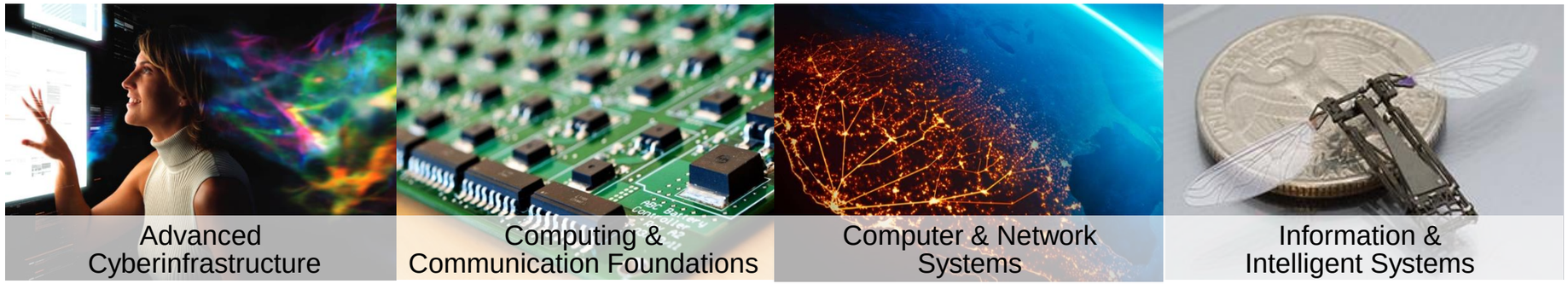
Research Directions
NSF Directorate of Computer and Information Science and Engineering
(With an Emphasis on AI)



Jim Kurose
Assistant Director, NSF
Computer & Information Science & Engineering

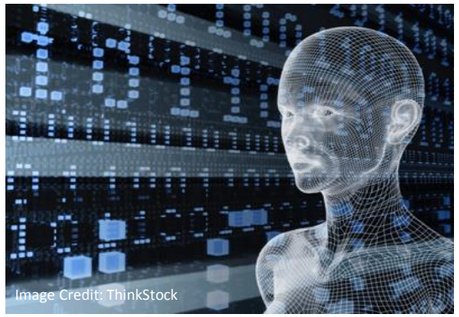
6th Annual Federal R&D Agency Workshop
State University System of Florida
Oct. 2018

Outline

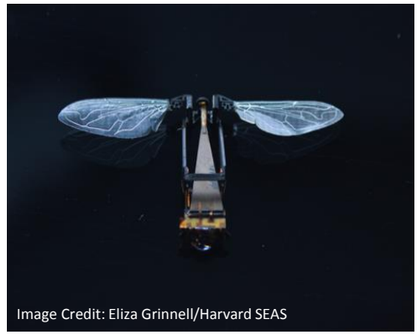

NSF/CISE Overview
Budget Overview
Selected Programmatics
Looking Forward

CISE programs address national priorities

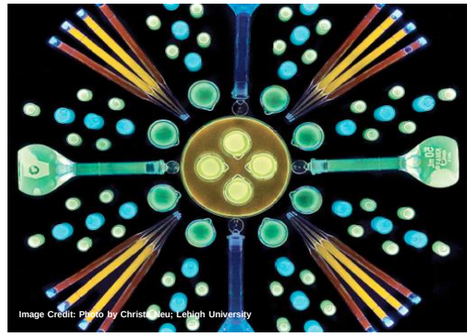
Big Data & AI



Cybersecurity



Robotics & Manufacturing

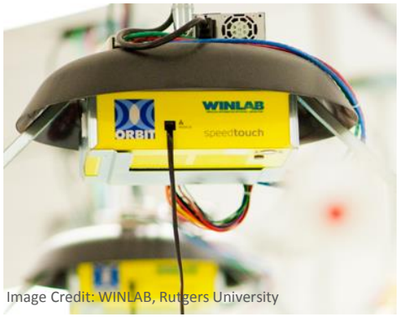


Quantum Information Sciences

Advanced Cyberinfrastructure

Smart Communities

Computer Science Education



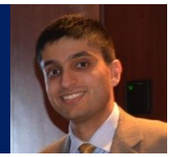
Advanced Wireless Research

CISE Organization

Senior Advisor
Howard Wactlar

Senior Advisor
Irene Qualters

CISE Directorate
Jim Kurose, AD
Erwin Gianchandani, DAD



Office of Advanced Cyberinfrastructure (OAC)
Manish Parashar, OH

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

Computing and Communication Foundations (CCF)
Rance Cleaveland, DD

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

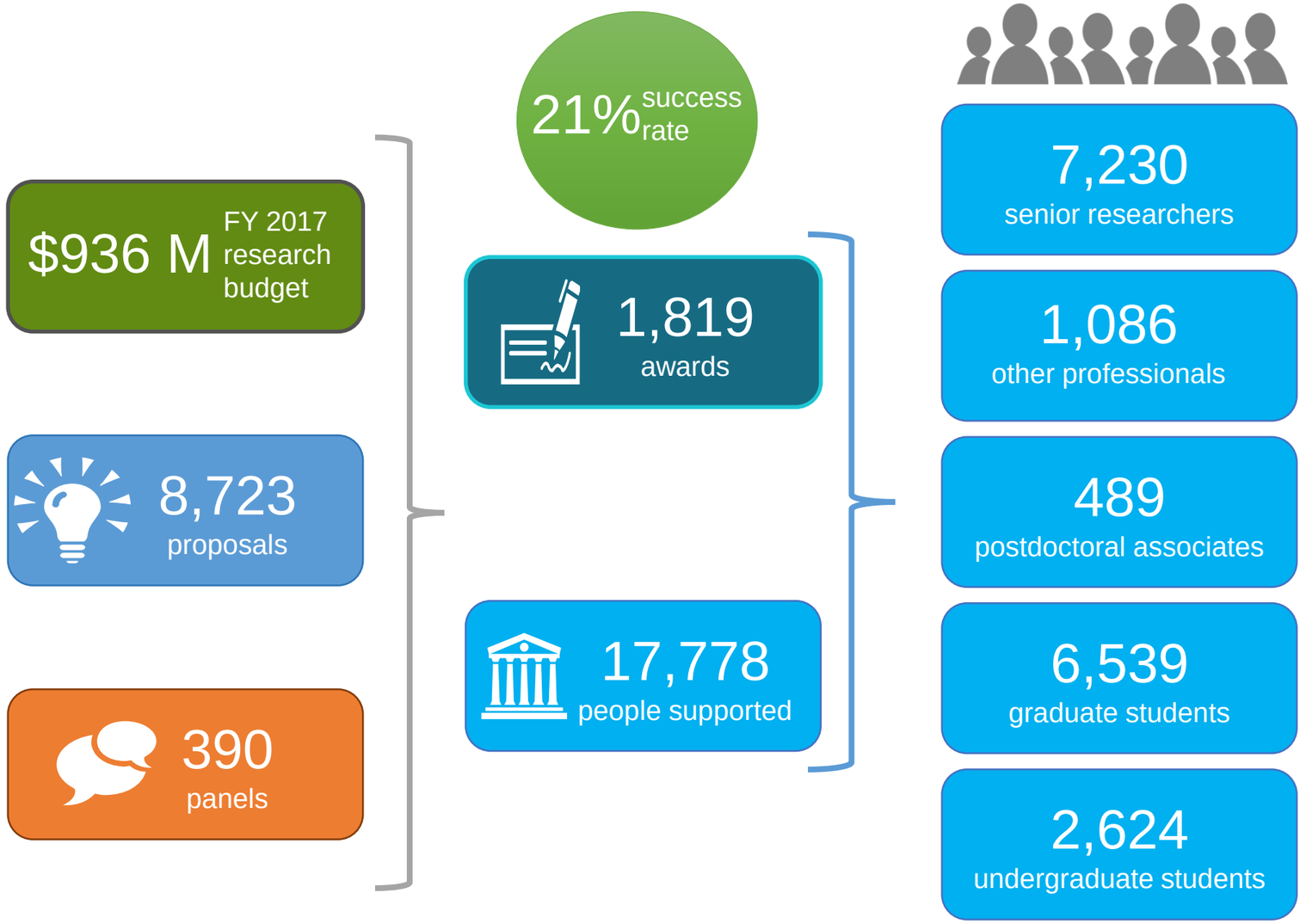
Computer and Network Systems (CNS)
Ken Calvert, DD

