonics; Photonics integrated circuits; Optical communication components; Single-photon & quantum devices; Optical imaging & sensing
Dominique Dagenais & Mahmoud Fallahi

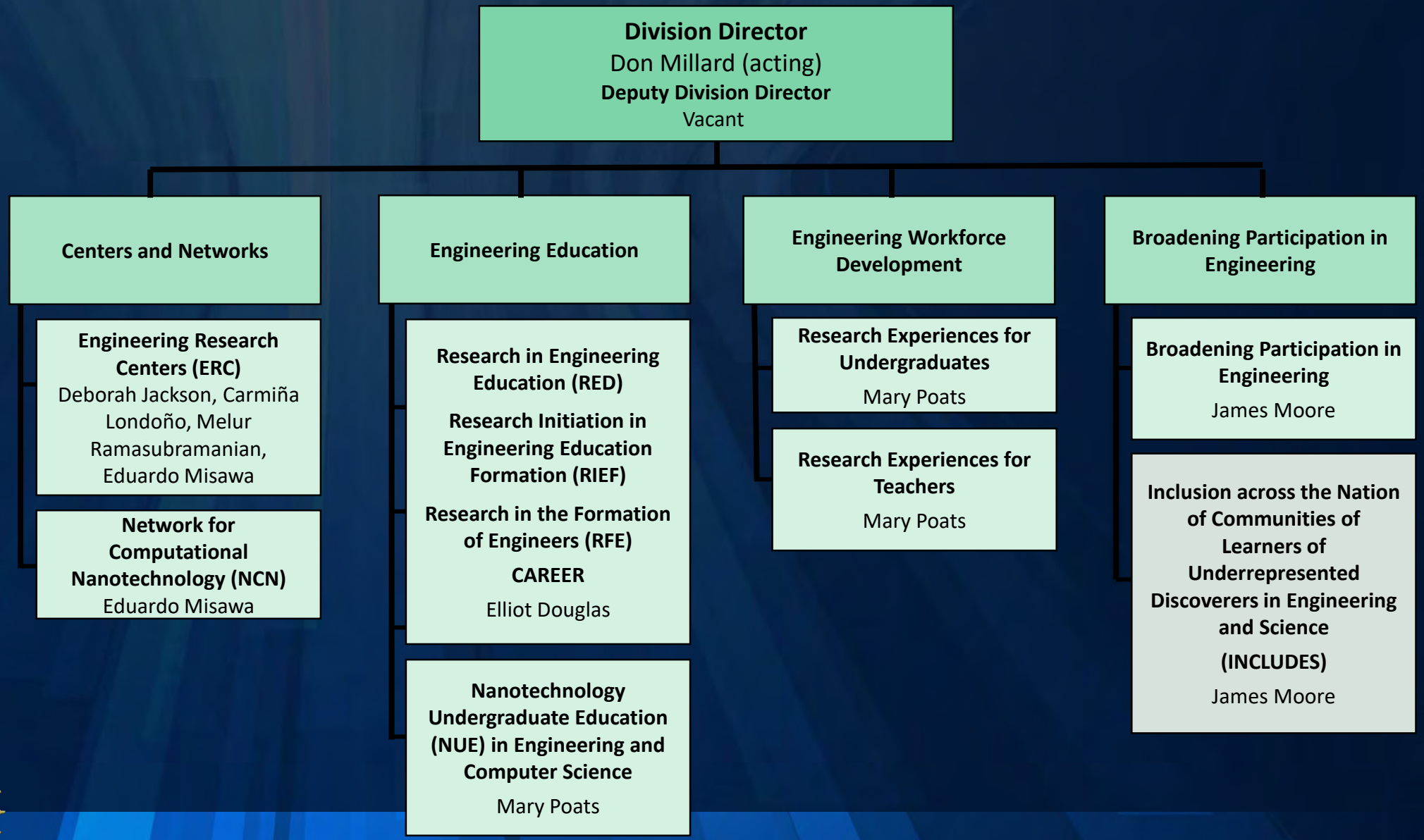
Bioelectronics & biomagnetic devices; Magnetics, spin electronics & quantum devices; Next-generation memories; Sensor device technologies
Usha Varshney

Microwave/mm-wave/THz devices & components, electromagnetic effects & components based on them; Nanoelectronics & next-generation devices, semiconductor material–device interaction & reliability; Electromagnetic propagation & scattering; Wide-bandgap semi-conductors & devices, circuits, device/circuit simulation & modeling; Metamaterial & plasmonic-based devices & components
Dimitri Pavlidis

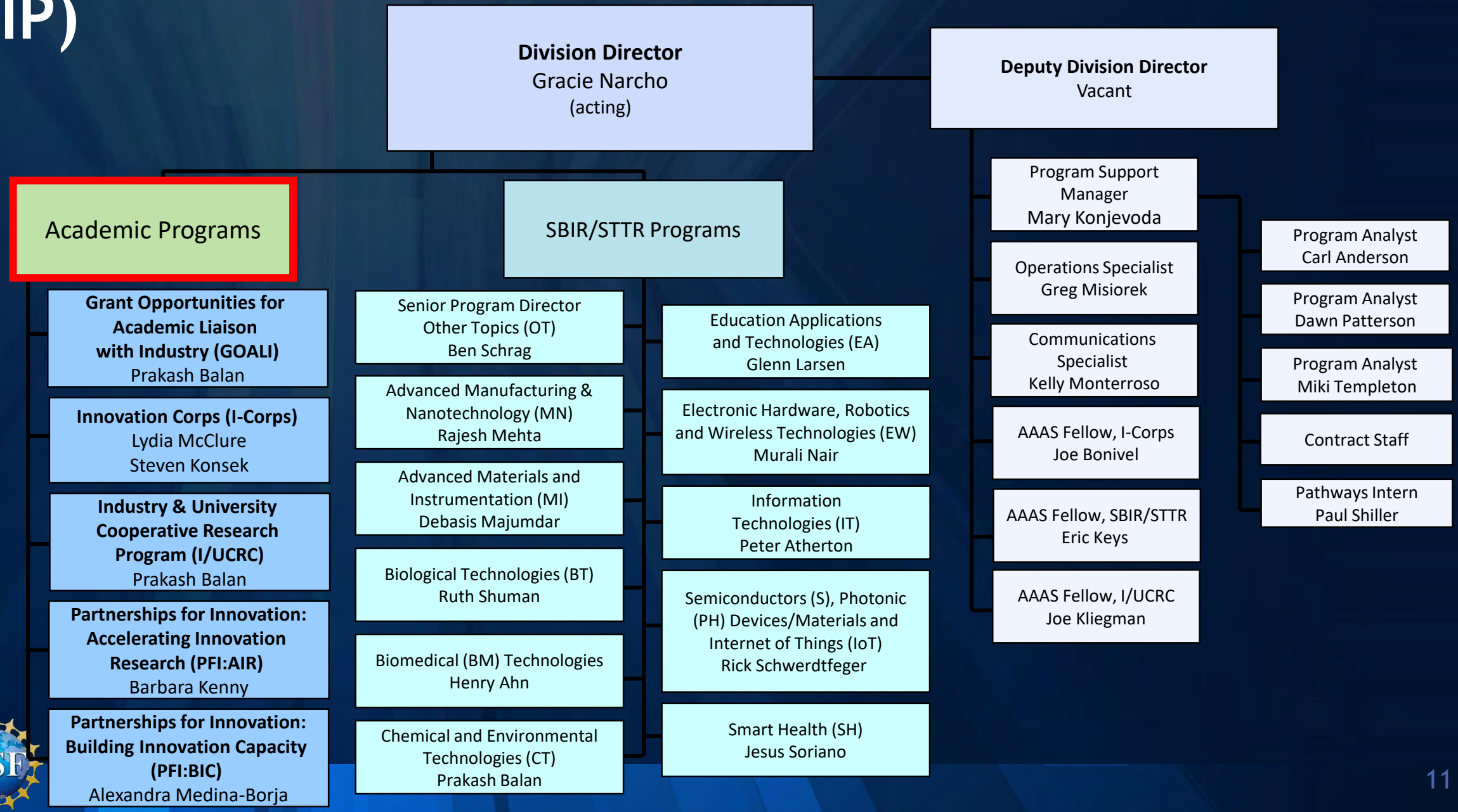
Energy, Power, Control and Networks (EPCN)

