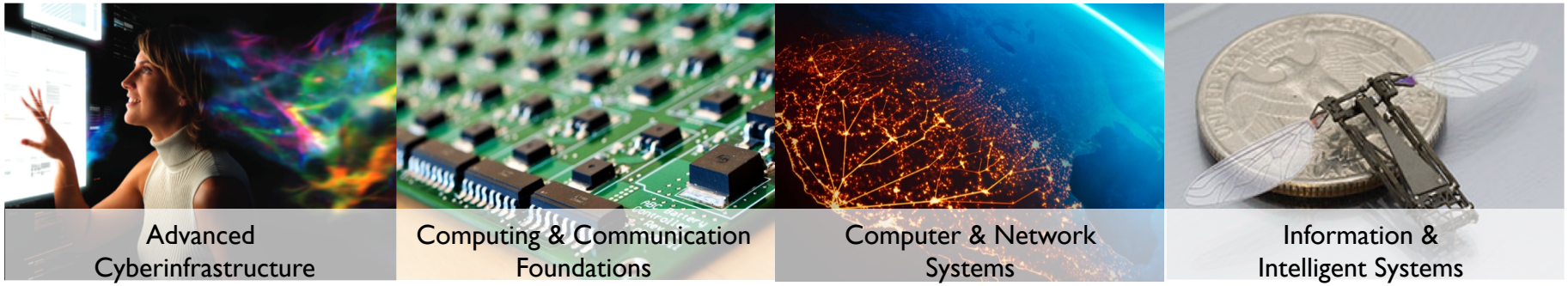
An Expanding and Expansive View of Computer and Information Science and Engineering



Fay Cobb Payton, PhD
Program Director, NSF
Computer & Information Science & Engineering

UMBC

September 2018

Outline


CISE: the National Imperative
CISE Overview
Programmatics
Looking Forward

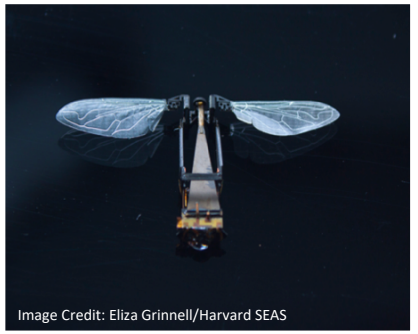
National Science Foundation's Mission

National Science Foundation's Mission

CISE programs address national priorities

Big Data & AI

Cybersecurity



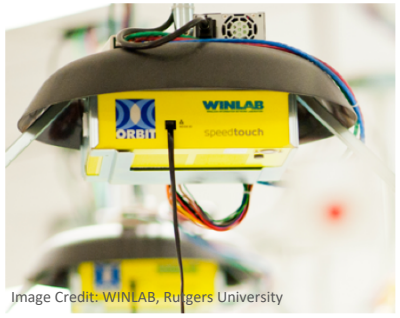
Robotics & Manufacturing

Understanding the Brain

Advanced Cyberinfrastructure

Smart Communities

Computer Science Education

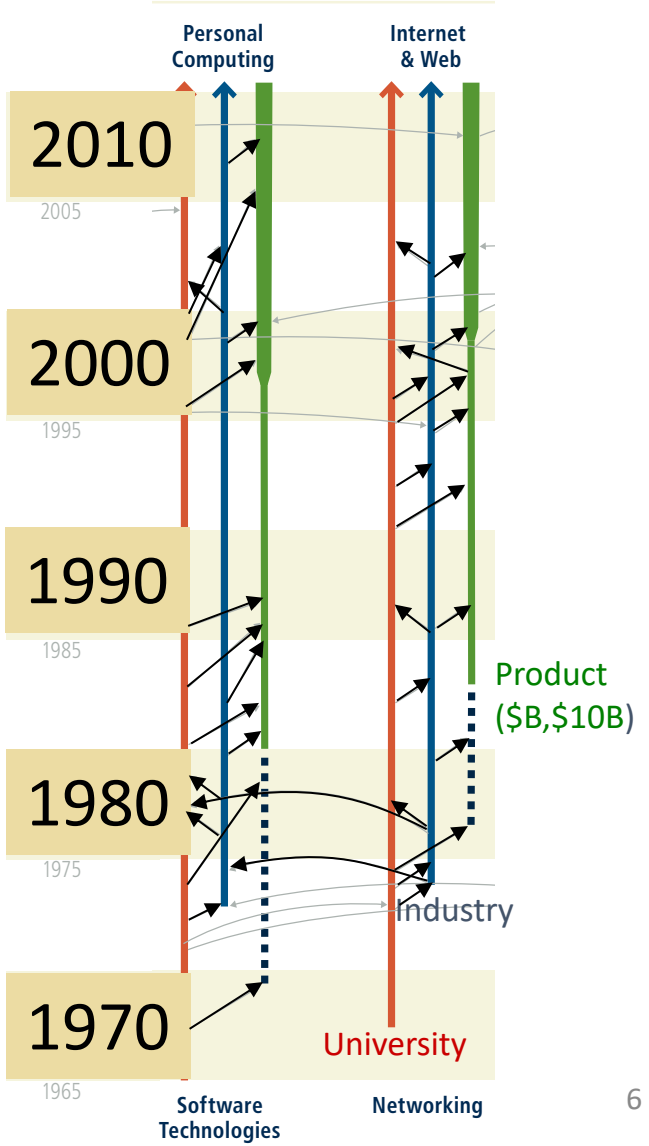


Advanced Wireless Research

Economic impact of CISE: From Federally-funded research to billion-dollar industries

