NATIONAL SCIENCE FOUNDATION

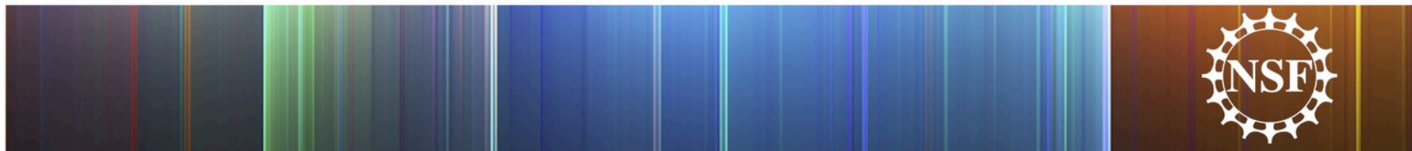
FISCAL YEAR 2016 BUDGET REQUEST

Dr. Jim Kurose
Assistant Director, CISE

Image Credit: *Thinkstock*

CISE's Economic and Societal Context

- CISE is at the center of an ongoing societal transformation and will be for decades to come.
- Advances in computing, communications and information technologies and cyberinfrastructure:
  - underpin economic prosperity, national security;
  - drive U.S. competiveness and sustainable economic growth;
  - accelerate the pace of discovery and innovation; and
  - are crucial to achieving national and societal priorities, including education and workforce development



CISE and National Priorities


Image Credit: *ThinkStock*

Understanding the Brain


Image Credits: *Texas A&M University*

Risk & Resilience


Image Credit: *NASA*

Food-Energy-Water Systems

Health & Wellbeing


Image Credit: *MicroStrain, Inc.*

Manufacturing, Robotics, & Smart Systems


Image Credit: *ThinkStock*

Secure Cyberspace


Image Credit: *Georgia Computes! Georgia Tech*

Education and Workforce Development

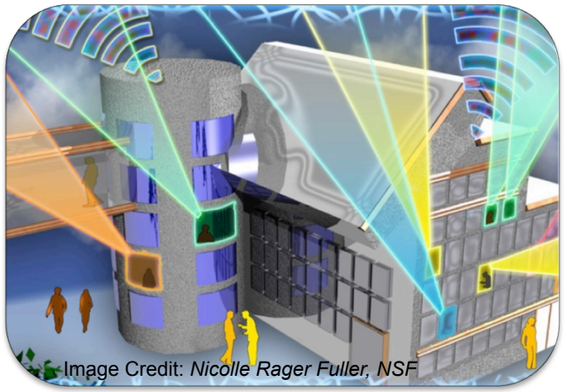


Image Credit: *Nicolle Rager Fuller, NSF*

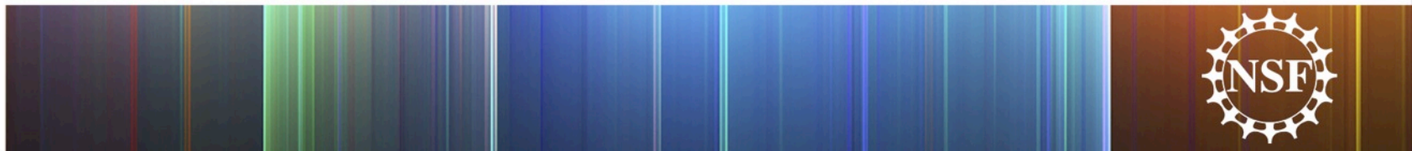
Broadband & Universal Connectivity

CISE Mission

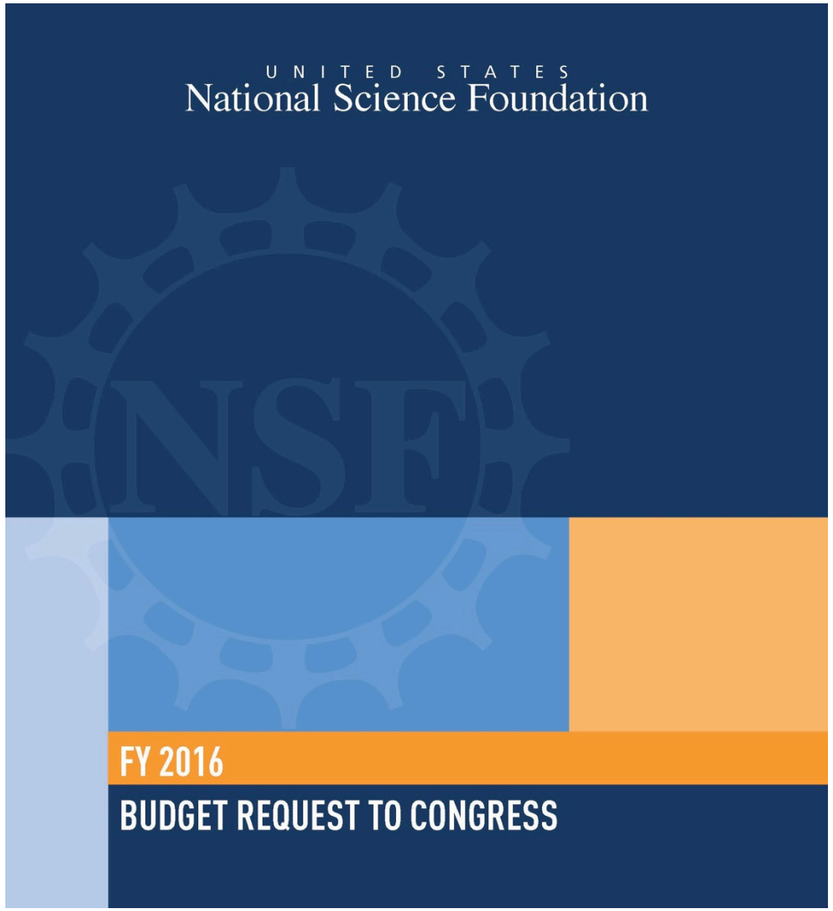
Exploring the frontiers of computing

- Promote progress of CISE research and education
- Advance the development and use of cyberinfrastructure
- Promote understanding of principles and uses of advanced computer, communications, and information systems in support of societal priorities
- Contribute to universal, transparent and affordable participation in a knowledge-based society

These frontiers have interfaces with all the sciences, engineering, education and humanities and a strong emphasis on innovation for society.