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

Information and Intelligent Systems (IIS)
Henry Kautz, DD

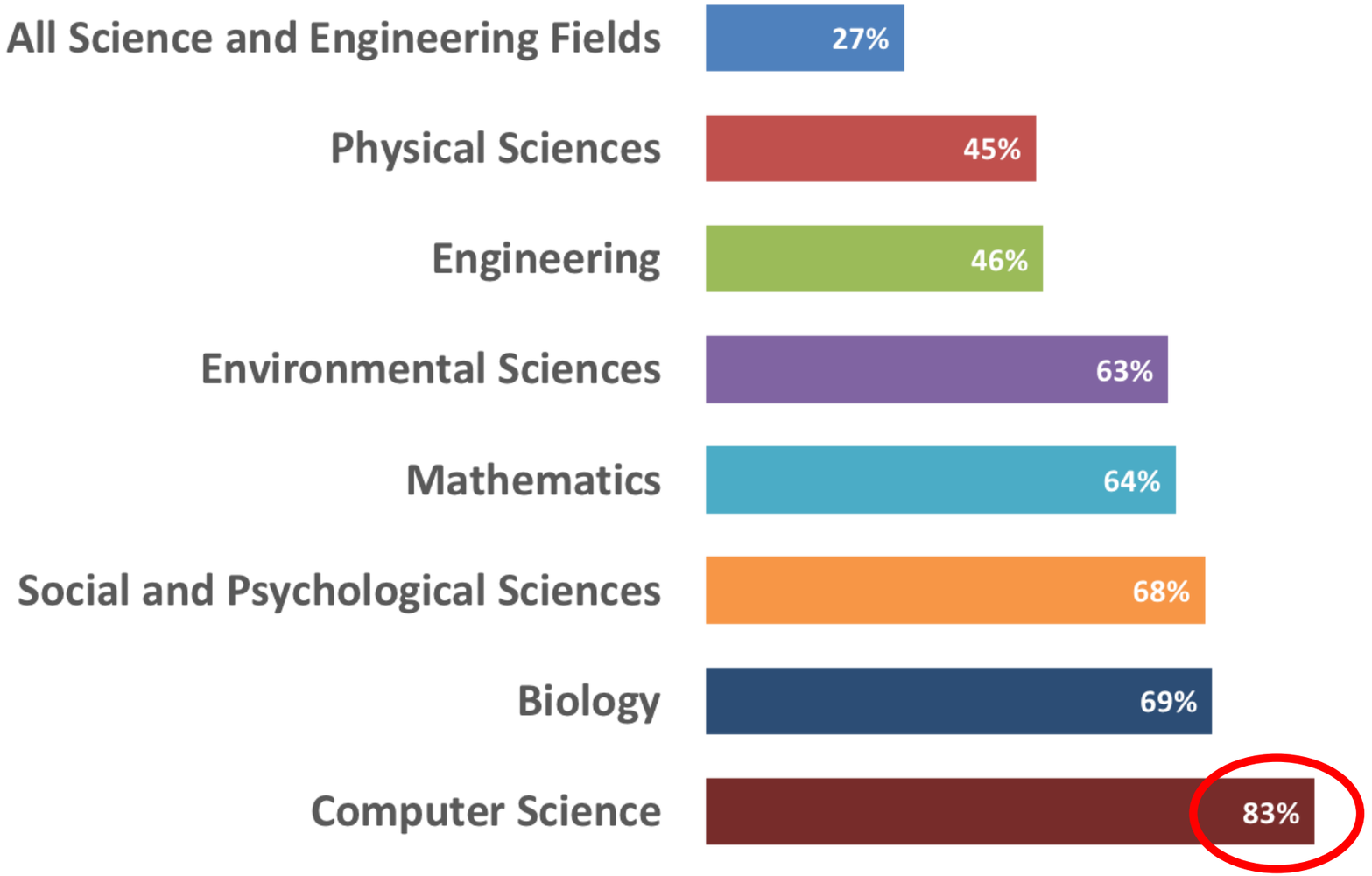
- Cyber Human Systems
- Information Integration and Informatics
- Robust Intelligence

CISE by the Numbers: FY 2017



NSF Supports All Areas of Fundamental Research

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

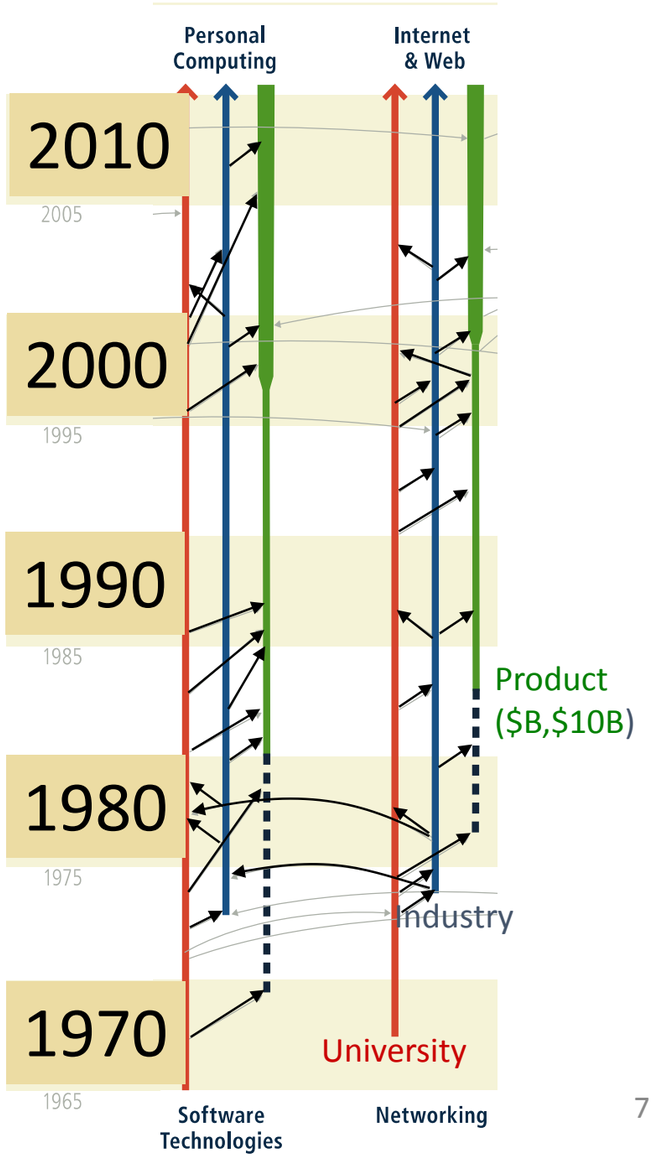


Source: NSF/NCSES, Survey of Federal Funds for Research & Development, FY 2015.

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

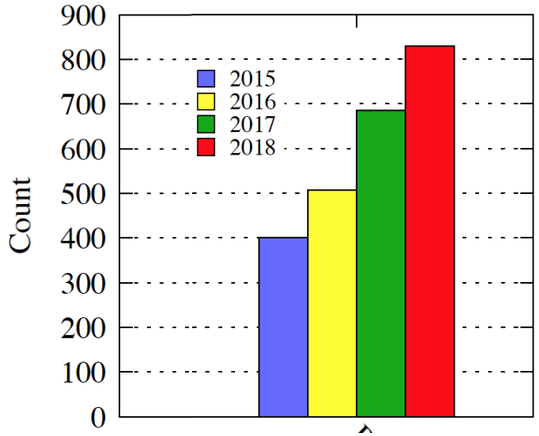
Software-Defined Networking (SDN)

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

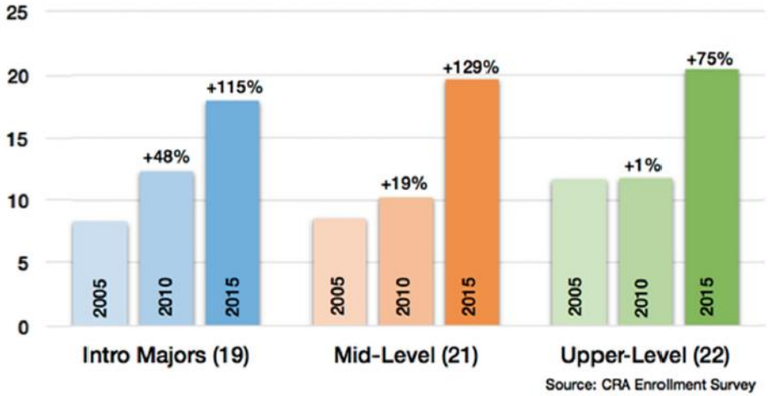
Open Programmable Mobile Internet 2020 project funded by NSF/CISE Expeditions program, 2008, N. McKeown, Stanford U.