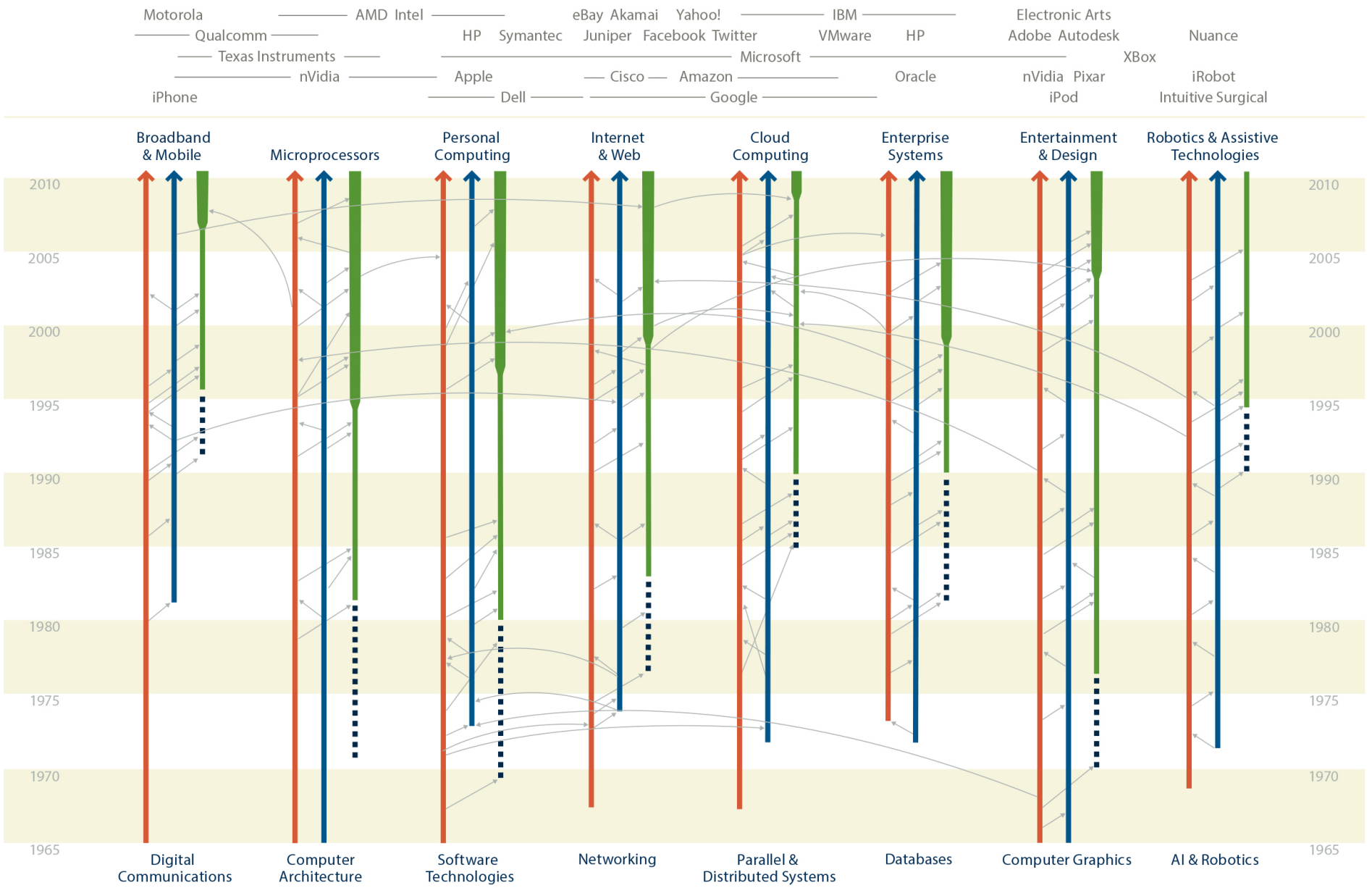
Advances in computing, communications, information technologies, and cyberinfrastructure:

- drive U.S. competiveness
  - IT accounts for 25% of economic growth since 1995;
  - resulted in many billion-dollar industries: networking, software, digital communications, computer graphics, AI and robotics, and more
- have profound impacts on our daily lives.



Source: National Research Council. 2016. *Continuing Innovation in Information Technology*.

…. across many industries



This impact continues today

Machine Learning

- Big Data Analytics Market: $125B (Forbes)
- Deep learning rooted in NSF-funded research on neural networks, reinforcement learning

"NSF is where all interesting research gets started…" - Eric Schmidt, Google / Alphabet

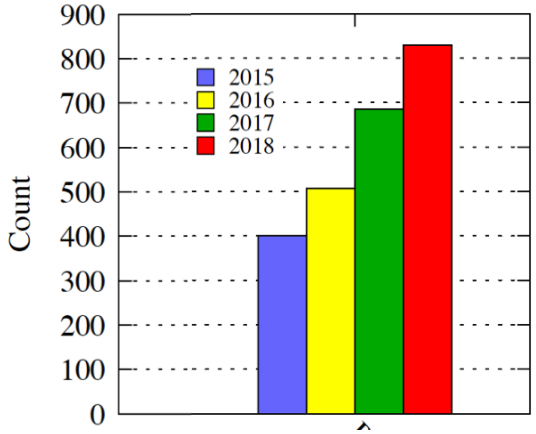
Software-Defined Networking (SDN)

- SDN Market: $18B in 2018 (IDC)
- SDN resulted from NSF-funded foundational research

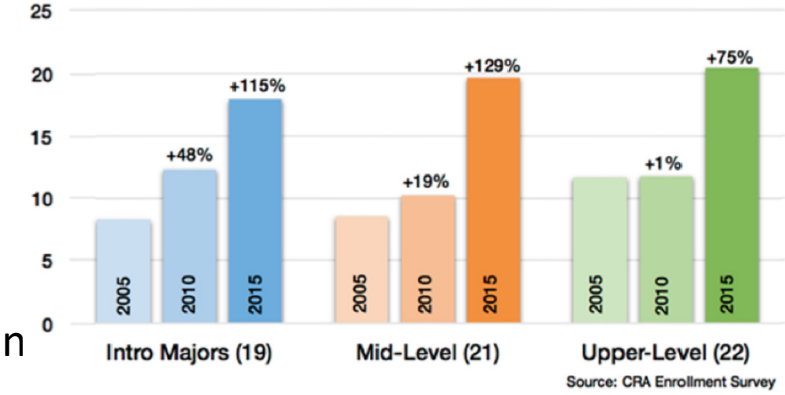
Open Programmable Mobile Internet 2020 project funded by NSF/CISE Expeditions program, 2008, N. McKeown, Stanford U.