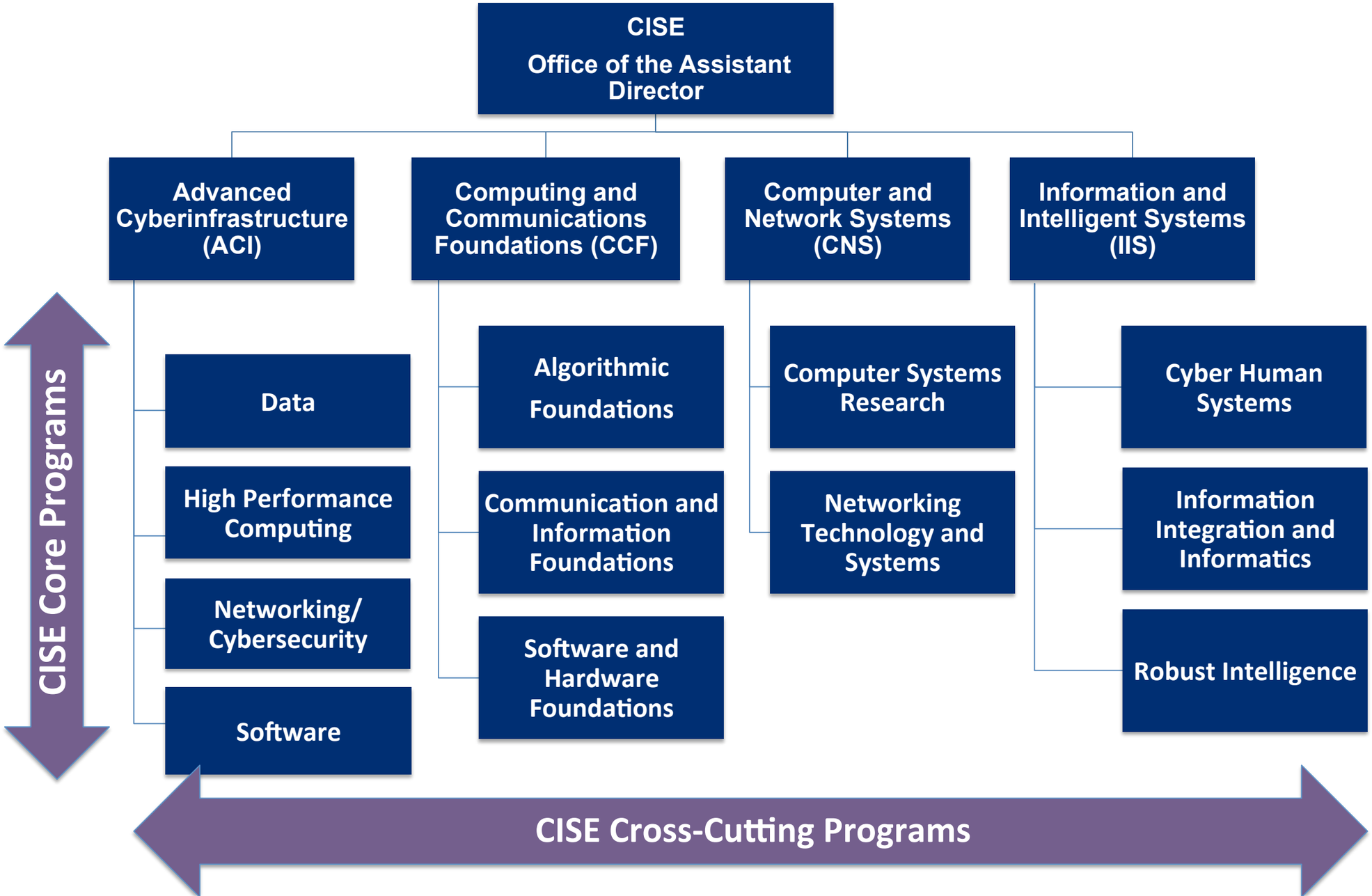


FY 2016 Budget Request



- **NSF**
  - FY 2016 Budget Request: $7723.55 Million
  - Increase over FY 2015 Est: $379.34 Million, +5.2%
- **CISE**
  - FY 2016 Budget Request: $954.41 Million
  - Increase over FY 2015 Est: $32.68 Million, +3.5%
- CISE FY 2016 request is shaped by investments in ***core research, education, and infrastructure programs*** as well as critical investments ***in NSF cross-directorate priorities and programs***.