Fundamental research powers innovation

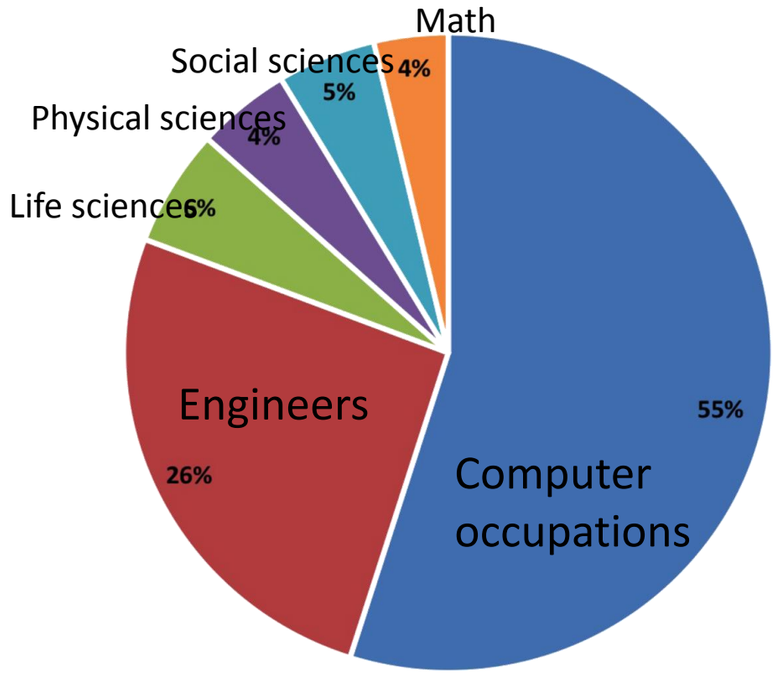
CISE Academic Community



"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