Fundamental research powers innovation

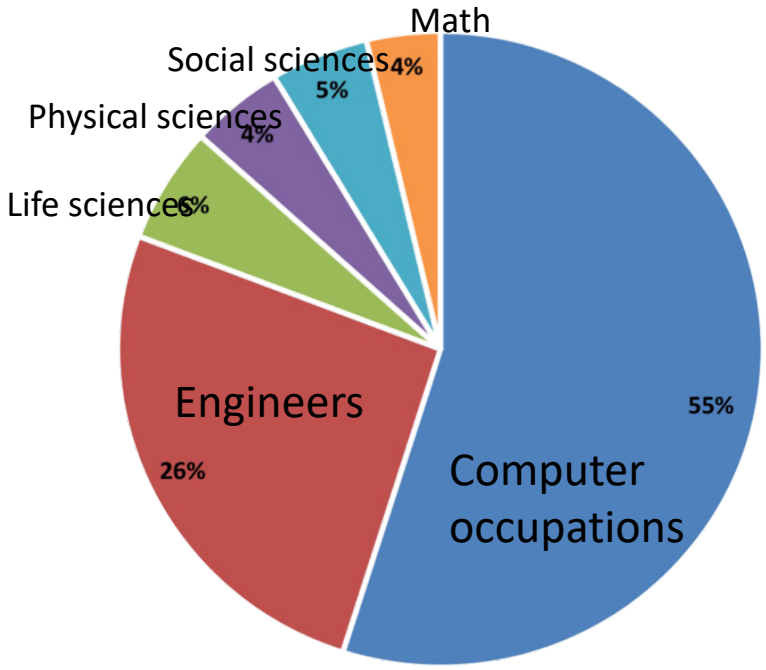
CISE Academic Community



"21% one-year, a 64% two-year, and a 107% three-year increase in the number of [tenure track CS faculty] positions being searched for" (Wills, Nov. 2017)



"Enrollments in CS courses and the number of CS majors have risen markedly since 2005 … no indication that enrollments will fall in the near term. Both CS majors and non-majors have contributed significantly to the recent growth" (NASEM 2017)



Job Openings
2014 – 2024
(growth and replacement)
US Bureau of Labor Statistics

It is an
exciting, impactful and important time
to be in
computer and information science and engineering!!

Outline


CISE: the National Imperative
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CISE Organization

CISE Directorate

Jim Kurose, AD

Erwin Gianchandani, DAD

Senior Advisor for Data Science
Chaitan Baru

Senior Advisor
Irene Qualters

Office of Advanced Cyberinfrastructure (OAC)

Manish Parashar, OH

- Data
- High Performance Computing
- Networking/ Cybersecurity
- Software

Computing and Communication Foundations (CCF)

Bala Kalyanasundaram, Acting DD

- Algorithmic Foundations
- Communication and Information Foundations
- Software and Hardware Foundations

Computer and Network Systems (CNS)

Ken Calvert, DD

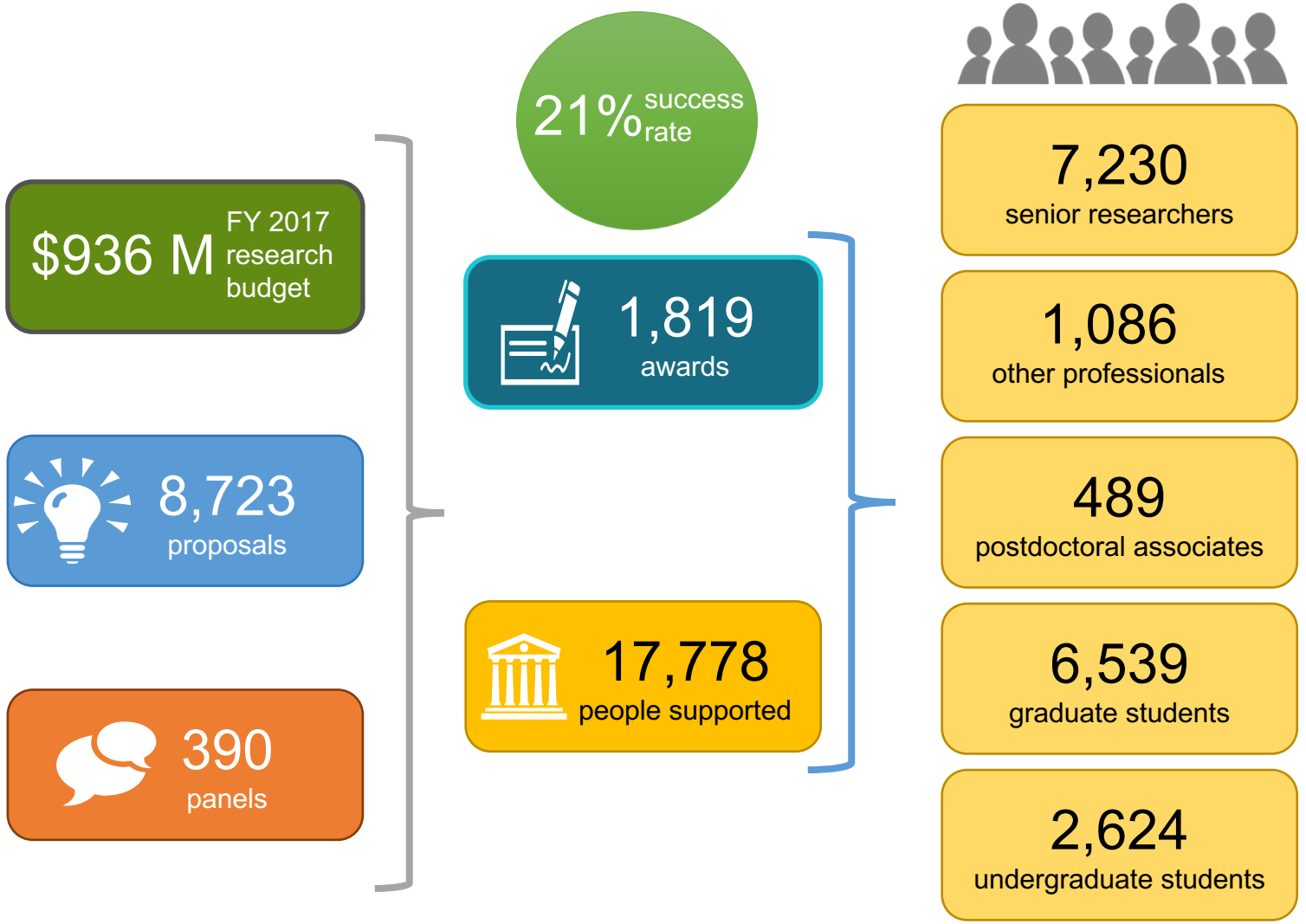
- Computer Systems Research
- Networking Technology and Systems
- Education and Workforce Development