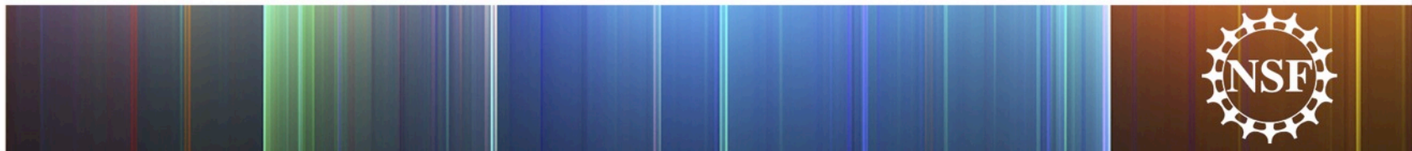
CISE Organization



CISE's Commitment to the Core

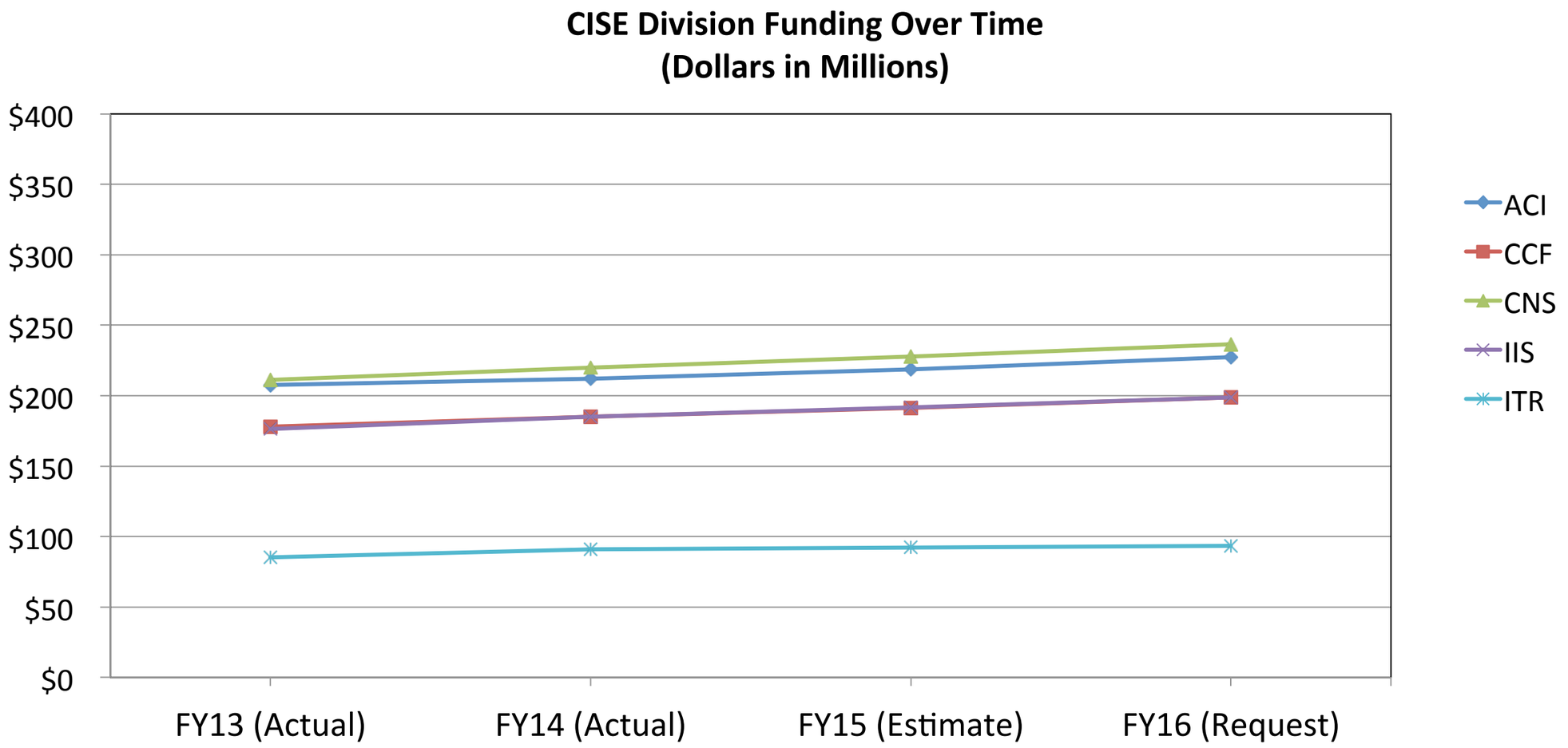
CISE continues to cast a wide net and to let the best ideas surface, rather than pursuing a prescriptive research agenda. It engages the research community in developing new fundamental ideas, which are then evaluated by the best researchers through the merit review process.

This process, which supports the vast majority of unclassified computing research in the United States, has led to innovative and transformative scientific results with enormous economic impact and societal benefits.