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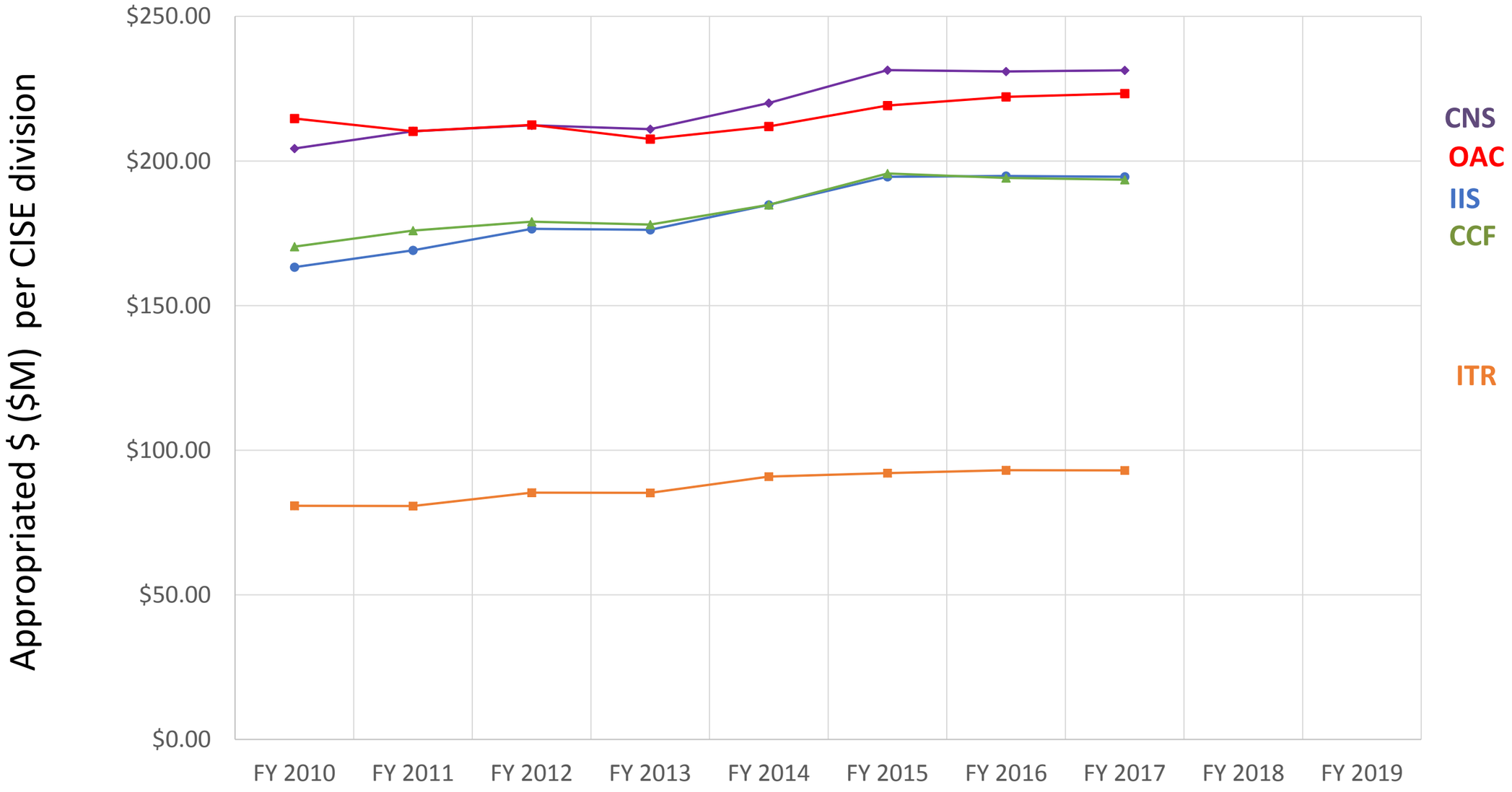
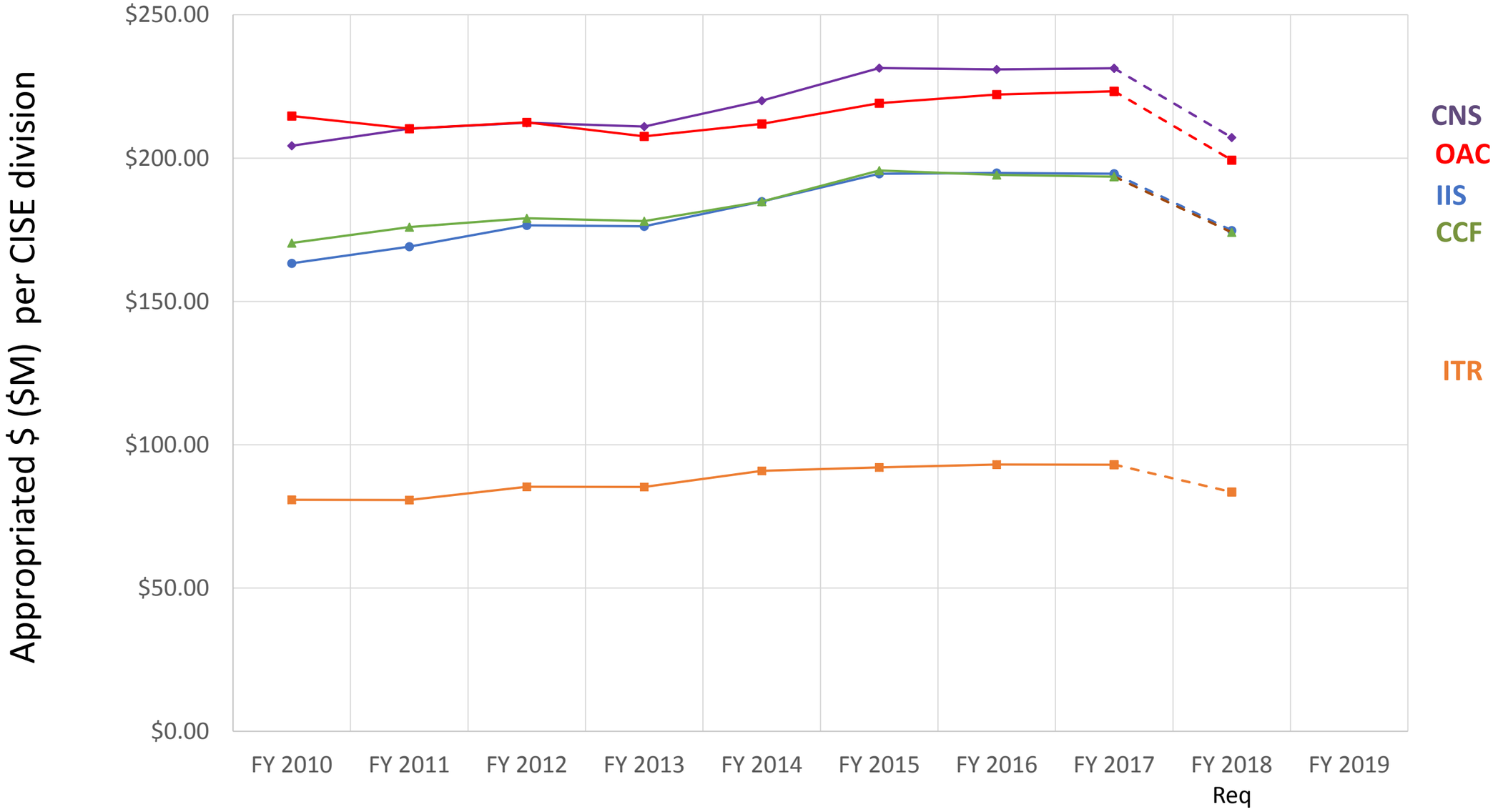
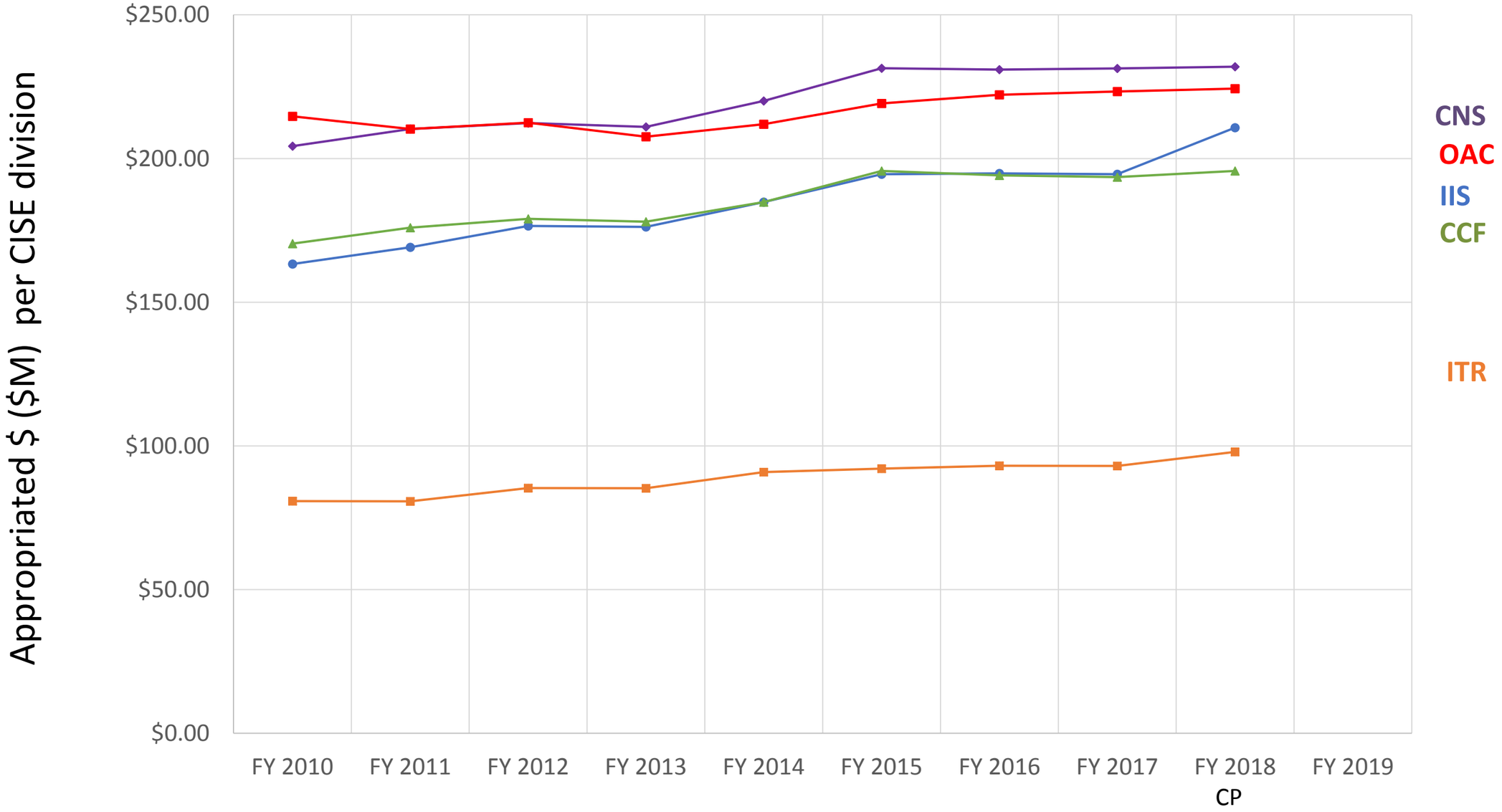
NSF/CISE Division Budgets