Information and Intelligent Systems (IIS)

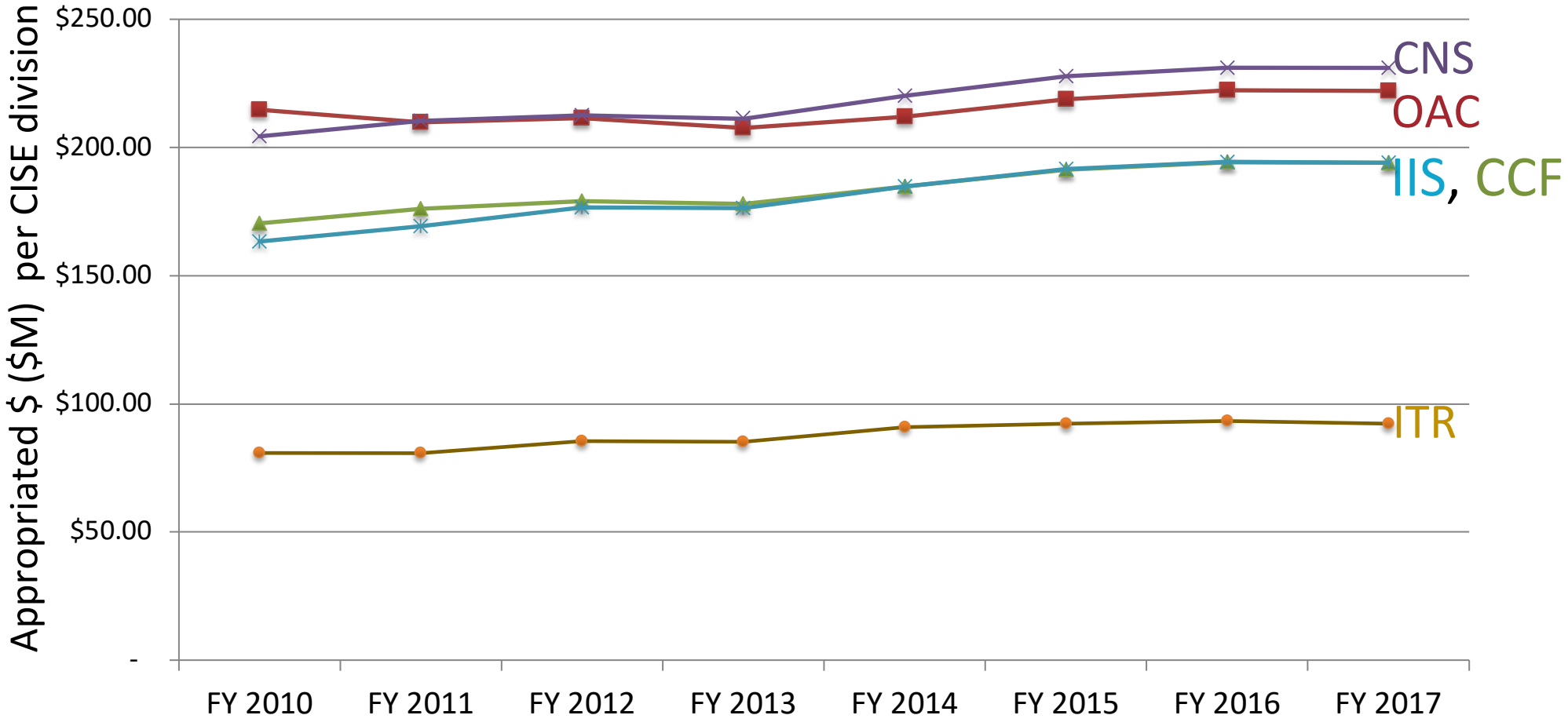
Howard Wactlar, Acting DD

- Cyber Human Systems
- Information Integration and Informatics
- Robust Intelligence