Growing Division Budgets

Modest, sustained growth across all CISE divisions

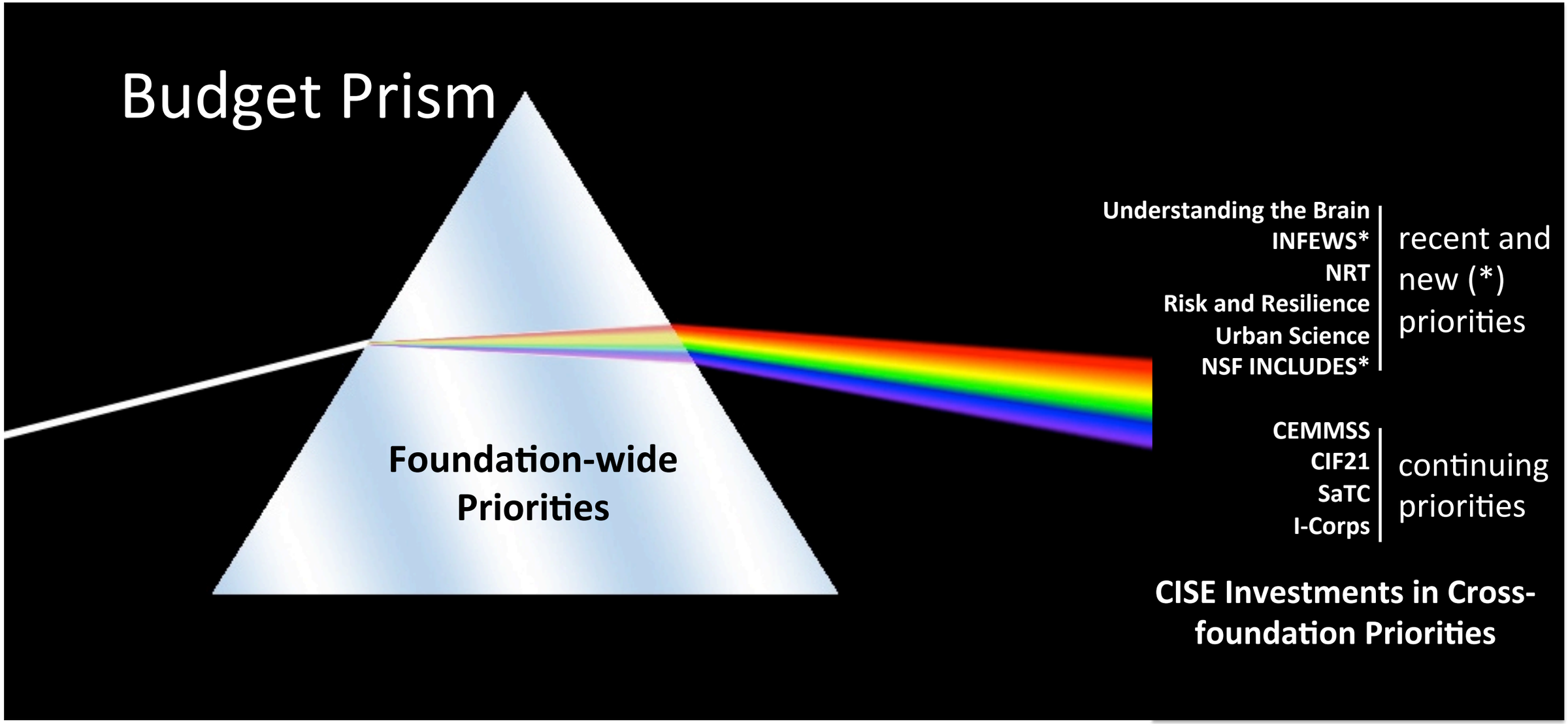


Snapshot of CISE FY 2014 Activities

	CISE
Budget	$893M
Number of Proposals	7,436
Number of Awards	1,682
Success Rate	~23%
Average Annualized Award	$199K
Number of Panels Held	302
Number of People Supported	16,774

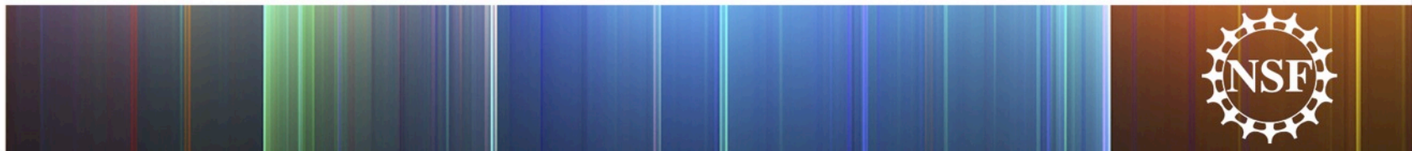
	CISE
Senior Researchers	6,663
Other Professionals	1,123
Postdoctoral Associates	491
Graduate Students	6,064
Undergraduate Students	2,433

Budget Prism



CISE Investments in NSF Priorities

Area of Investment	FY 2015 Estimate ($M)	FY 2016 Request ($M)
Understanding the Brain	$16.50	$28.58
INFEWS	---	$13.50
NSF Research Traineeship	$13.38	$9.69
Risk and Resilience	$6.50	$8.00
Urban Science	$1.00	$3.50
INCLUDES	---	$1.78
CEMMSS	$89.00	$94.11
CIF21	$84.21	$84.21
SaTC	$70.00	$70.50
I-Corps	$11.00	$11.65



Understanding the Brain (UtB)

Improving understanding of the brain

CISE Investment: $28.58 M

- Partnership among all NSF directorates
- Includes the BRAIN Initiative
- CISE focus:
  - Collaborative Research in Computational Neuroscience (CRCNS)
  - Integrative Strategies for Understanding Neural and Cognitive Systems
  - MIT STC: Center for Brains, Minds and Machines: The Science and the Technology for Intelligence
  - Advancing computational infrastructure

BRAIN INITIATIVE
BRAIN RESEARCH THROUGH ADVANCING INNOVATIVE NEUROTECHNOLOGIES

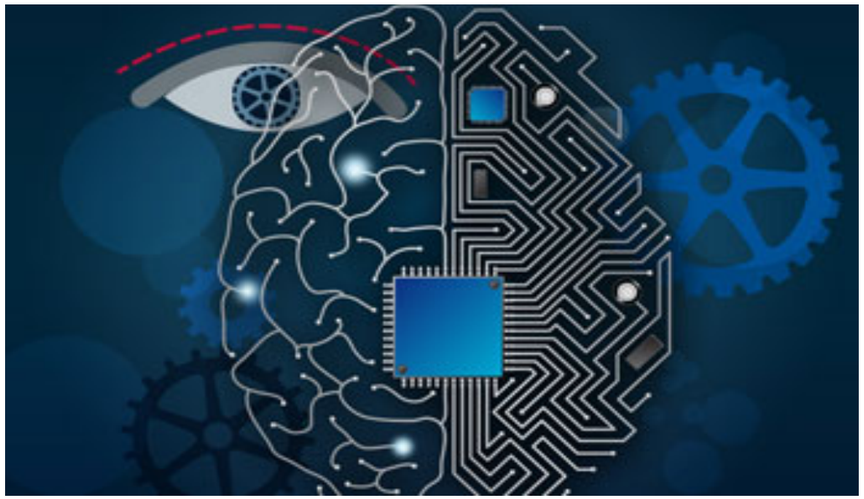


Image Credit: *Christine Daniloff/MIT*

CISE Research for Understanding the Brain

ACI

CNS

CCF

IIS

- Computational neuroscience; modeling brain structure, activity and function
- Cognition, perception, language, learning, social behavior
- Neuro-inspired algorithms, machine learning, devices, architectures
- Cyber-physical systems, brain-computer interfaces
- Advanced CI for data-intensive research, data integration, networking
- Workforce development

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

Securing and protecting food, energy and water resources

CISE Investment: $13.50 M

- Partnership among all NSF directorates
- CISE focus:
  - New resource management algorithms, architectures
  - Real-time coordination, communications
  - Robust observation, sensing, inference
  - Large-scale data analysis/management, including modeling, simulation
  - Optimization of complex systems
  - Advancing computational infrastructure

NSF Research Traineeship (NRT)

Preparing professionals in emerging STEM fields vital to the nation

CISE Investment: $9.69 M

- Partnership among: BIO, CISE, EHR, ENG, MPS, and SBE
- Includes priority research theme of data-enabled science and engineering

Image Credit: *Indiana University*

Risk and Resilience

Creating new approaches and engineering solutions to make interdependent critical infrastructure systems resilient