Control theory & hybrid dynamical systems; Networked multi-agent systems; Cyber physical systems modeling & control; System theory for biology & medicine; Modeling of the brain; Control & optimization in buildings, transportation, & robotics; Adaptive & intelligent systems; Neural networks; Energy harvesting, storage devices & systems; Solar & wind energy & integration of renewables with grid; Monitoring, protection & cyber security of power grid; Advanced power electronics & electric machines; Electric & hybrid electric vehicles; Innovative grid-tied power electronic converters; Policy, economics, consumer behavior & the power grid
Eyad Abed and Radhakisan Baheti

Engineering Education and Centers (EEC)



Industrial Innovation and Partnerships (IIP)



ENG Investments

A brief overview of some new and exciting themes…

RESEARCH THEME

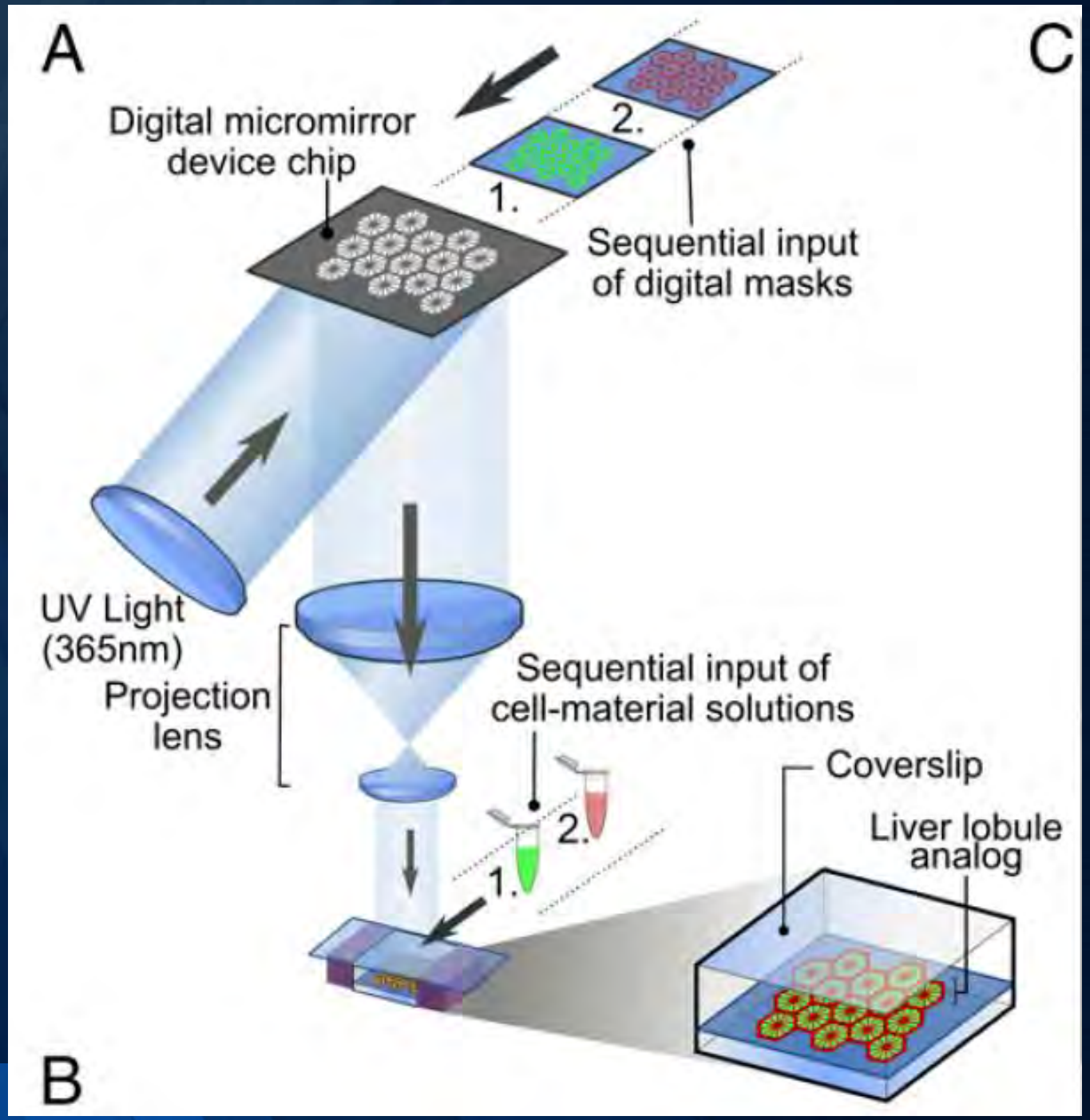
Advanced Manufacturing

Enabling More Capable, Accessible, and Distributed Manufacturing

- Cybermanufacturing Systems program
  - Accessible, cost-effective and distributed manufacturing for the “Factory of the Future”
- Nanosystems design and scalable nanomanufacturing
- Advanced biomanufacturing

- 3D Printing of liver tissue
- For early dug screening and disease modeling

Shaochen Chen etc., UCSD



RESEARCH THEME

Energy, Water, Food, and Critical Infrastructure

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

NSF-wide initiative and collaboration with NIFA

Illustration credit: Nicolle R. Fuller, Sayo-Art LLC

Risk and Resilience

Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)

- Understanding, design, and innovation of Interdependent Critical Infrastructure (ICI) systems and processes to deliver essential goods and services despite disruptions, whether human-induced or natural