CISE by the Numbers: FY 2017

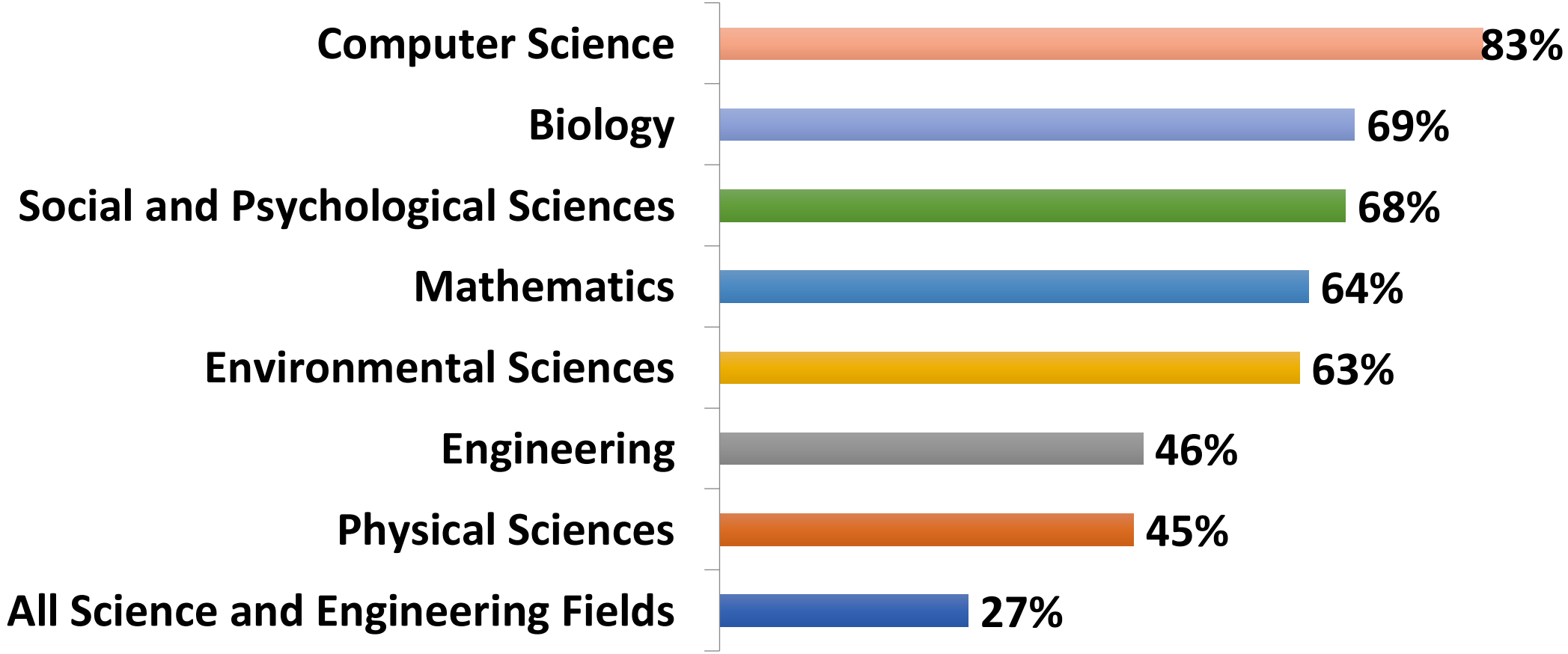


NSF/CISE Division Budgets



NSF Supports All Areas of Fundamental Research

NSF support as a percentage of total federal support for basic academic research



Source: NSF/NCSES, "Survey of Federal Funds for Research and Development"

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An expanding, expansive view of computing

An expanding, expansive view of computing

Human-technology frontier

Assistive technologies, affective computing, social informatics, mind/machine interface, brain

Science, societal applications

Science, engineering, humanities health, security, environment. energy, transport, commerce, education

Nano, quantum, molecular, optical

Smart vehicles & buildings, cyber-physical systems, swarms, mobile/cloud

Changing "physicalness" of computing

computing embedded around us

Harnessing the Data Revolution (HDR)

Enabling 21st-century science, engineering, and education to move toward effective use of digital data to advance discovery

- Fundamental research in data-centric mathematics, statistics and computational, and computer science
- Fundamental research on data-centric algorithms and systems
- Data-driven research in all NSF research domains
- data-centric, science-driven, research cyberinfrastructure (CI) ecosystem
- creation and nurturing of a 21st-century data-capable workforce

Includes CISE investments in the following programs: BIGDATA, DIBBs, TRIPODS

Harnessing the Data Revolution (HDR)

TRIPODS: Transdisciplinary Research in Principles of Data Science

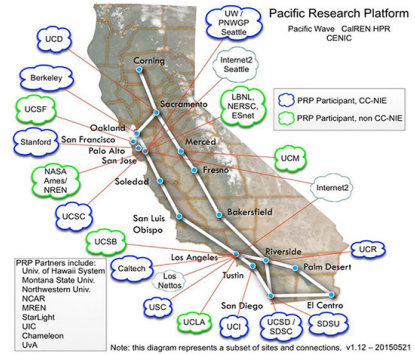
- Bringing together statistics, mathematics, theoretical computer science communities to develop theoretical foundations of data science through integrated research, training activities
- CISE, MPS

BIGDATA: Critical Techniques, Technologies and Methodologies for Advancing Foundations and Applications of Big Data Sciences and Engineering

- *Foundations:* fundamental techniques, theories, methodologies, technologies
- *Innovative Applications:* application-driven novel techniques, methodologies, technologies
- CISE, BIO, EHR, ENG, GEO, MPS, SBE
- AWS, Google Cloud, Microsoft Azure

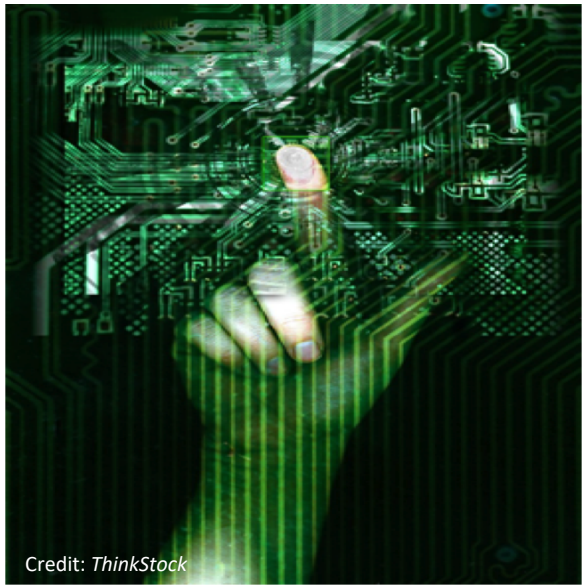
DIBBs: Data Infrastructure Building Blocks

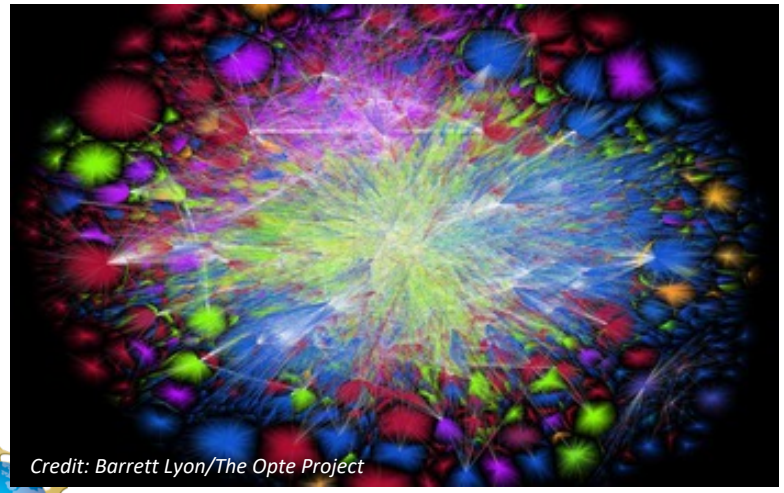
- Robust, shared data-centric cyberinfrastructure capabilities
- accelerating interdisciplinary research in areas stimulated by data
- CISE (OAC) and other directorates



Theory *Systems & applications* *Cyberinfrastructure*

Secure and Trustworthy Cyberspace (SaTC)