Image Credit: FEMA

Image Credit: NOAA

CISE Investment: $8.0 M

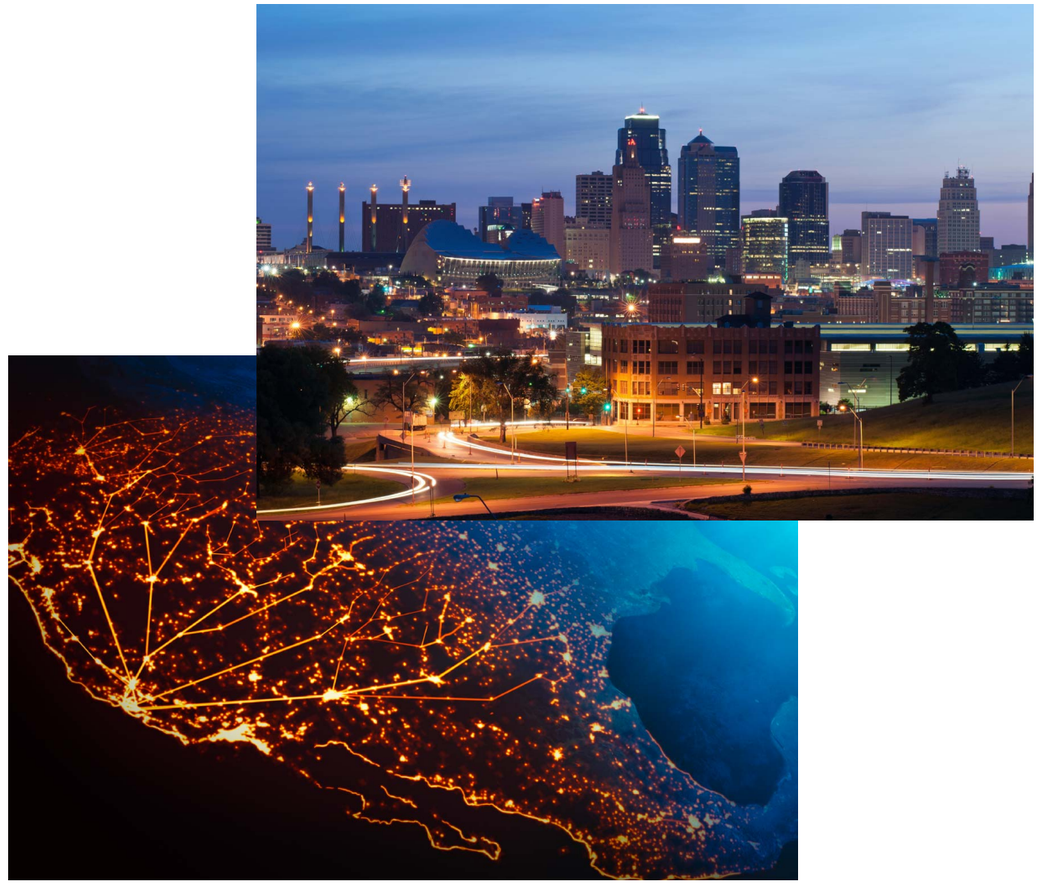
- Partnership among CISE, ENG, and SBE
- CISE focus:
  - Critical Resilient Interdependent Systems and Processes (CRISP)

Urban Science

Addressing pressing urban challenges

CISE Investment: $3.50 M

- Partnership with CISE, ENG and SBE
- CISE focus:
  - Enabling integration of networked computing systems, physical devices, data sources, and infrastructure leading to smart cities



Images: *Courtesy of us-ignite.org*

NSF Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES)

Broadening participation for those typically underrepresented in STEM fields

CISE Investment: $1.78 M

- Partnership across NSF
- Focus:
  - Preparation, participation, and advancement of those traditionally underserved and/or underrepresented in STEM
  - Core CISE focus for many years

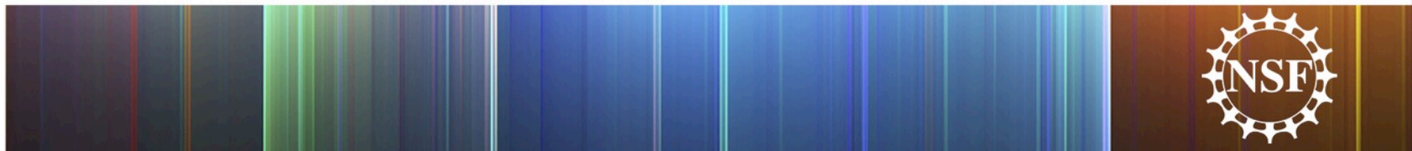
Image Credit: *John C. Williams, Humanoid Engineering & Intelligent Robotics (HEIR) Lab, Marquette University*

Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS)

Accelerating advances in 21st century smart engineered systems that sense, respond, and adapt to the environment

CISE Investment: $94.11M

- Partnership among BIO, CISE, EHR, ENG, and MPS
- CISE focus:
  - Advanced Manufacturing
  - Cyber-Physical Systems (CPS)
  - National Robotics Initiative (NRI)



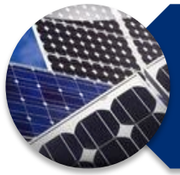
CEMMSS

Cyber-Physical Systems (CPS)

Deeply integrating computation, communication, and control into physical systems

- Partnership between CISE and ENG
- Multi-agency commitments: DHS, DOT, NASA, and NIH
- Serves multiple key national priorities
- Includes *Transition to Practice* option
- NSF co-chairs, with NIST, interagency (NITRD) Cyber Physical Systems Senior Steering Group