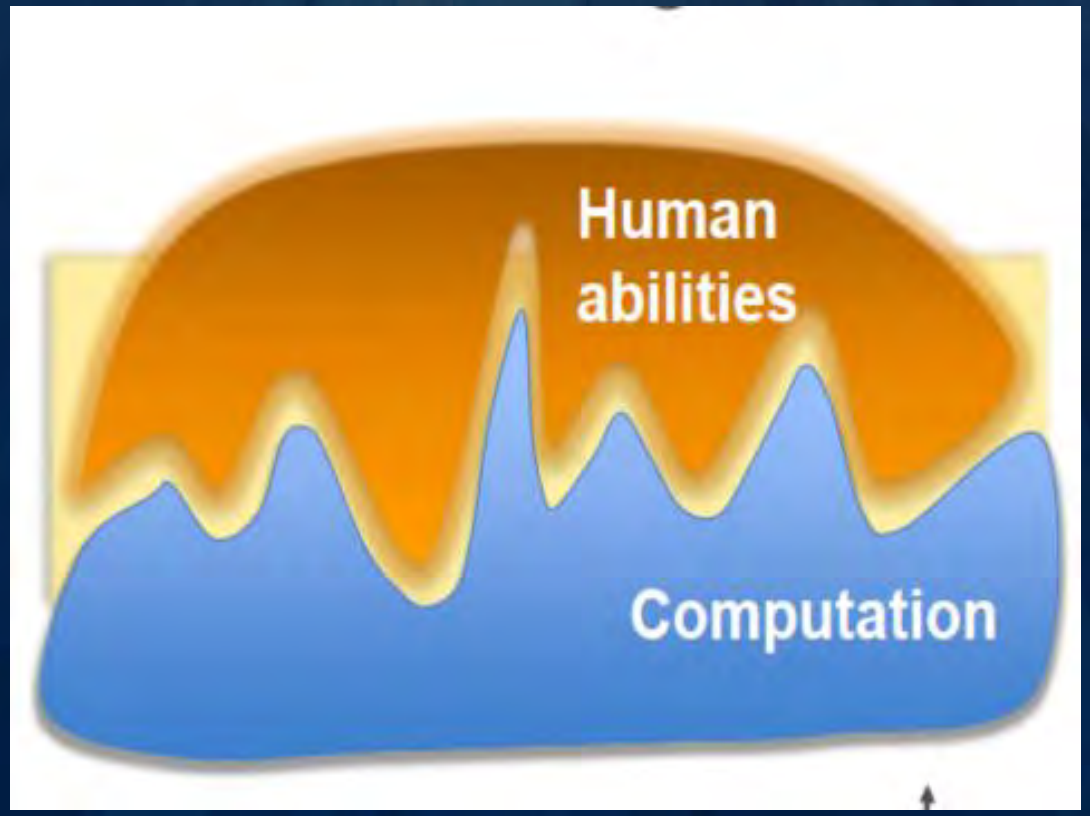
Credit: ©Fotolia/ collage N. Hanacek

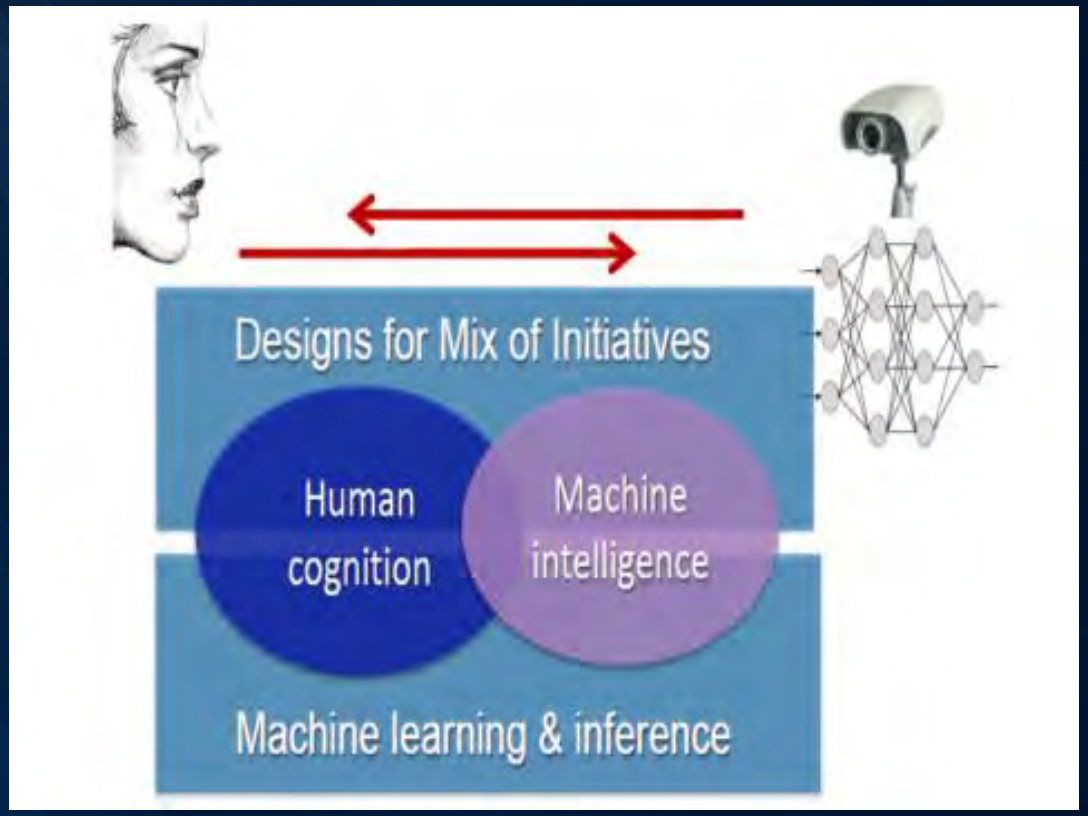
RESEARCH THEME

Smart Systems

Human Cognition and Behavior and Engineered Systems

How to harness machine intelligence to augment human cognition and human decision-making capabilities



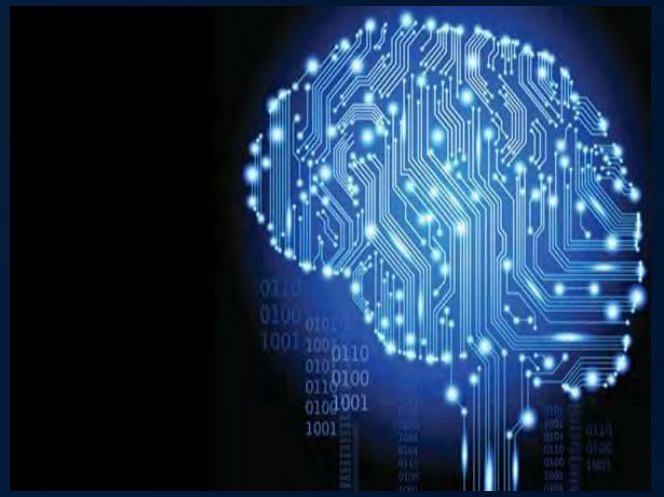


Source: Intelligent Cognitive Assistants (ICA) report, 2016.

Smart Systems

- National Robotics Initiative (NRI)
- Cyber-Physical Systems (CPS)
  - Integration of computational algorithms and physical components
- Human-Centered smart service systems (translational)
- Smart and Connected Communities
- Smart & Connected Health
- **Mind, Machine and Motor Nexus (M3X)**

Machines → Smart Machines → Human Centered Cognitive Engineered Systems



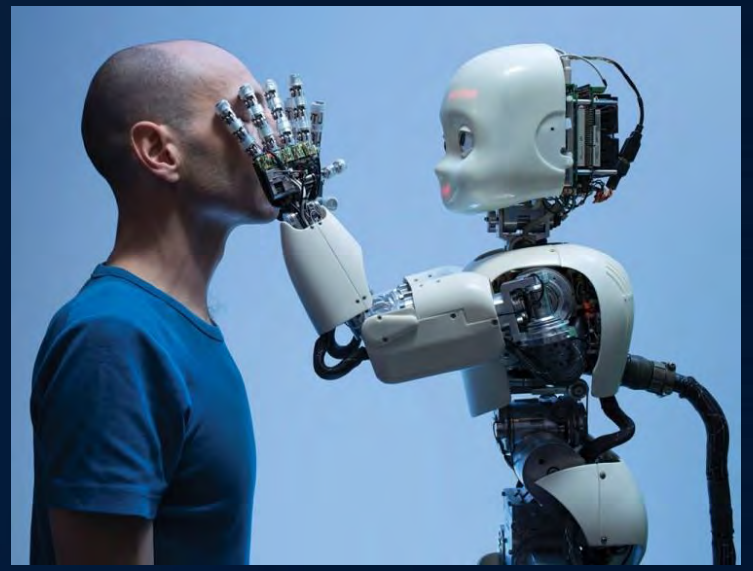
- Achieve functionality
- Improve productivity/consistency/ quality