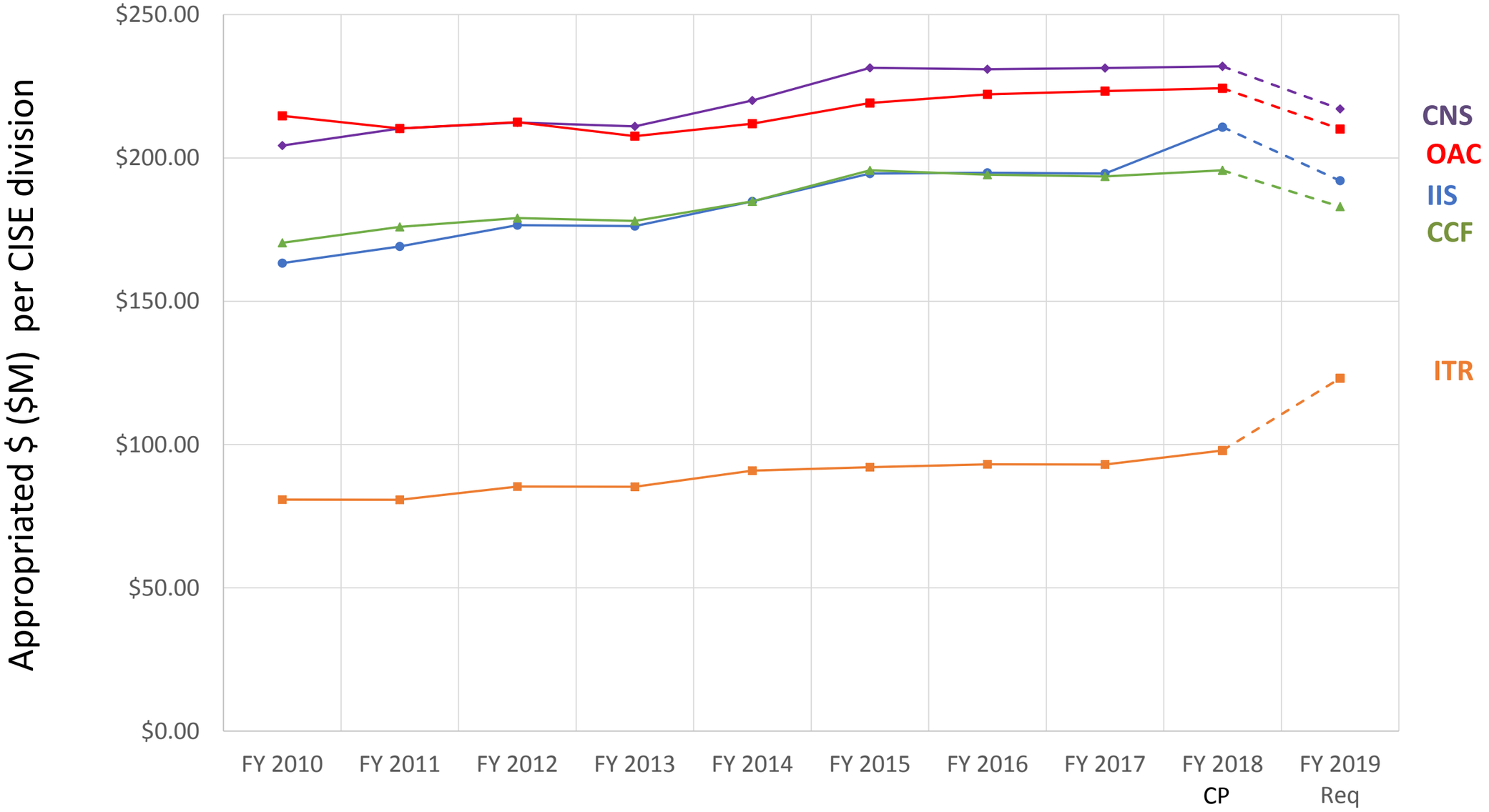
NSF/CISE Division Budgets



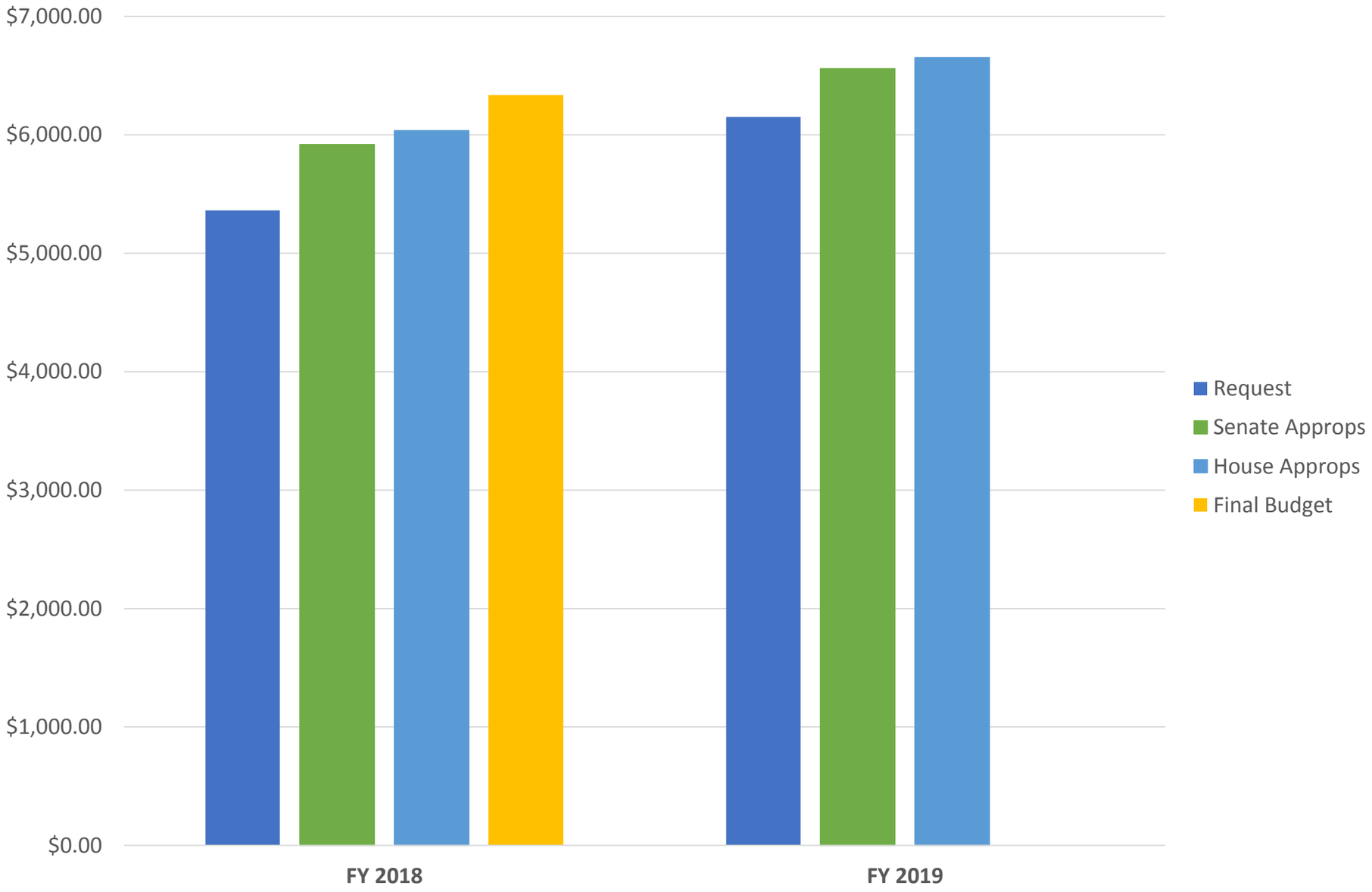
NSF/CISE Division Budgets



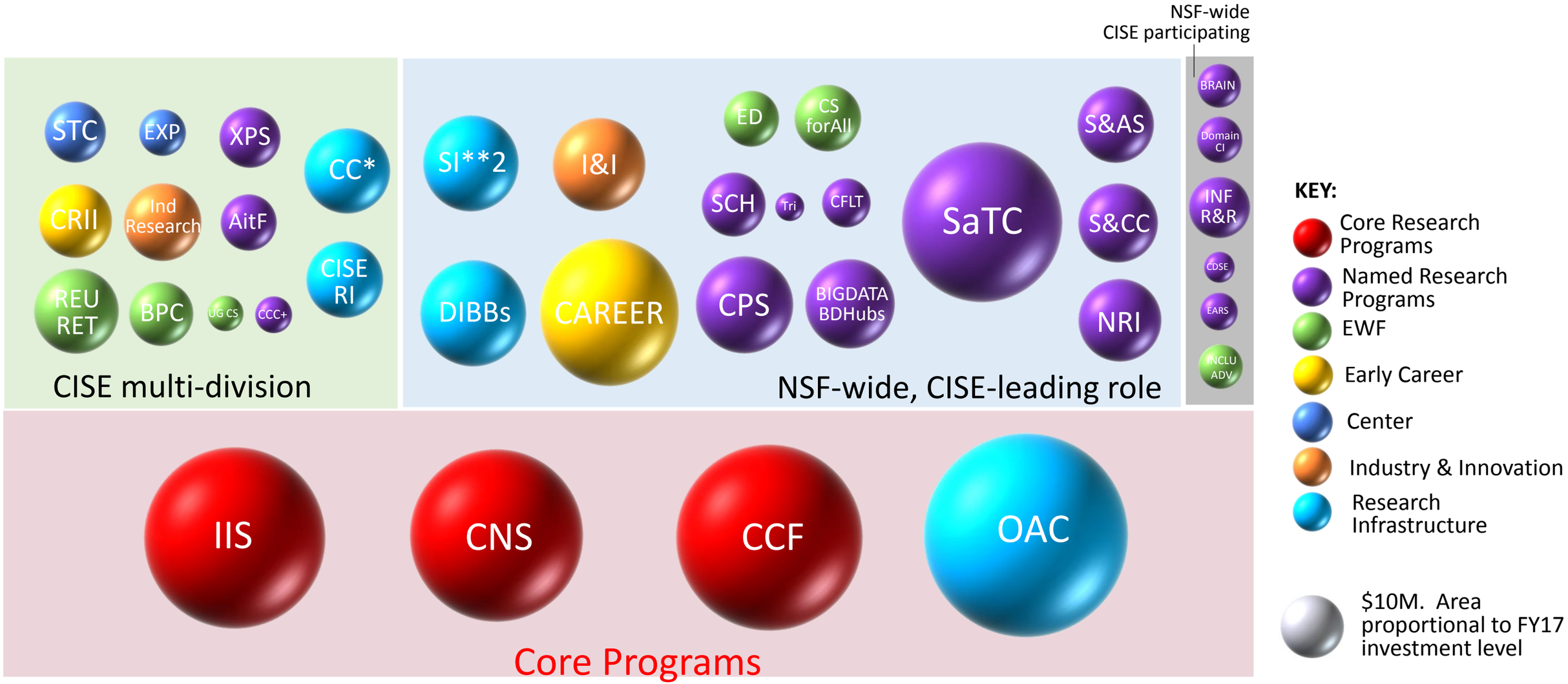
NSF/CISE Division Budgets



NSF R&RA Budget (FY 2018 - FY 2019)



CISE Programmatics: Overview



Outline

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AI framework: “Narrow” vs. “General”

Narrow AI

- Solving individual tasks in specialized, well-defined domains: speech recognition, image recognition, and translation
- Source of much recent excitement, e.g. “deep learning”, IBM Watson, DeepMind's AlphaGo

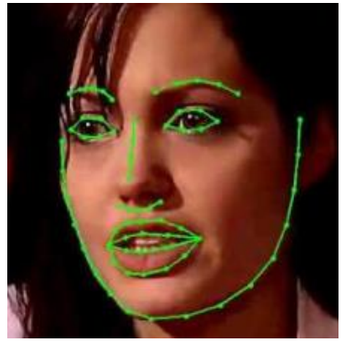
General-purpose AI

- Exhibiting flexibility and versatility of human intelligence in a broad range of cognitive domains, including learning, reasoning, creativity, and planning
- Transferring what is learned or experienced in one task to another
- “intent,” “meaning,” and “understanding” in AI systems

AI framework: "Narrow" vs. "General"