Transportation



Energy and Industrial Automation

Healthcare and Biomedical

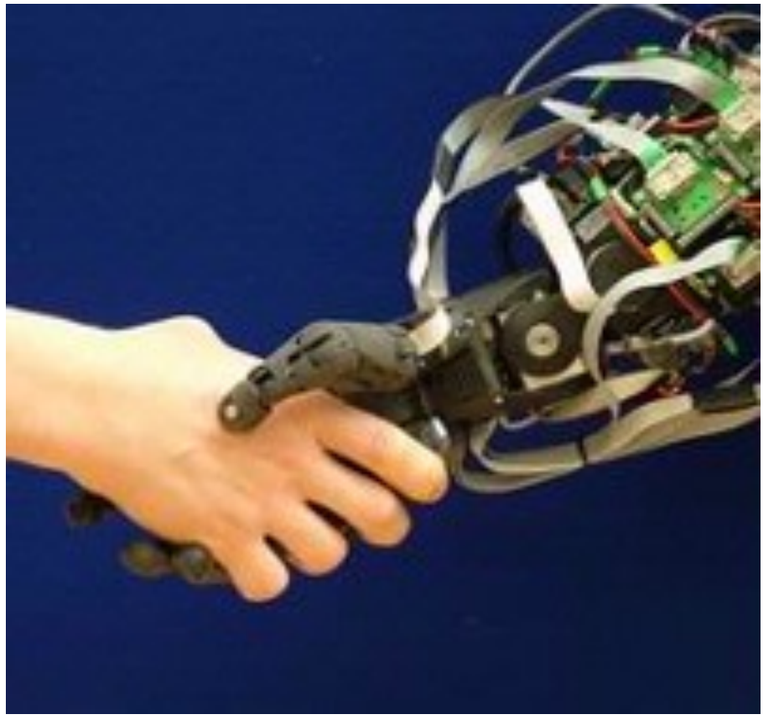
Critical Infrastructure

CEMMSS

National Robotics Initiative (NRI)

Developing the next generation of collaborative robots to enhance personal safety, health, and productivity

- Partnership among CISE, ENG, SBE, and EHR
- Multi-agency commitments: NSF, DARPA, NASA, NIH, and USDA
- Serves multiple national priorities
- Strong coupling with industry and startups



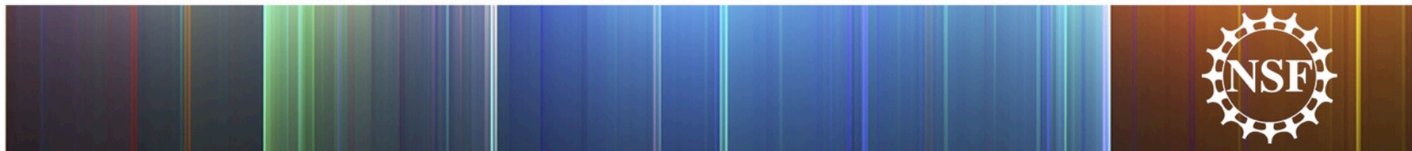
Credit: *Bristol Robotics Lab*

Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)

Accelerating the progress of scientific discovery and innovation

CISE Investment: $84.21 M

- Partnership among BIO, CISE, ENG, GEO, MPS, and SBE
- CISE focus:
  - BIGDATA
  - Data Infrastructure Building Blocks (DIBBs)
  - Software Infrastructure for Sustained Innovation (SI^2)
  - Computational and Data-enabled Science and Engineering
  - Data Science Pilots



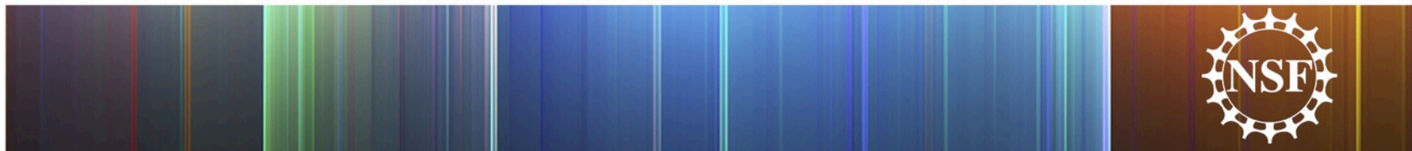
CIF21

Critical Techniques and Technologies for Advancing Foundations and Applications of Big Data Science & Engineering (BIGDATA)

Foundational research for managing, analyzing, visualizing, and extracting knowledge from large, diverse, distributed, and heterogeneous data sets

Foundations
development of novel techniques, theoretical analysis, or experimental evaluation of techniques

Innovative Applications
development of new or innovative adaptations of existing techniques, methodologies, and technologies for application areas



CIF21

Data Infrastructure Building Blocks (DIBBs)

Developing data infrastructure for multiple scientific disciplines

- Encourages robust and shared data-centric cyberinfrastructure capabilities
- Aims to accelerate interdisciplinary and collaborative research in areas stimulated by data

Credit: *Texas Advanced Computing Center*

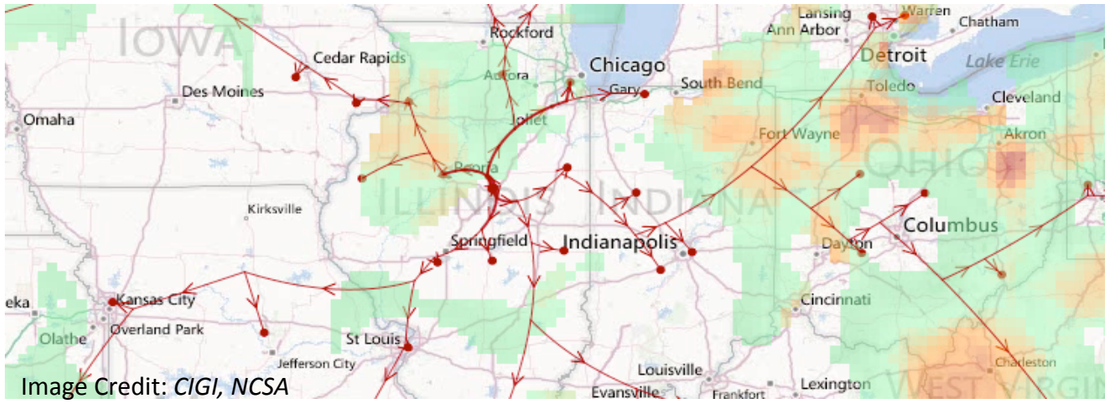


Image Credit: *CIGI, NCSA*

Secure and Trustworthy Cyberspace (SaTC)

Securing our Nation's cyberspace

CISE Investment: $70.50 M

- Interdisciplinary partnership: CISE, SBE, EHR, ENG, and MPS
- Aligns with President's *Strategic Plan for the Federal Cybersecurity Research and Development Program* (2011)
- CISE focus:
  - SaTC solicitation
  - NSF/Intel Partnership on Cyber-Physical Systems Security and Privacy (CPS-Security)
  - Education