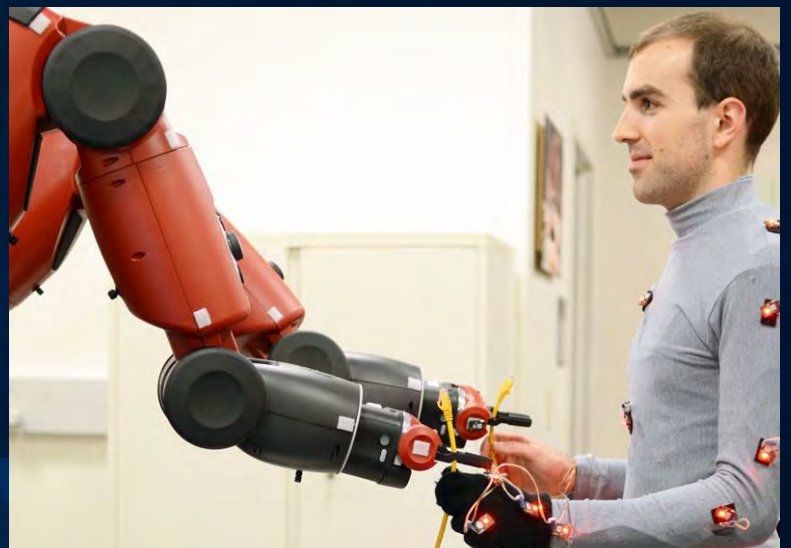
- Achieve functionality
- Improve productivity/consistency/ quality
- Has some learning/decision making capacity

- Achieve functionality
- Improve productivity/consistency/quality
- Has greater learning/decision making capacity
- Collaborate with humans
- Evolve in time as they learn

M3X: Mind, Machine and Motor Nexus

- Integrated treatment of human intent, perception, and behavior in interaction with embodied and intelligent engineered systems and as mediated by motor manipulation.
- Advance the holistic analysis of cognition and of embodiment as present in both human and machine elements.
- Encompass not only how mind interacts with motor function in the manipulation of machines, but also how, in turn, machine response and function may shape and influence both mind and motor function.
- Systems science and engineering; mechatronics; cognitive, behavioral and perceptual sciences; and applied computing..





Looking to the Future…

Looking Ahead: Ten Big Ideas

Navigating the New Arctic

Harnessing Data for 21st Century Science and Engineering

Work at the Human-Technology Frontier: Shaping the Future

RESEARCH IDEAS

Understanding the Rules of Life: Predicting Phenotype

The Quantum Leap: Leading the Next Quantum Revolution

Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

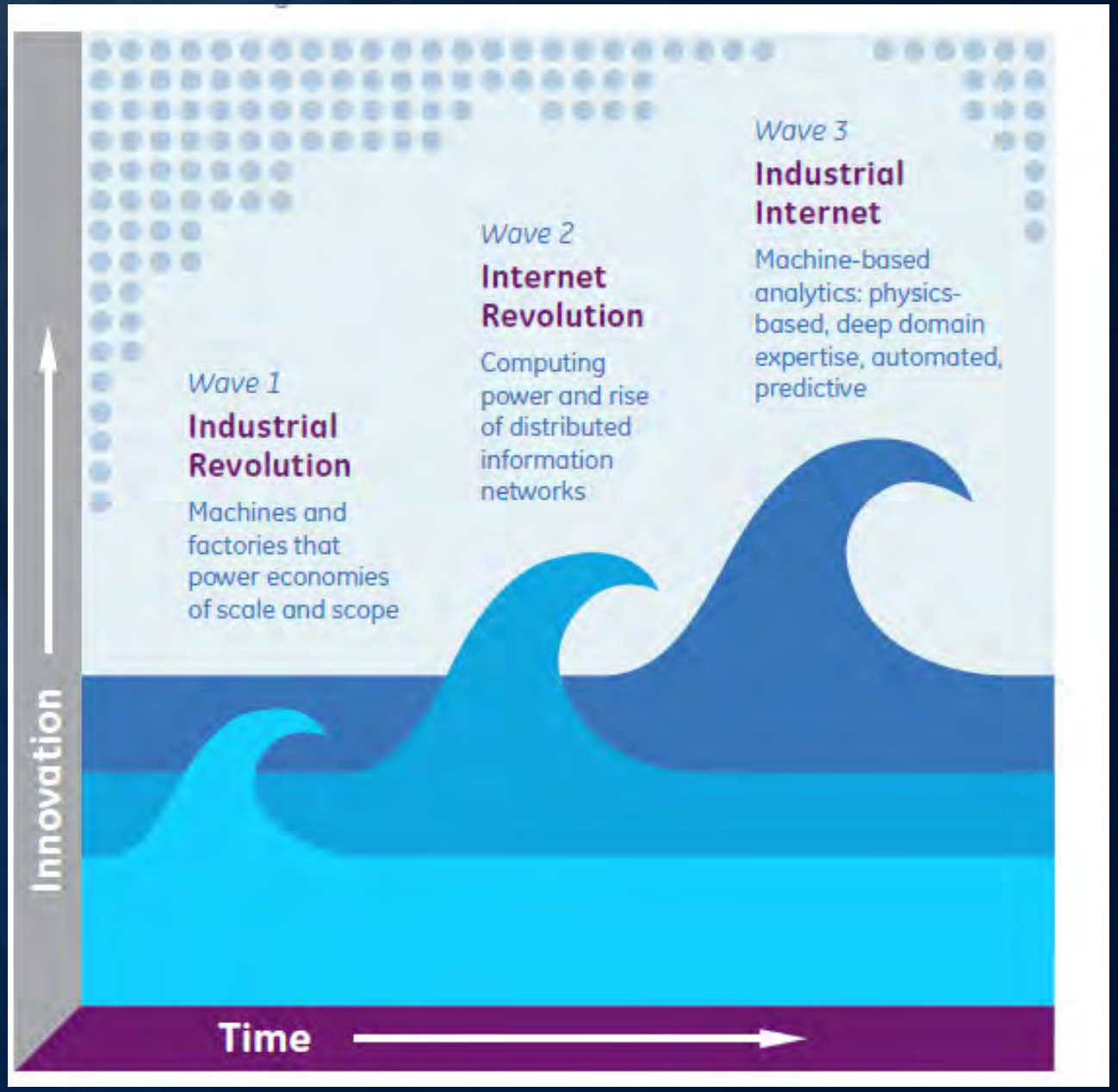
Growing Convergent Research at NSF

NSF-Includes: Enhancing Science and Engineering through Diversity

Mid-scale Research Infrastructure

NSF 2050: Seeding Innovation

*"The **deeper meshing** of the digital world with the world of machines holds the potential to bring about profound transformation to global industry, and in turn to many aspects of daily life, including the way many of us do our jobs."*



Source: Industrial Internet: Pushing Boundaries of Minds and Machines, GE.