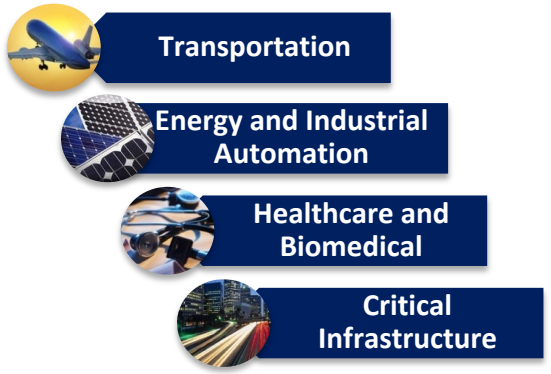


- SaTC solicitation designations:
  - Trustworthy Computing Systems
  - Social, Behavioral and Economic Sciences
  - *Secure, Trustworthy, Assured and Resilient Semiconductors and Systems (STARSS), jointly offered with the Semiconductor Research Corporation (SRC)*
  - Transition to Practice (TTP)
- Cybersecurity education

The Human-Technology Frontier

Cyber-Physical Systems (CPS): Deeply integrating computation, communication, and control into physical systems

- develop core system science for complex cyber-physical systems in multiple application areas
- CISE, ENG
- DHS, DOT, NASA, NIH, USDA



NRI-2.0: Ubiquitous Collaborative Robots: Developing the next generation of collaborative robots to enhance personal safety, health, and productivity

- accelerate development and use of collaborative robots
- CISE, EHR, ENG, SBE
- DOD, DOE, USDA

The Human-Technology Frontier

Smart & Connected Communities (S&CC):

improving quality of life for all

- interdisciplinary, integrative research to improve understanding, design, sustainability of intelligent infrastructure
- engaging local residents, stakeholders, government across rural, coastal, urban, border communities
- CISE, EHR, ENG, SBE

Smart and Connected Health (SCH): transforming healthcare knowledge, delivery, and quality of life through IT

- safe, effective, efficient, patient-centered, proactive, predictive health and wellness technologies
- CISE, ENG, SBE
- Joint with NIH

Cyberlearning and Future Learning Technologies:

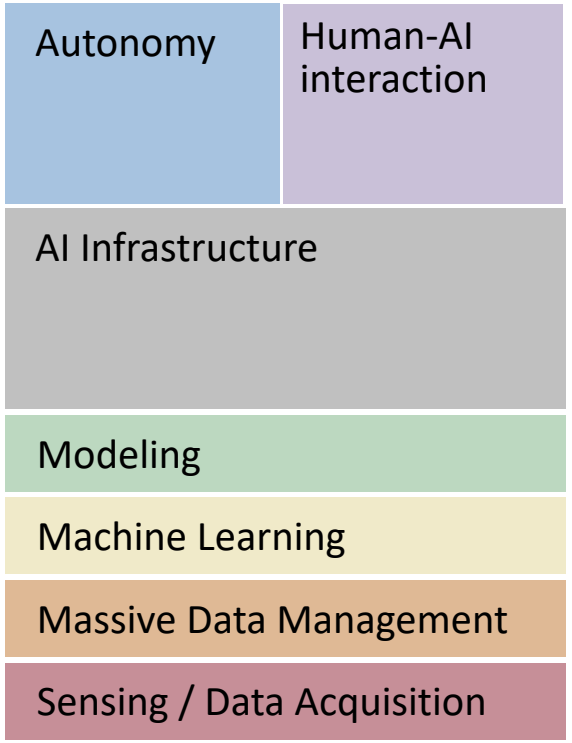
expanding and transforming learning and educational opportunities and outcomes for learners and workers of all ages

- technologies to enable lifelong learning, including adult re-training
- CISE, EHR, ENG, SBE

Artificial Intelligence

Transformative science that holds promise for tremendous societal and economic benefit with potential to revolutionize how we discover, work, learn, and communicate

- CISE core research programs:
  - Cyber-human Systems
  - Robust Intelligence
- Cross-directorate programs:
  - BIGDATA
  - NRI-2.0: Ubiquitous Collaborative Robots
  - Smart & Connected Communities
  - Smart and Connected Health
  - Collaborative Research in Computational Neuroscience
- CISE Expeditions in Computing
- *AI+X:* ML as a new horizontal
- Overall CISE investment: $120M



CISE Education and Workforce

Computer Science for All (CSforAll)

- access to rigorous, engaging CS education for *all K-12* students
- Computer Science Principles : *new* College Board CS AP exam (2017)

CS Undergrad Education (CS+X)

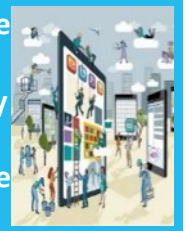
- integrating computing with other fields of knowledge, challenge areas
- builds on previous CISE investments in REvolutionizing engineering and computer science Departments (RED) program

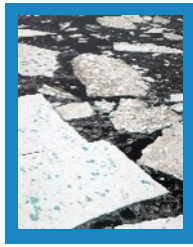
NSF's 10 Big Ideas for Future Investment

RESEARCH IDEAS

Harnessing Data for 21st Century Science and Engineering

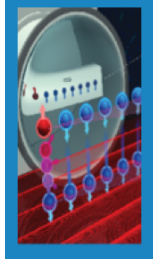
Work at the Human-Technology Frontier: Shaping the Future





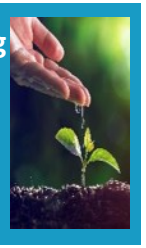
Navigating the New Arctic

Windows on the Universe: Multi-messenger Astrophysics



Quantum Leap: Leading the Next Quantum Revolution

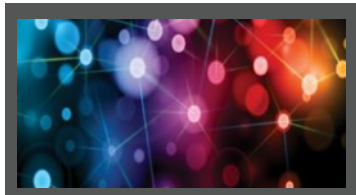
Understanding the Rules of Life: Predicting Phenotype