Image Credit: *ThinkStock*

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Innovation Corps (I-Corps)

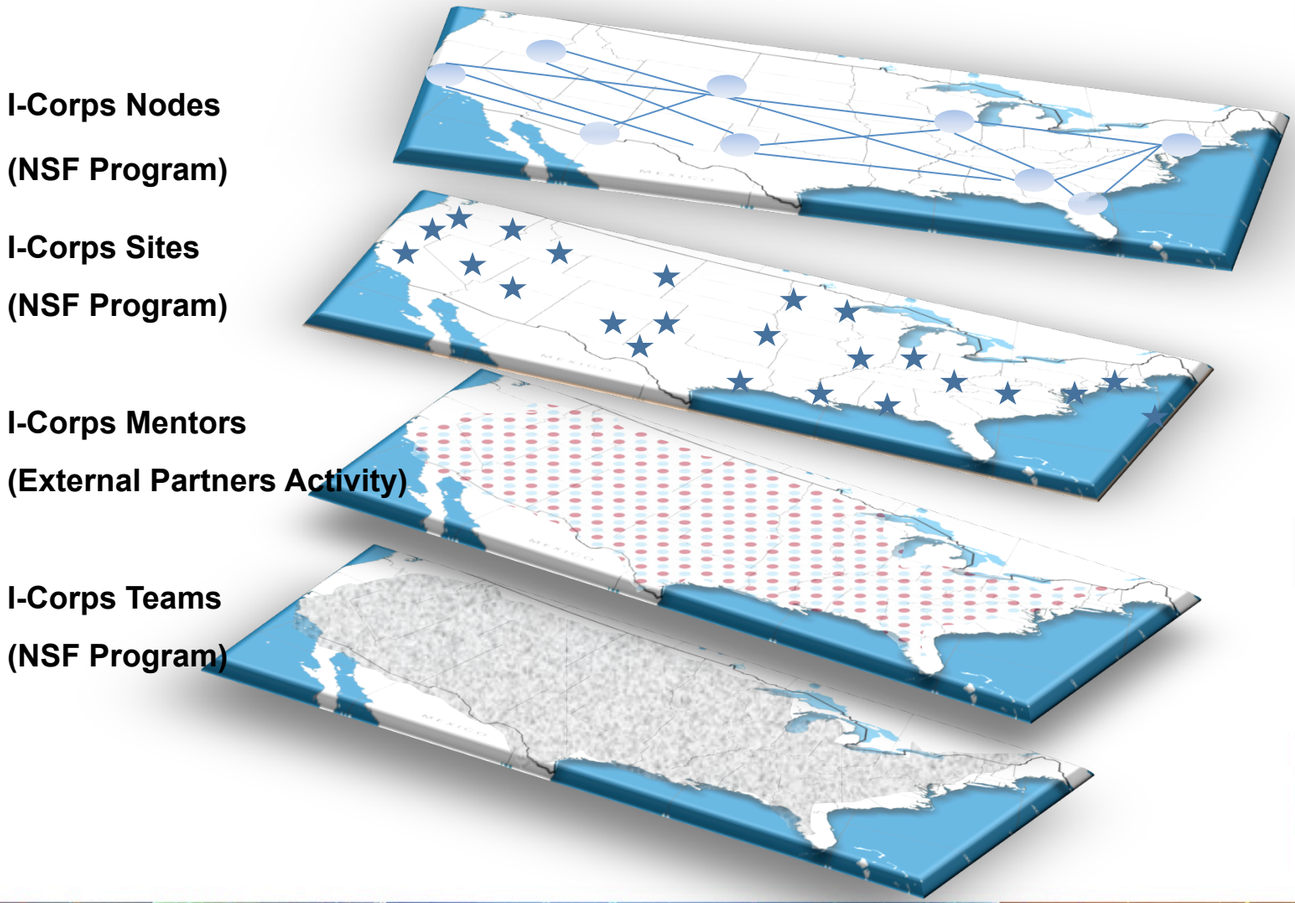
Accelerating innovations from the laboratory to the market