WORK AT THE HUMAN-TECHNOLOGY FRONTIER: SHAPING THE FUTURE

Past research investments are bearing fruit today

NSF projects foster human-technology partnership

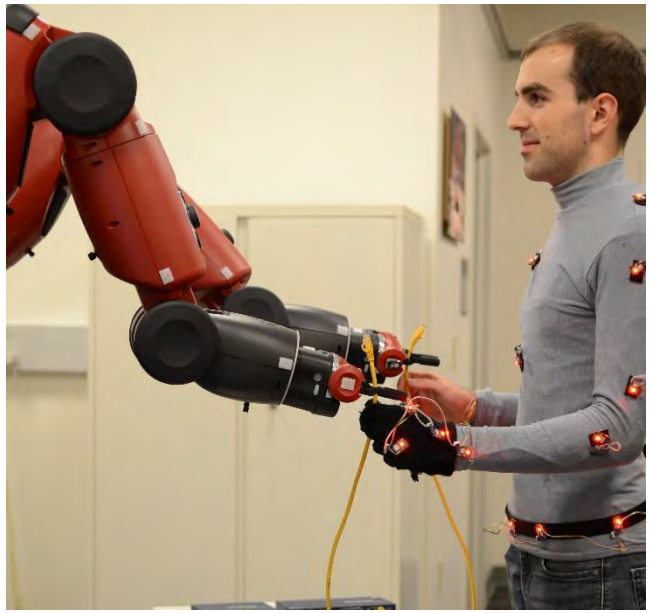
Wearable robotic glove restores independence for stroke victims

Transformative advances in manufacturing enable a new model for small business

Smart prosthetic arm and hand with sense of touch

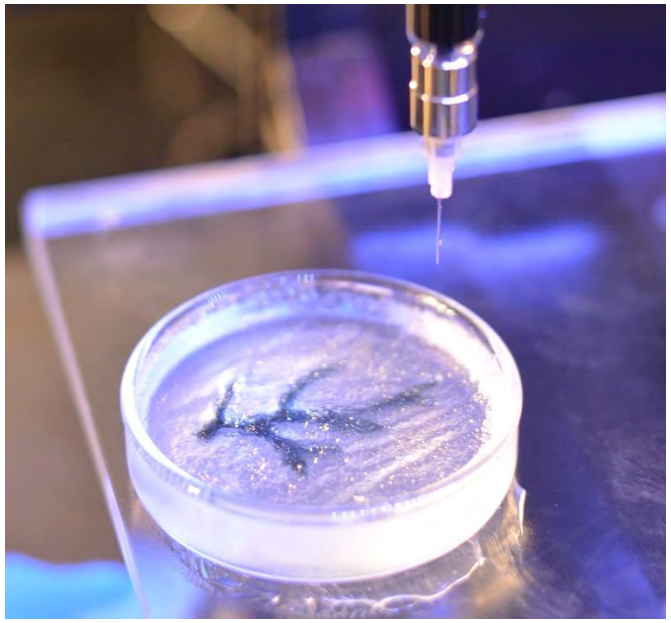
Today's investments will shape the future workplace

NSF recognizes the importance of meaningful work to the national quality of life



Cooperative robot learns to work with human partner

Intelligent meeting room increases productivity



3D printing of complex, soft, and living materials

Four themes to mobilize NSF's multidisciplinary communities:

- Human-Technology Symbiosis
- Augmenting the Individual
- Illuminating the Emerging Socio-Technological Landsc
- Fostering Lifelong and Pervasive Learning

A Trend of Convergence

Deep integration of knowledge, tools, techniques, and modes of thinking to address pressing societal problems and profound research questions

Convergence of engineering, physical science, computer science, life science, and social and behavioral science

Dear Colleague Letter: Growing Convergence Research at NSF https://www.nsf.gov/pubs/2017/nsf17065/nsf17065.pdf

- Convergence as a process for catalyzing new research directions:
  - Deep integration across disciplines.
  - Research driven by a specific and compelling problem.
- Big Ideas:
  - Harnessing the Data Revolution for 21st Century Science and Engineering
  - Navigating the New Arctic
  - The Quantum Leap: Leading the Next Quantum Revolution
  - Work at the Human-Technology Frontier: Shaping the Future

Convergence DCL

- HTF Workshop awards: up to one year of support for projects that do not exceed $100,000 in total. HTF Workshop proposals: May 15, 2017.
- HTF RCN awards: four to five years of support for projects with total budgets that do not exceed $500,000. HTF RCN proposals: June 1, 2017.

Some unsolved questions

- How can engineered systems respond and adapt appropriately to sensed human signals (cognitive, physical, and emotional)?
- What are computable theories of cognition and embodiment for human-machine systems?
- How can mathematical optimization best integrate human variability [and the dynamic effects of human interaction with the engineered system] in their formulations?
- How can we develop models of control and actuation that allow for co-adaptation of engineered systems and humans, that is, that can react to humans adapting to the system while the system adapts to the human.

RCNs designed to

- promote new collaboration among scientists with diverse expertise who share a common interest in a new or developing area
- new groups and networks advance fields and create novel directions and opportunities for research
- strengthen interdisciplinary research and international partnerships.
- will not directly support costs related to primary research.
- RCNs can be used for synthesis activities where existing data and collaboration are utilized to advance knowledge in disciplinary and cross-disciplinary areas.

RESEARCH THEME

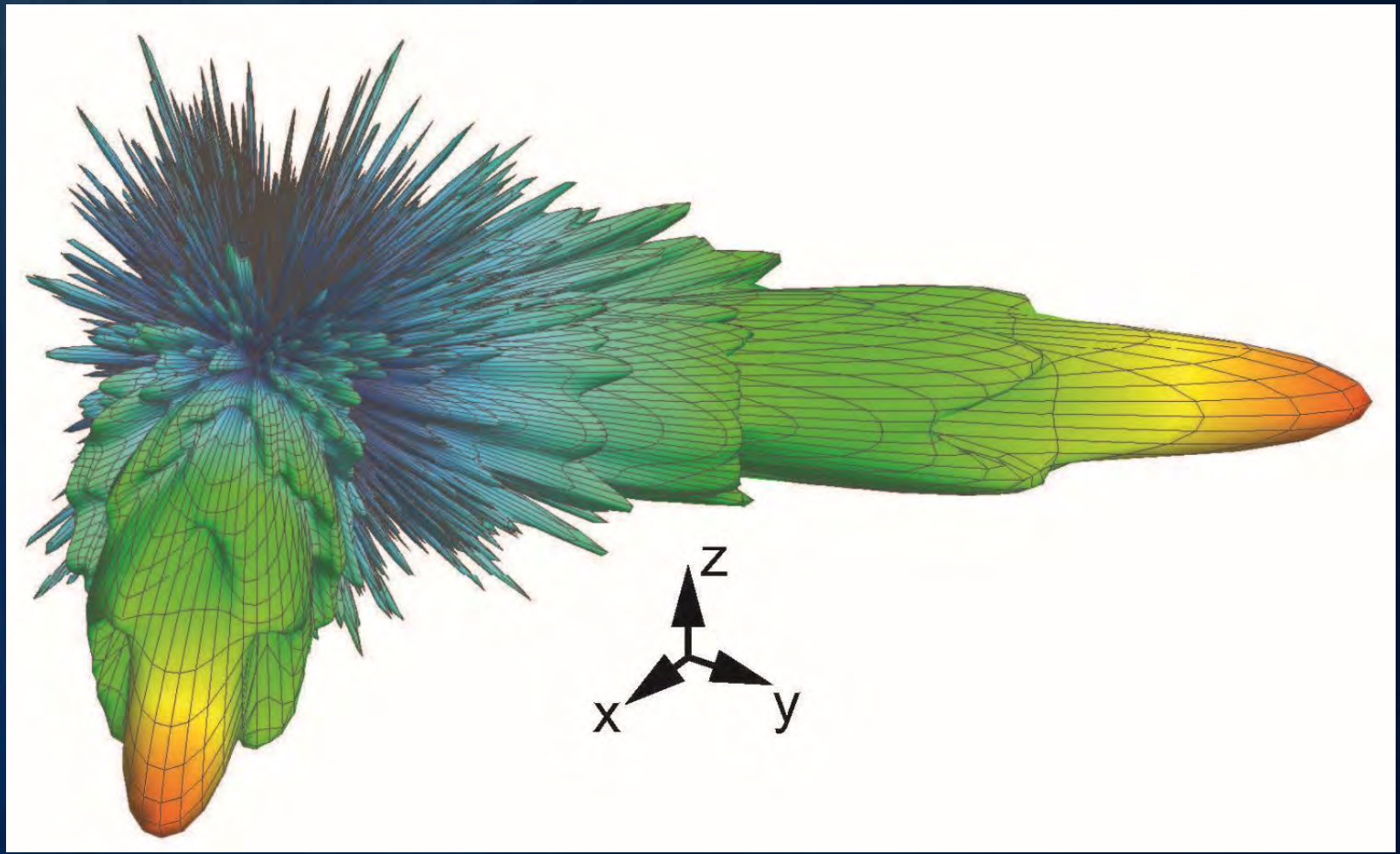
High-Performance Computing and Wireless Communication