PROCESS IDEAS

Mid-scale Research Infrastructure

NSF 2026



Growing Convergence Research at NSF

NSF INCLUDES: Enhancing STEM through Diversity and Inclusion

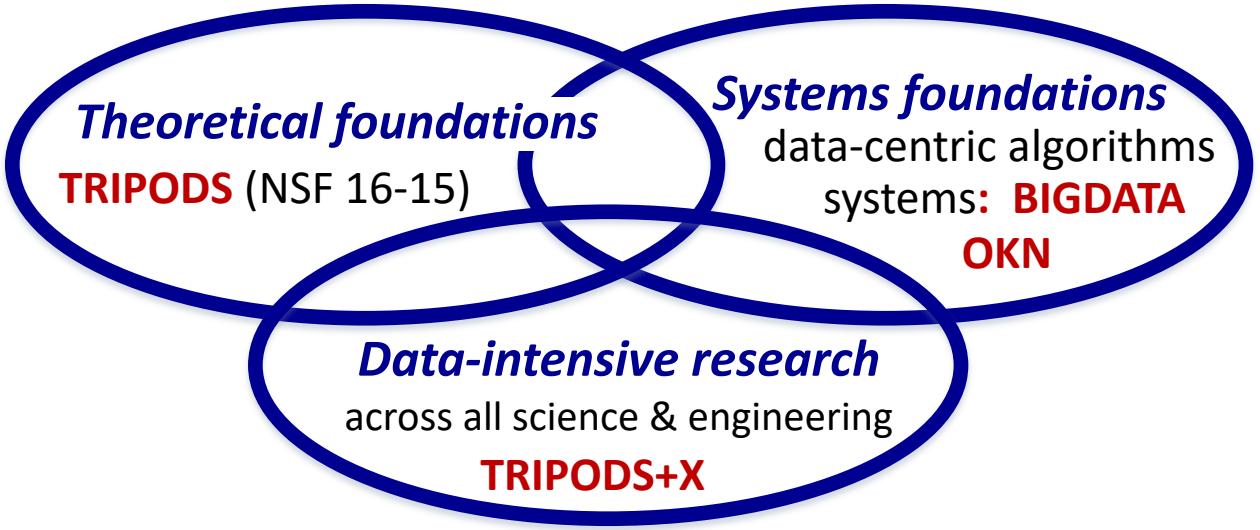
" … bold questions that will drive NSF's long-term research agenda -- questions that will ensure future generations continue to reap the benefits of fundamental S&E research.

"AI is the universal connector that interweaves all of our Big Ideas; data science is changing the very nature of scientific inquiry, and AI's use of data has the potential to revolutionize everything we do in science."

F. Cordova, Director, NSF, Sept. 2017

Harnessing the Data Revolution (HDR)

Research across all NSF Directorates



Educational pathways

Innovations grounded in an education-research-based framework
NASEM study: data science, the undergraduate perspective, NSF Research Traineeships. GRF

Advanced cyberinfrastructure

Accelerating data-intensive research.
Midscale infrastructure (Midscale RFI)

The Future of Work at the Human-Technology Frontier

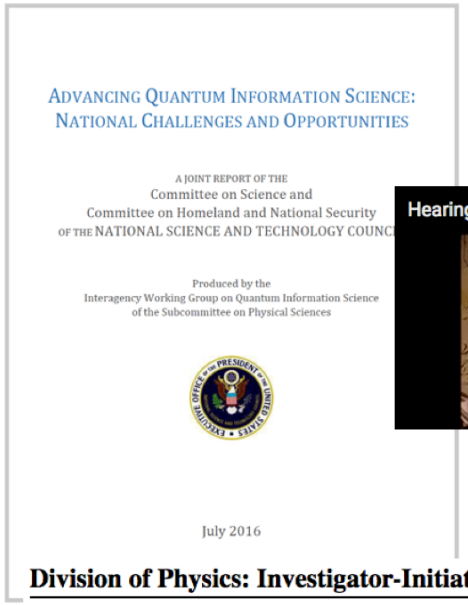
"a unique opportunity to actively shape the development and use of technologies to improve the quality of work while also increasing productivity and economic growth"

Research Themes

- Building the human-technology partnership
- Augmenting human performance
- Illuminating the socio-technological landscape
- Fostering lifelong learning

Quantum Leap: Leading the Quantum Revolution

- **Fundamentals** that advance our understanding of uniquely quantum phenomena and their interface with classical systems
- **Elements** that measure, model, control, and exploit quantum particles
- **Software systems and algorithms** that enable quantum information processing
- **Workforce**, including training a new generation of scientists, engineers



ADVANCING QUANTUM INFORMATION SCIENCE:
NATIONAL CHALLENGES AND OPPORTUNITIES

A JOINT REPORT OF THE
Committee on Science and
Committee on Homeland and National Security
OF THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

Produced by the
Interagency Working Group on Quantum Information Science
of the Subcommittee on Physical Sciences

July 2016

Division of Physics: Investigator-Initiated Research Projects (PHY)

PROGRAM SOLICITATION
NSF 17-561

REPLACES DOCUMENT(S):
NSF 16-566

National Science Foundation
Directorate for Mathematical & Physical Sciences
Division of Physics

Emerging Frontiers In Research And Innovation 2017 (EFRI-2017)

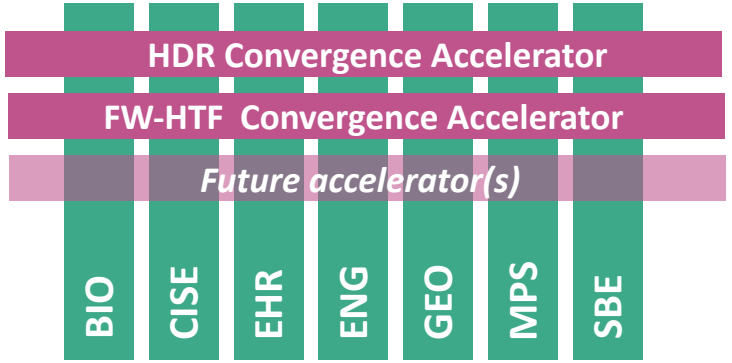
1. ADVANCING COMMUNICATION QUANTUM INFORMATION RESEARCH IN ENGINEERING (ACQUIRE)