Narrow AI

Classification:
a child playing
with blocks



(facial) recognition

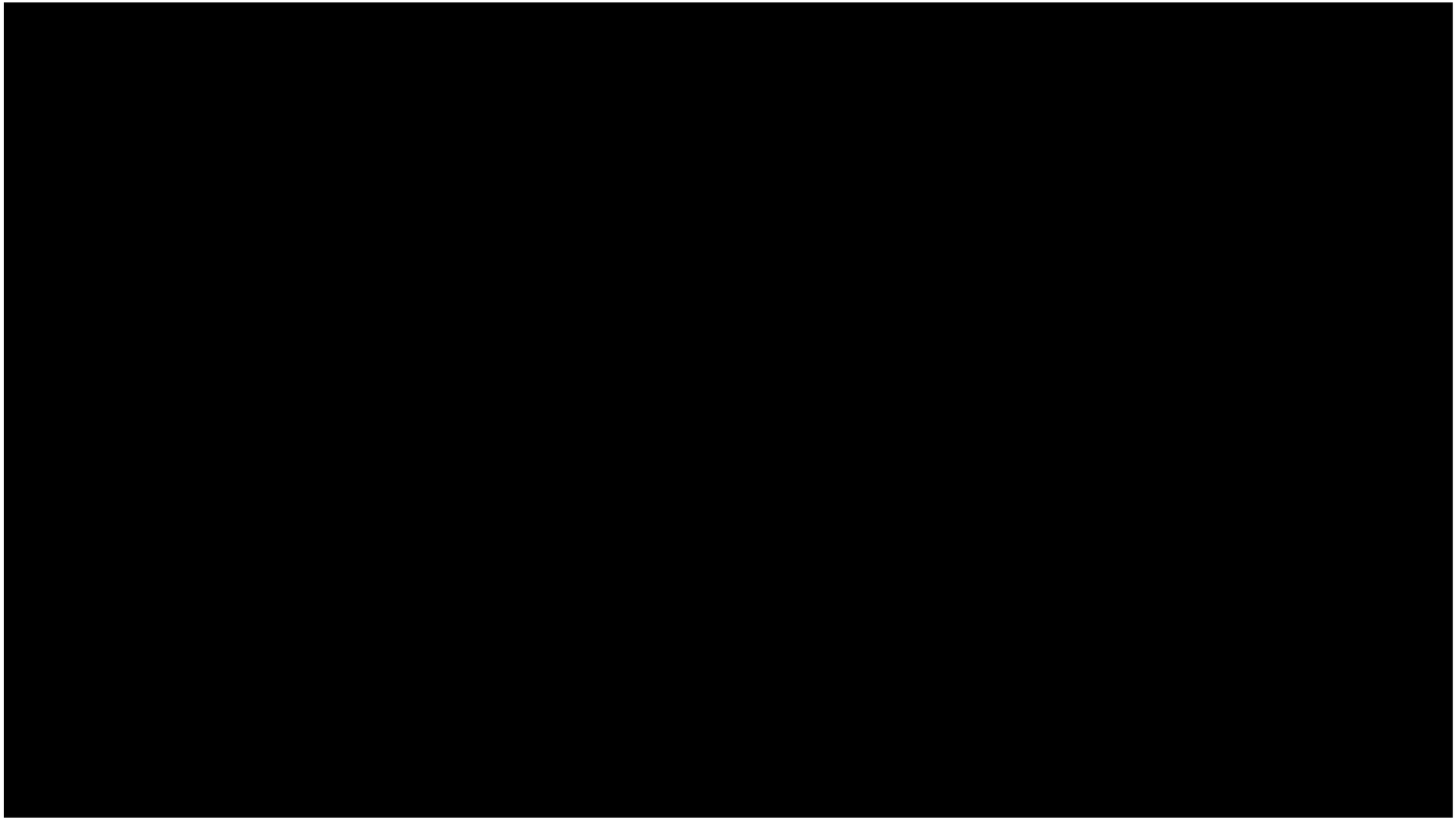
A stop sign (?)

General-purpose AI

Intelligent, flexible, cooperative behavior

Credit: J. Tenenbaum. MIT Center for Mind, Brain, and Machines

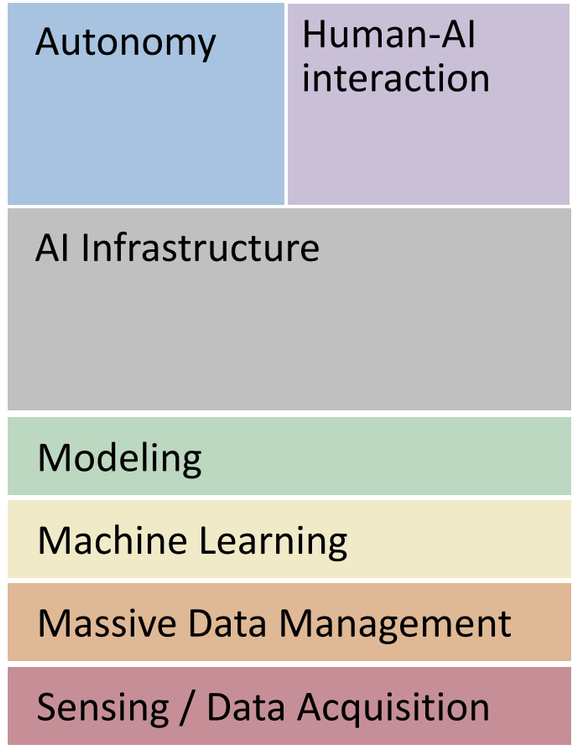
AI framework: “Narrow” vs. “General”