Energy-Efficient Computing: from Devices to Architectures (E2CDA)

- Improvements in computing performance are severely limited by the amount of energy needed to manipulate, store and transport data
- E2CDA invests in radical new approaches – from brain-inspired architectures to hybrid digital-analog designs
- Partnership between NSF (ENG and CISE) and SRC

Spectrum-efficient, Energy-efficient and Secure Wireless Communication (SpecEES)

Jointly supported by ENG and CISE



Credit: Hani Mehrpouyan, Boise State University

RESEARCH THEME

Engineering Education, Broadening Participation and Innovation

Changing the culture of engineering education

- REvolutionizing engineering and computer science Departments (RED) (afternoon talk will focus on this)
- NSF INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science
  - **Aims to achieve scale for inclusion in STEM**
  - **Involves collective impact-type approaches and collaborative networks**
  - **Preliminary Proposal Due Date(s)** ***(required)***: February 14, 2017
  - **Full Proposal Deadline(s)**: May 16, 2017

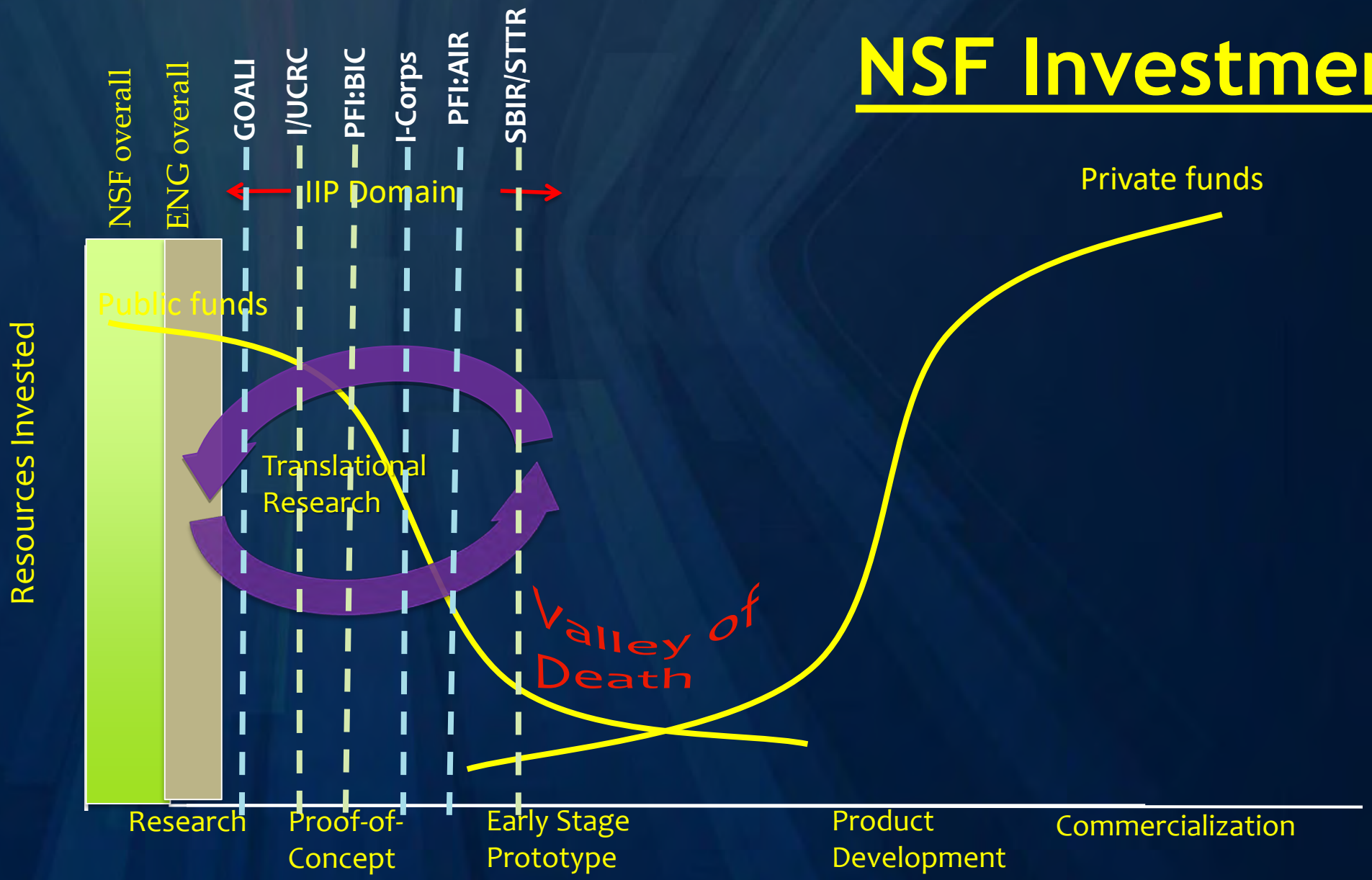
NSF INCLUDES is a multi-year program with three essential components currently under development:

- INCLUDES Design and Development Launch Pilots: $300K
  - Two-year pilot projects that explore the feasibility of bold, innovative ways for solving a broadening participation challenge in STEM.
  - Deliver models or prototypes, which incorporate data and measurement infrastructures, supporting collective efforts aimed at increasing the active participation of those who have been traditionally underserved and underrepresented in all STEM fields.
- NSF INCLUDES Alliances: leverage existing Design and Development Launch Pilots (not yet developed)
  - catalyze NSF's broadening participation investments, with each Alliance committed to collectively solving a specific set of objectives.
- NSF INCLUDES Backbone Organization: will drive activities for all NSF INCLUDES Alliances over the lifecycle of the initiative