Convergence Accelerators

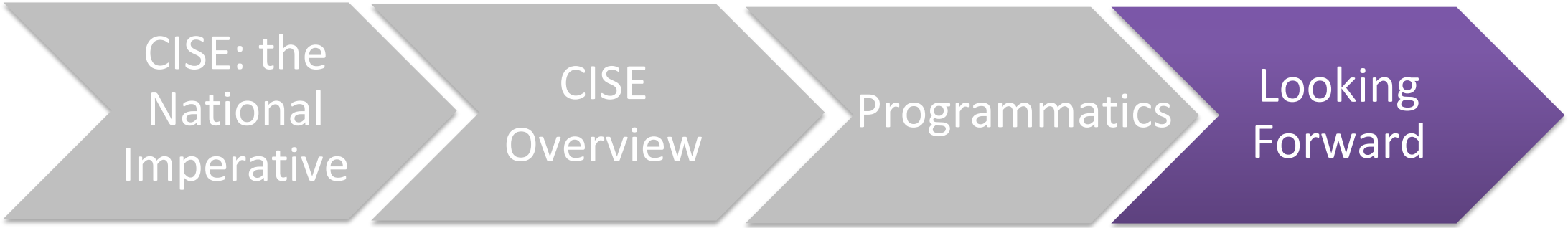
Accelerating Discovery through Convergence Research

Motivation. Changing nature of science research - research frontiers at intersection of existing disciplines

- time-limited entities: accelerating impactful *convergence* research in areas of national importance
- innovating in organizational structure to better enable frontier research
- separate (from directorates) in leadership, budget, and programmatics; but aligned with, relying on, and building on foundational disciplinary research
- emphasis on translational research, partnerships



Outline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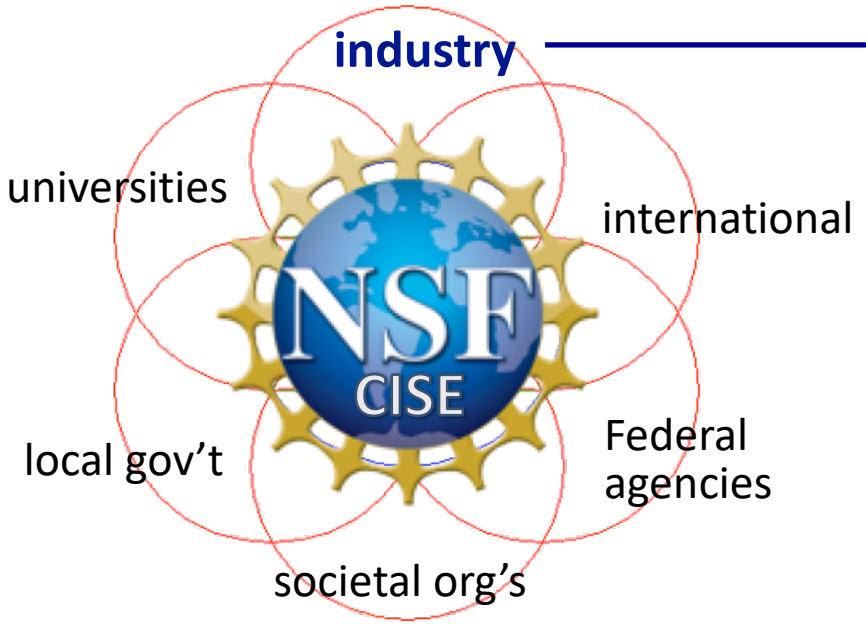
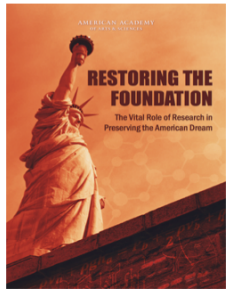
Partnerships: Many dimensions

*Partnerships **build capacity, leverage resources, increase the speed of translation** from discovery to innovation*



- **Joint NSF/industry research solicitations:** Intel (5), SRC (8), VMware (2)
- **Research infrastructure:** PAWR: Platforms for Advanced Wireless Research, cloud credit for BIGDATA, (AWS, Google, Microsoft)
- **Individual project-based:** I/UCRC, Intrans, GOALI



Prescription 3: Establishing a More Robust National Government-University-Industry Research Partnership

A direct partnership with a single industry partner

NSF/CISE and Intel Partnership

Five Joint Solicitations:

- Cyber-Physical Systems Security and Privacy
- Visual and Experiential Computing
- Computer-Assisted Programming for Heterogeneous Architectures
- Information-Centric Networking in Wireless Edge Networks
- Foundational Microarchitecture Research

Typical model for each joint solicitation:

Total investments: $6-8 million total

Funding ratio: 1:1 NSF:Intel

Awards: ~2-6 awards, $500,000-$3 million used over 3 years

An NSF-led public-private partnership:
Platforms for Advanced Wireless Research (PAWR)

$100M public-private investment to create four city-scale testing platforms to enable and accelerate fundamental wireless research going beyond 5G

- $50M CISE investment over 7 years
- $50M Industry Consortium investment from >25 networking vendors, device manufacturers, and wireless carriers

NOKIA Bell Labs · SAMSUNG · KEYSIGHT TECHNOLOGIES · NATIONAL INSTRUMENTS · Sprint · ORACLE · JUNIPER NETWORKS · ERICSSON · sigfox

COMMSCOPE · VIAVI · INTERDIGITAL · intel · QUALCOMM · AT&T · T-Mobile · Anritsu · Vapor DATA. DRIVEN. · CROWN CASTLE

verizon · CTIA The Wireless Association · htc · SSC · CARLSON WIRELESS TECHNOLOGIES · atis · TIA ADVANCING GLOBAL COMMUNICATIONS · FiberTower · MathWorks

PAWR Project Office managed by: usignite · Northeastern

Get Involved!

- Volunteer to reviews proposals, serve on panels
- Visit NSF, get to know your program(s) and program director(s)
- Participate in NSF, CCC/CRA workshops, visioning activities
- Work within your institution to support and reward interdisciplinary research
- Join NSF: serve as program officer, division director, or science advisor

THANKS!

Follow us on Twitter @NSF_CISE

Join CISE-ANNOUNCE email

cise-announce-subscribe-request@listserv.nsf.gov

From: "Kurose, James" <JKUROSE@nsf.gov>
Date: Monday, February 12, 2018 at 6:19 PM
To: "cise-announce@listserv.nsf.gov" <cise-announce@listserv.nsf.gov>
Subject: President's FY 2019 Budget Request for NSF

Dear CISE Community,

Each year, the President transmits to Congress a budget request for the Executive Branch of the Federal Government, including a request for the National Science Foundation (NSF). Today, the President officially submitted that request for fiscal year (FY) 2019, which begins October 1, 2018, and continues through September 30, 2019. **The President's FY 2019 Budget**