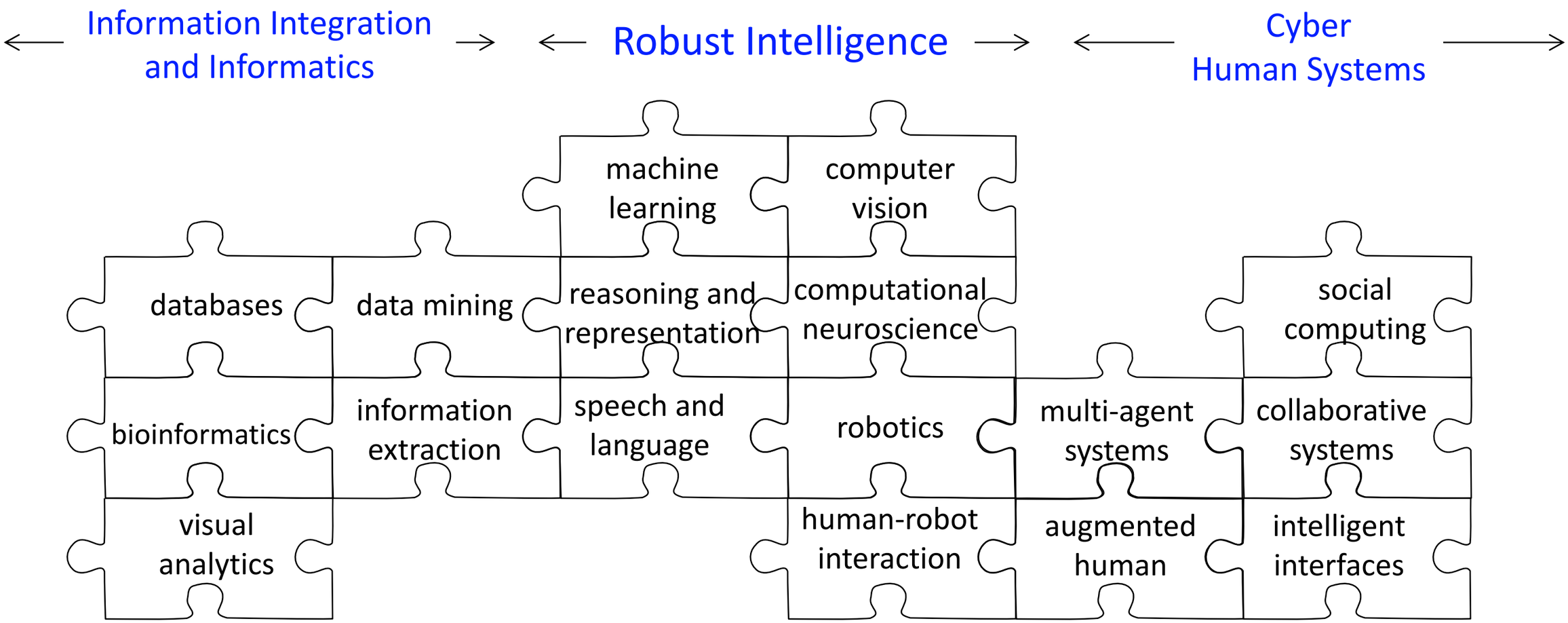
Artificial Intelligence

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

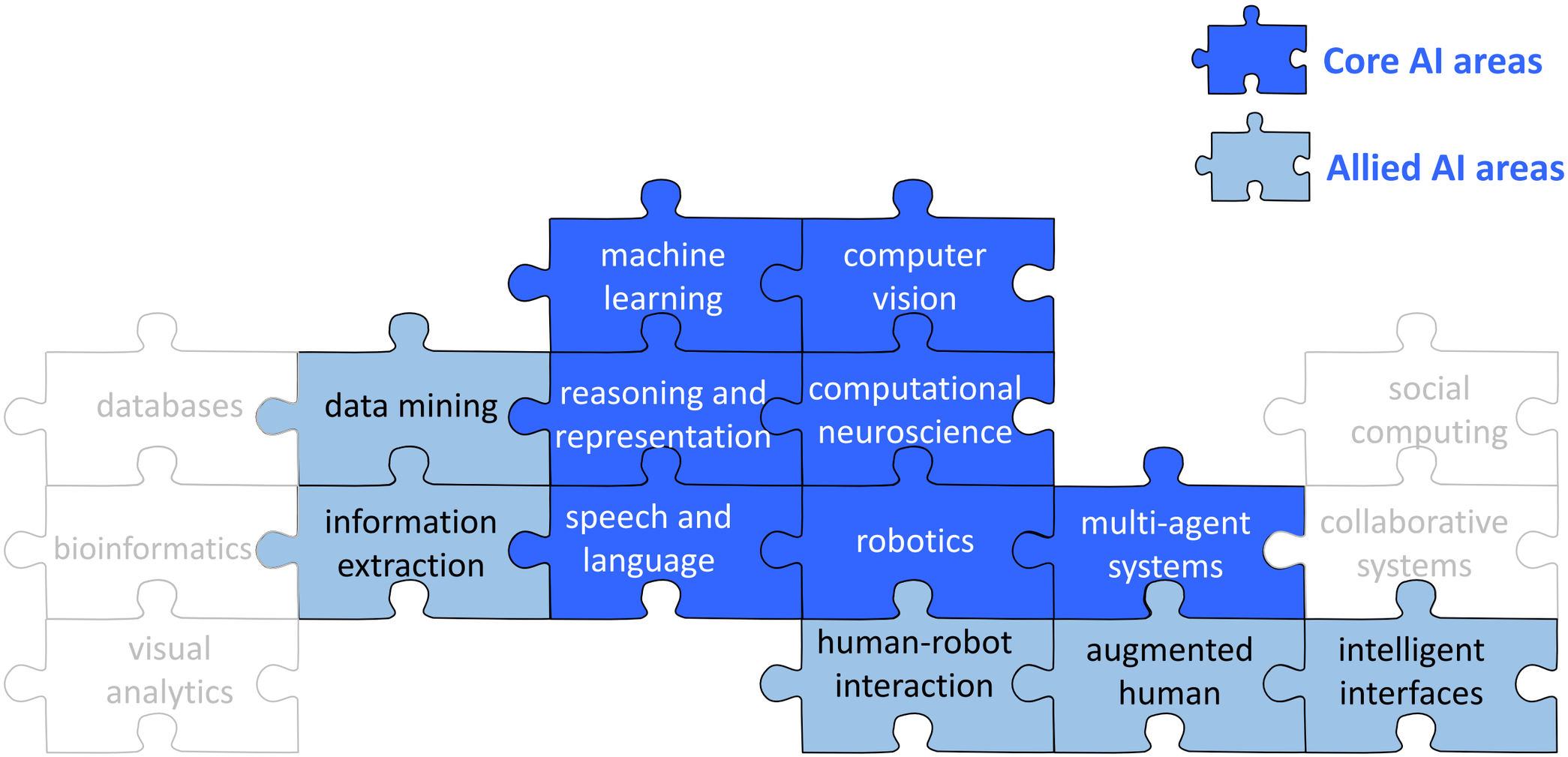
- CISE core research programs:
  - Cyber-human Systems
  - Robust Intelligence
- Cross-directorate programs:
  - BIGDATA
  - NRI-2.0: Ubiquitous Collaborative Robots
  - Smart & Connected Communities
  - Smart and Connected Health
  - Collaborative Research in Computational Neuroscience
- CISE Expeditions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



CISE "core" programs and AI



CISE “core” programs and AI



Smart and Connected Communities (S&CC)

Improving quality of life, health, well-being, and learning in communities

- Smart and connected community - a community that synergistically integrates intelligent technologies with the natural and built environments, including infrastructure, to improve the social, economic, and environmental well-being of those who live, work, or travel within it.
  - integrative research that addresses the technological and social dimensions of smart and connected communities
  - meaningful community engagement that integrates community stakeholders within the project
- Cross-Directorate: CISE, EHR, ENG, SBE
- Growing Collaboration with other agencies


Image Credit: NSF


Image Credit: US Ignite

NSF: National Leadership in AI

Office of Science & Technology Policy (OSTP)

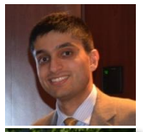
Lynne Parker
Assistant Director for AI

Jim Kurose (former)
Assistant Director for AI

National Science and Technology Council (NSTC)

France Cordova
AI Select Committee
Co-chair (with DARPA, OSTP)

Erwin Gianchandani
Jim Kurose
MLAI co-chairs



Request for Information on Update to the 2016 National Artificial Intelligence Research and Development Strategic Plan

NSF Big Ideas

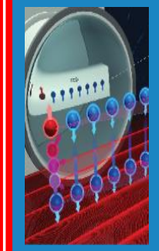
RESEARCH IDEAS

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

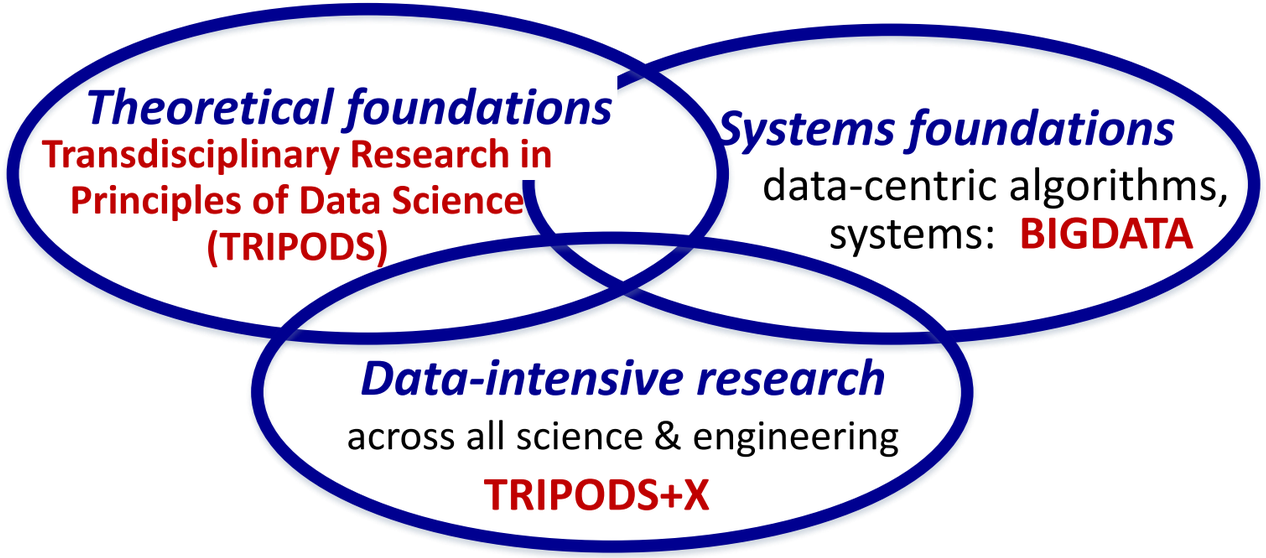
Growing Convergence Research at NSF

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. "

Harnessing the Data Revolution

Research across all NSF Directorates



Educational pathways

Innovations grounded in an education-research-based framework

NASEM study on data science at the undergraduate level;
NSF Research Traineeship (NRT);
NSF Graduate Research Fellowship Program (GRFP)

Advanced cyberinfrastructure

Accelerating data-intensive research.

Cyberinfrastructure for Sustained Scientific Innovation (CSSI);
Scalable data-driven Cyberinfrastructure Dear Colleague Letter (DCL);
Midscale infrastructure (Midscale Request for Information (RFI))

The Future of Work at the Human-Technology Frontier

Improving the quality of work while also increasing productivity and economic growth with increased technologies

Research Themes

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

American Innovation and Competitiveness Act (AICA): midscale

One Hundred Fourteenth Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Monday, the fourth day of January, two thousand and sixteen

An Act

To invest in innovation through research and development, and to improve the competitiveness of the United States.

"a gap between the established parameters of the Major Research Instrumentation and Major Research Equipment and Facilities Construction programs"

NSF 18-013

Dear Colleague Letter: Request for Information on Mid-scale Research Infrastructure

October 6, 2017

Overview

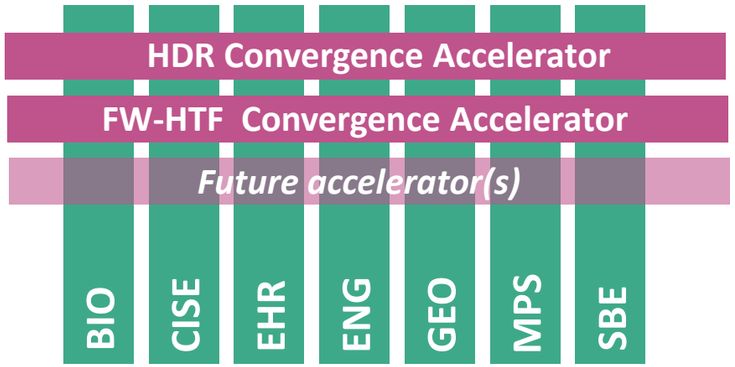
This Request for Information (RFI) is issued in response to the American Innovation and Competitiveness Act (AICA, Public Law No. 114-329), Section 109. NSF seeks information on existing and future needs for mid-scale research infrastructure projects from the US-based NSF science and engineering community.