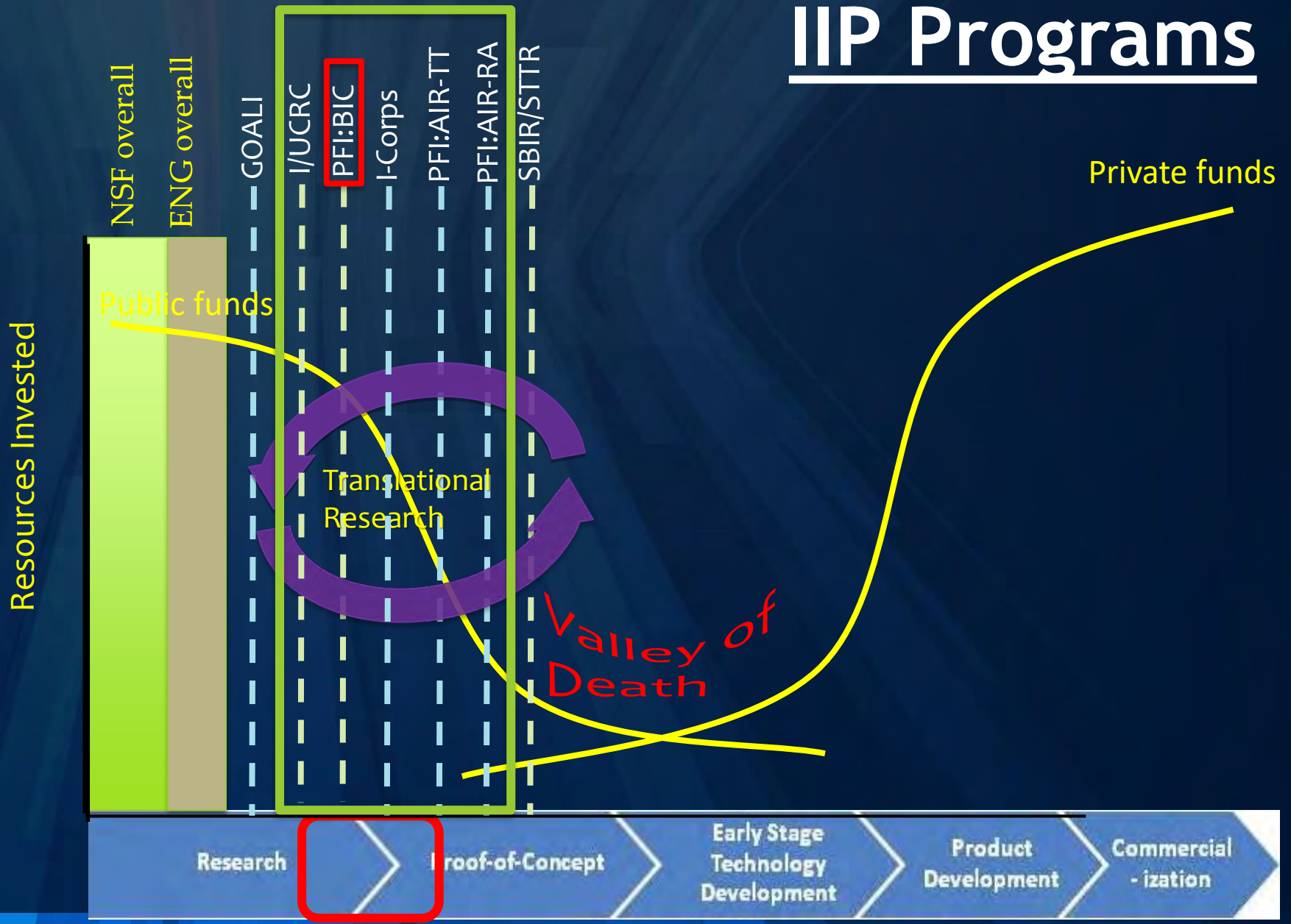
Credit: Marco Hatch, Western Washington University

A trend towards translation and innovation…

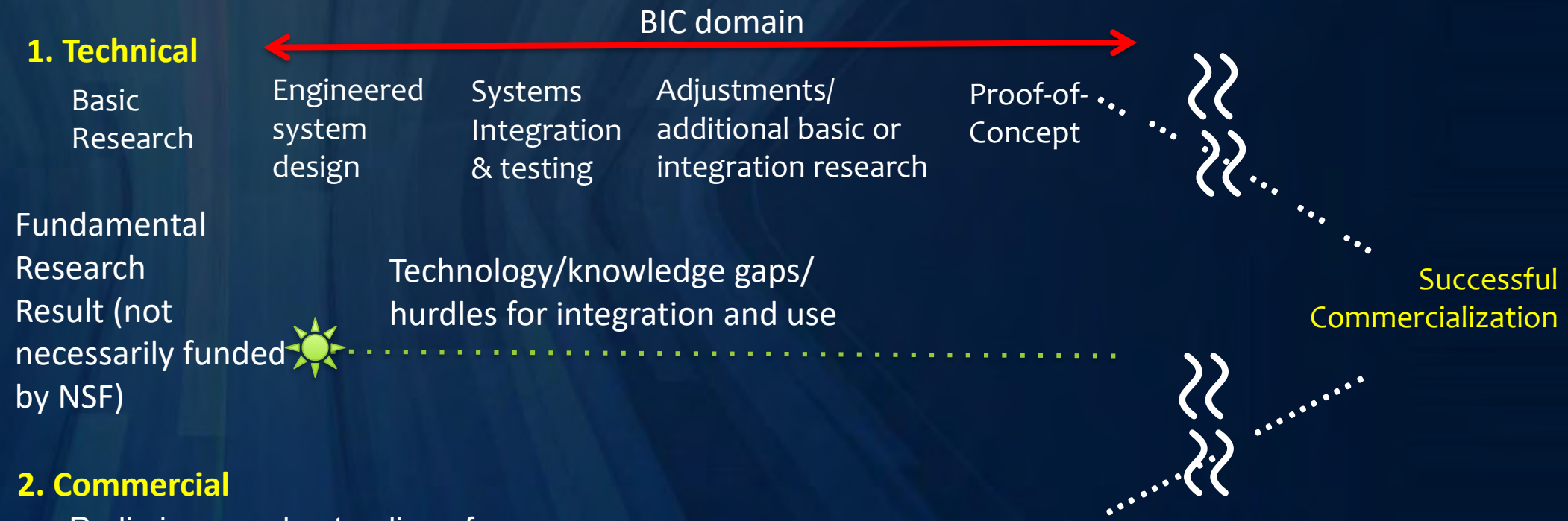
NSF Investments



IIP Programs



Partnerships for Innovation:Building Innovation Capacity in - Smart Service Systems



http://http://www.nsf.gov/eng/iip/pfi/bic.jsp

Innovation Corps

Providing Experiential Entrepreneurial Education

- National Innovation Network with 8 Nodes and 51 Sites
- 192 universities in 44 states
- Over 800 teams have completed the NSF curriculum to date
- Over 320 companies created, 3 acquisitions
- Raised more than $83 million in follow-on funding
- Partnerships with 11 other Federal agencies

Engineering and Biology

Science's Top 10 Breakthroughs of 2013

1. **Cancer Immunotherapy**
2. **CRISPR:** Site-specific Gene-editing
3. Perovskite Solar Cells
4. **Vaccine Design**
5. **CLARITY:** The imaging technique, which renders brain tissue
6. **Mini-Organs:** Researchers growing mini, human-like "organoids" for liver buds, mini-kidneys and tiny brains
7. Cosmic Rays Traced to Supernova Remnants
8. **Human Cloned Embryos:** Derive stem cells from cloned human embryos
9. **Why We Sleep:** Brain Mapping & Imaging
10. **Our Microbes, Our Health**

Themes, Issues and Questions for the Future

- Multidisciplinary, center-scale engineering research
- Advanced manufacturing
- Smart systems: modeling and embodiment of human-technology collaborative systems
- High-performance computing and secure, energy-efficient communication research
- Water, food, energy and critical infrastructure

- How to prepare future engineers
- How to move the needle in diversity and inclusion
- How to stimulate a dynamic innovation ecosystem

FEW TIPS FOR JUNIOR FACULTY

Support for New Investigators

- The Faculty Early-Career Development (CAREER) program is one of many NSF funding opportunities for new investigators
- All NSF programs support new investigators as part of regular ("core") research competitions
- More than 33% of research proposals submitted to NSF are from new (not previously NSF-funded) investigators
- Approximately 20% of the research proposals from new investigators are submitted to the CAREER Program
  -- a Foundation-wide activity that offers NSF's most prestigious awards in support of early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the missions of their organizations

Why you need to talk to the PD before submitting….

Program Director's Recommendations

Consider Panel Advice

Program Research Agenda

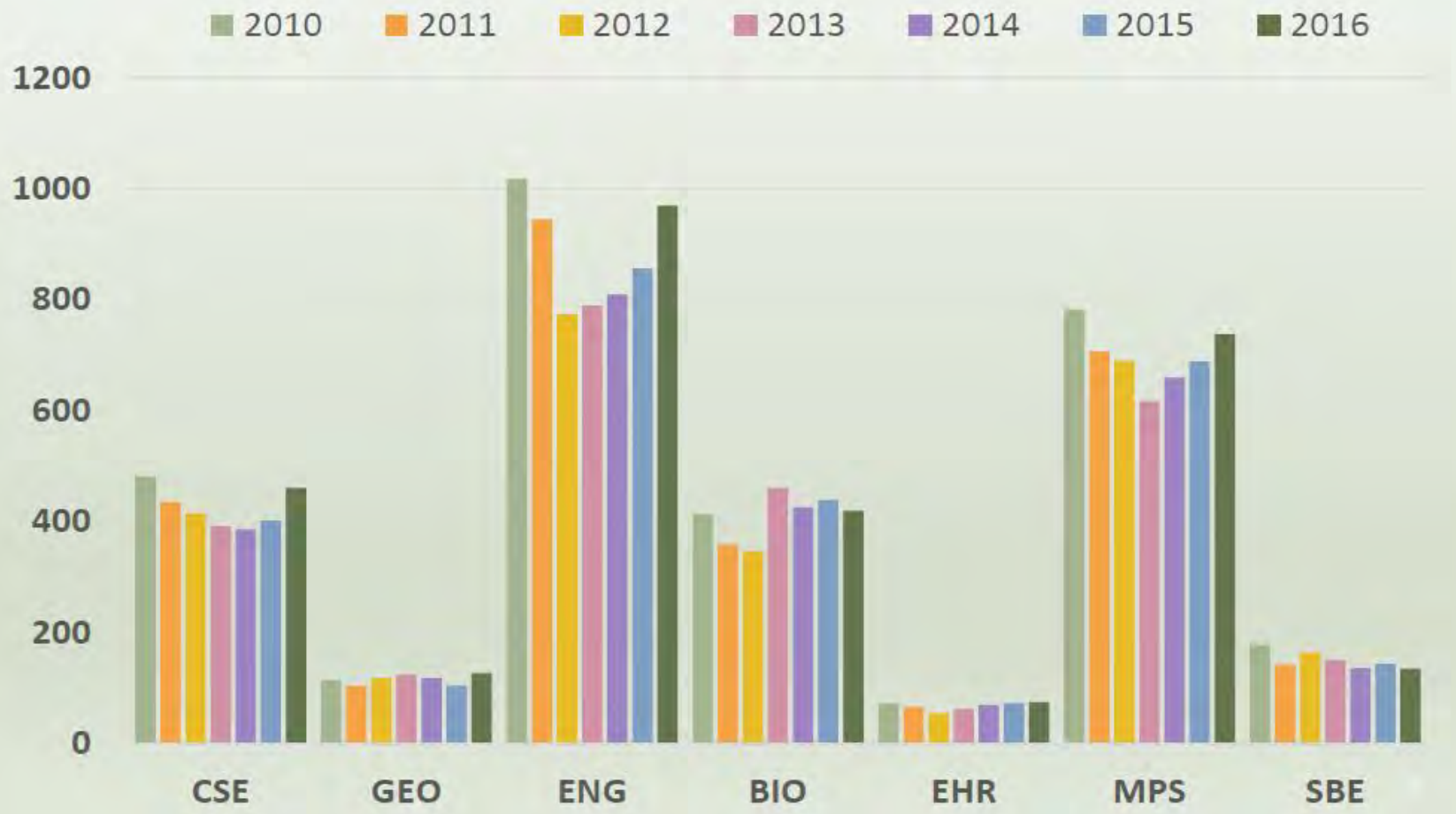
Portfolio Balance (topics, geographic, type of institution, type of PI, etc.)

Limited Budgets

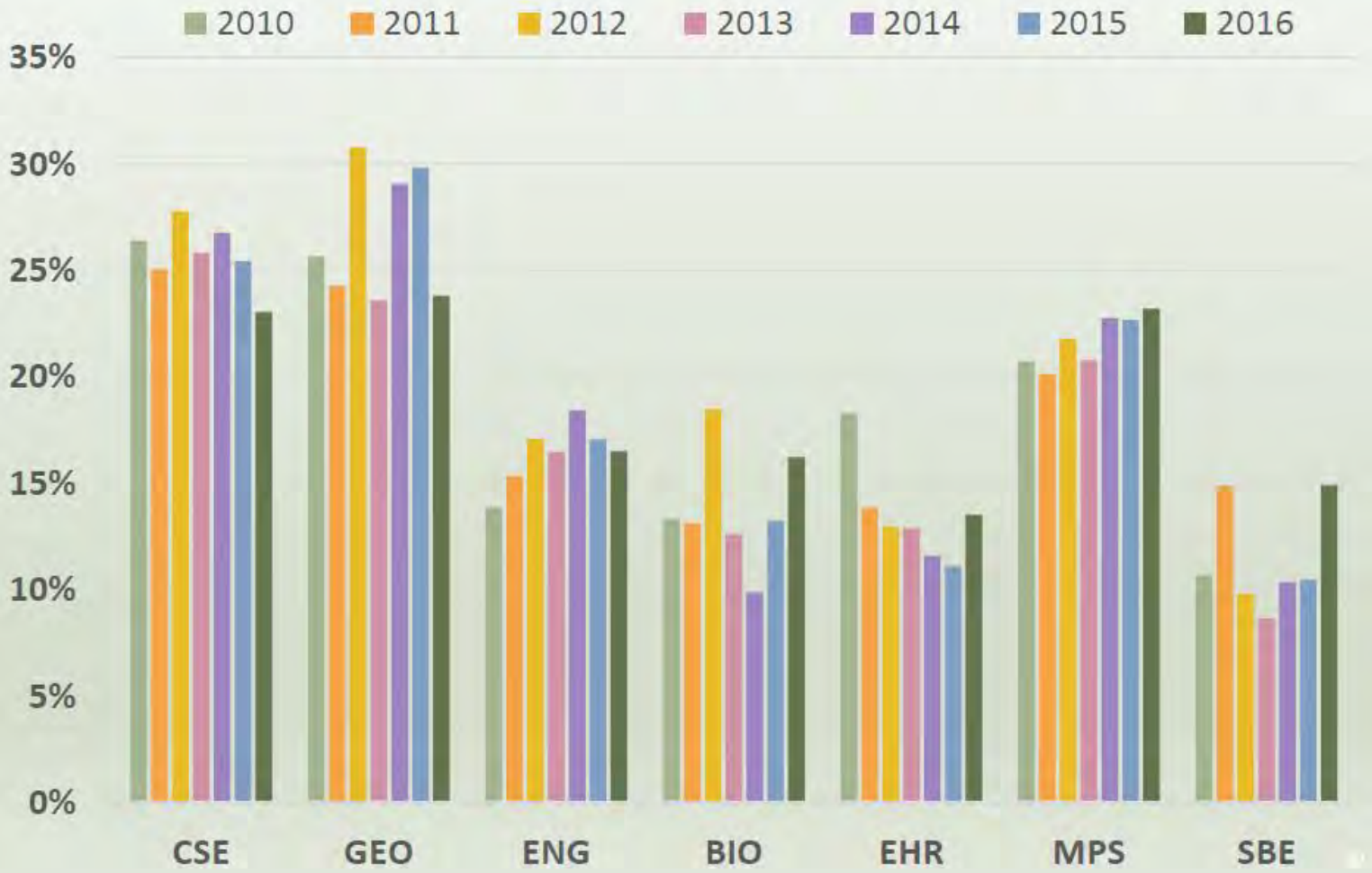
Many Panels (calibrate across panels)

Personal Background

Number of CAREER Proposals



CAREER Funding Rate



Questions or Comments?