Convergence Accelerators

Accelerating Discovery through Convergence Research

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

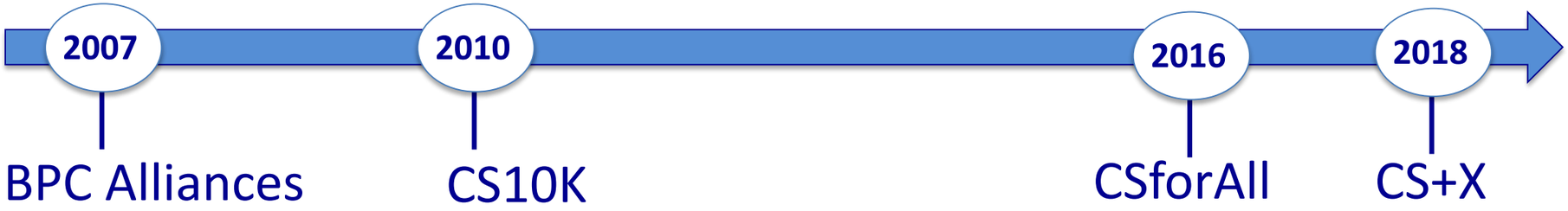
- *Research:* more intentionally managed, shorter timelines, milestones, deliverables, teams, partnerships.
- Time-limited entities: accelerating impactful *convergence* research in areas of national importance
- Innovating in organizational structure: separate (from directorates) in leadership, budget, and programmatics
  - aligned with, relying on, foundational disciplinary research



Outline

NSF/CISE Overview → Budget Overview → Selected Programmatics → Looking Forward

CISE Education and Workforce



Computer Science for All (CSforAll)

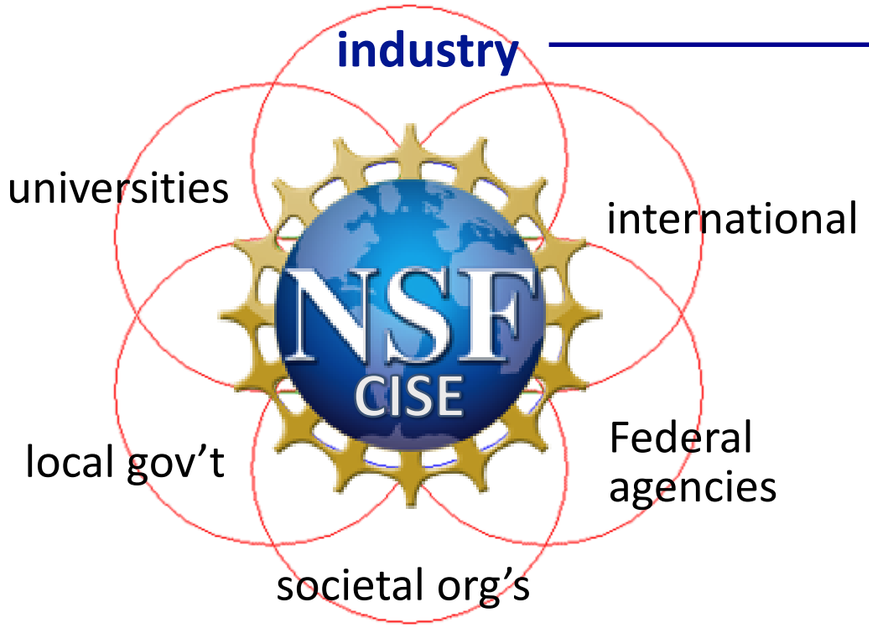
- access to rigorous, engaging CS education for *all K-12* students
- Computer Science Principles: *new* College Board CS AP exam (2017)

CS Undergrad Education (CS+X)

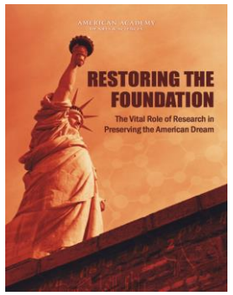
- integrating computing with other fields of knowledge, challenge areas
- builds on previous CISE investments in REvolutionizing engineering and computer science Departments (RED) program

Partnerships: Many dimensions

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

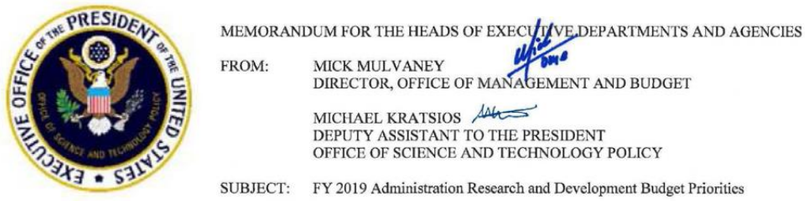


- **Joint NSF/industry research solicitations:** Intel (5), SRC (5), VMware (1)
- **Research infrastructure:** PAWR: Platforms for Advanced Wireless Research, cloud credit for BIGDATA, (AWS, Google, Microsoft)
- **Individual project-based:** I/UCRC, Intrans, GOALI



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

Opportunity: Tremendous federal interest in CISE



MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

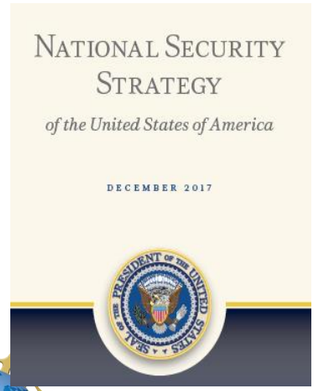
FROM: MICK MULVANEY
DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET

MICHAEL KRATSIOS
DEPUTY ASSISTANT TO THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: FY 2019 Administration Research and Development Budget Priorities

FY 2019, 2020 R&D Budget Priorities Memo

"Continued leadership in AI, quantum information science (QIS), and strategic computing is critically important to our national security and economic competitiveness. Advances in these areas promise opportunities for major scientific breakthroughs and are quickly transforming American life and industry. Agencies should invest in fundamental and applied AI research, including machine learning, autonomous systems, and applications at the human-technology frontier."



"prioritize emerging technologies critical to economic growth and security, such as data science, encryption, autonomous technologies,… advanced computing technologies, and artificial intelligence. "

House Oversight: Game Changers: AI (Feb., March 2018)

HSST: Science Infrastructure (March 2017)

HSST: CS Education Roundtable (Sept. 2017)

HSST: American Leadership in Quantum Technology (Oct. 2017)

An *amazing* time to be in CISE!

Ubiquity

Computing is *everywhere* – across all of science and engineering, and all of society

Engagement

Computing intertwines with many *communities*

Urgency

Computing is *rapidly expanding and evolving*. There is tremendous opportunity … *now*!

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**

BACKUP

CISE Broadening Participation in Computing (BPC)

Action plan:

- **Highlight**: Emphasize BP in CISE solicitations
- **Pilot:** Require a “meaningful” BP activity in an expanding set of CISE Programs (expanding to core medium and large proposals, F18)
- **Support**: Provide resources for PIs
- **Review/Report**: Request BPC reporting BP in annual reports


NSF 17-110

Dear Colleague Letter: Pursuing Meaningful Actions in Support of Broadening Participation in Computing (BPC)

NSF Takes Steps to Combat Sexual Harassment in Science: Sept. 19, 2018

Basic research is done in all environments all over the world. All of those places must be harassment free.

New measures to combat sexual harassment at grantee institutions:

- new award requirements
- harassment-free research workplaces
- enhanced Web resources

News Release 18-082

NSF announces new measures to protect research community from harassment

New policy requires awardee institutions to report sexual harassment findings

https://www.nsf.gov/od/odi/harassment.jsp

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

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

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

Cyberinfrastructure, Cloud

2017 OAC Workshop

Final Report

The Future of Cloud for Academic Research Computing

Results of an NSF-Supported Workshop, Entitled "*Cloud Forward*"
Supported by NSF ACI/CSE Award 1632037

"The emerging conversation is not about whether academic research computing will take place in the cloud as has been the case with many previous reports and meetings, but rather how best to support it."

Workshop: Enabling CISE Research and Education in the Cloud (Jan. 2018)

Enabling Computer and Information Science and Engineering Research and Education in the Cloud

Full Text: PDF

2018 Technical Report

Authors:

Jennifer Rexford	Princeton
Magdalena Balazinska	University of Washington
David Culler	Institutional Profile Page
Jeannette Wing	Columbia

ACM DL DIGITAL LIBRARY

- Articulate the case for academic institutions to use the cloud
- Articulate the "business case" for cloud providers to support academic users
- Remove artificial costs that make cloud computing less attractive
- Create support structures for academics transitioning to the cloud
- Form a central entity to serve as a nexus between multiple cloud providers on one side and multiple academic institutions on the other

CISE priority setting: science community and other inputs