CISE Investment: $11.65 M

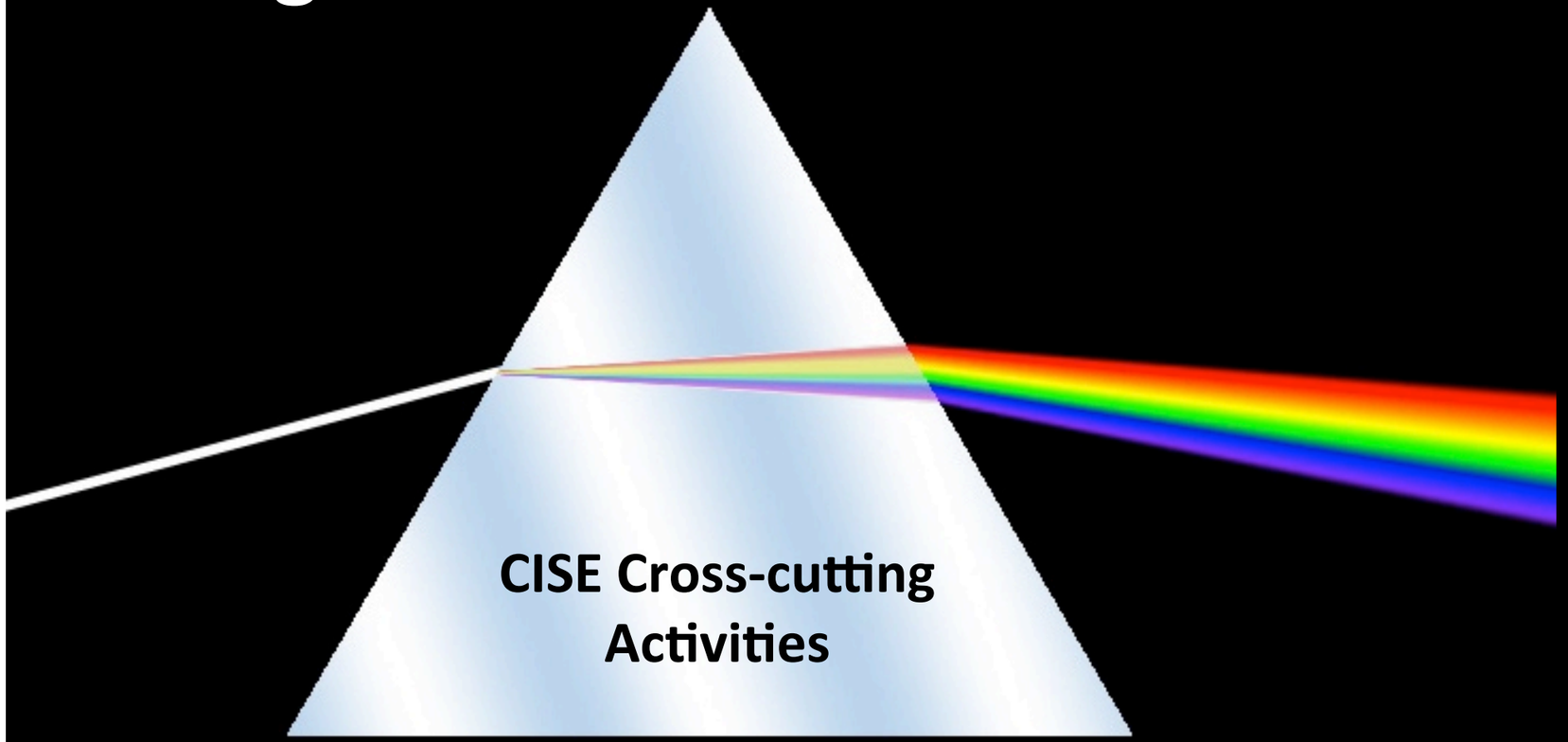
- Partnership among BIO, CISE, ENG, GEO, MPS, and SBE
- Focus:
  - Develop, nurture *national innovation ecosystem*

fundamental research, discovery → technologies, products, processes that benefit society

Building the Nation's I-Corps Fabric



Budget Prism



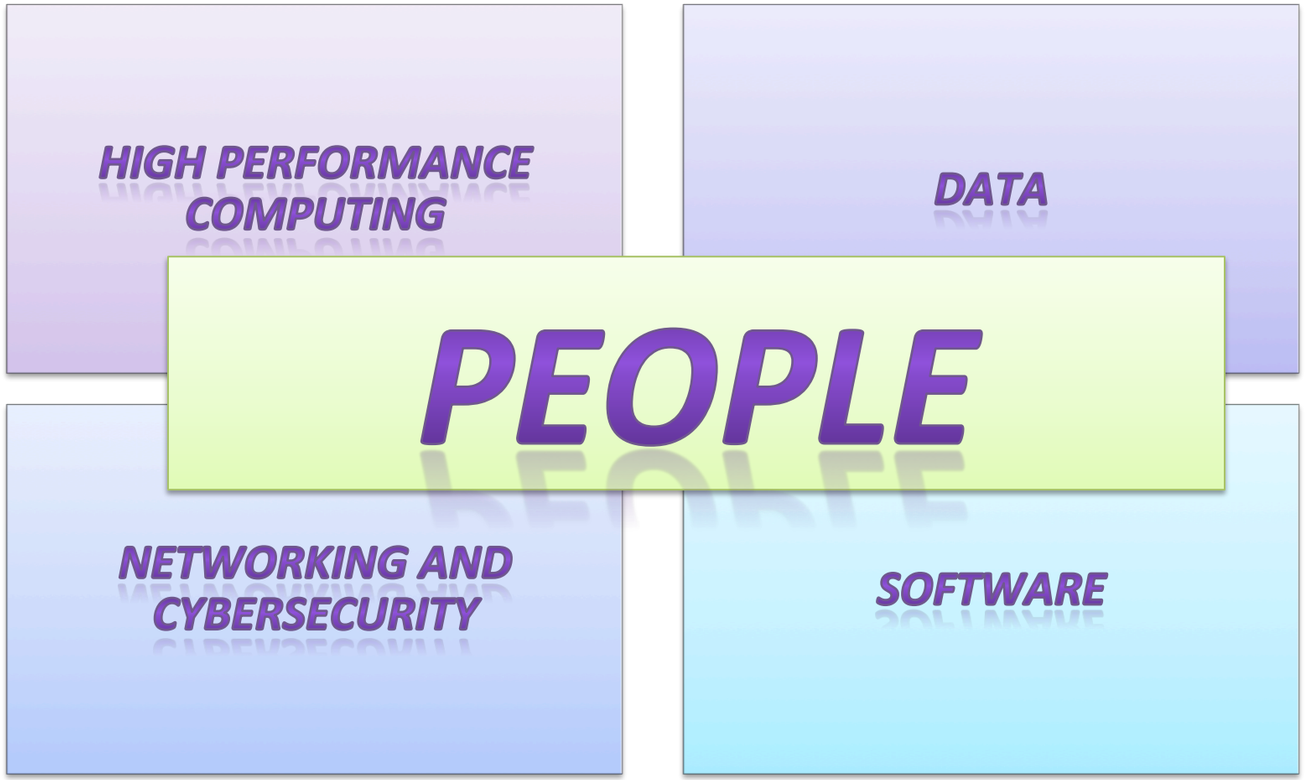
- **Algorithms in the Field, AitF**
- Campus Cyberinfrastructure –Data, Networking, and Innovation Program, CC*DNI
- CISE-MPS Interdisciplinary Faculty Program in Quantum Information Science
- CISE Research Infrastructure: Mid-Scale Infrastructure – NSFCloud
- Computer and Information Science and Engineering (CISE) Research Initiation Initiative, CRII
- Critical Resilient Interdependent Infrastructure Systems and Processes, CRISP
- **Cyberlearning and Future Learning Technologies**
- Cyber-Innovation for Sustainability Science and Engineering, CyberSEES
- Documenting Endangered Languages, DEL
- Enhancing Access to the Radio Spectrum, EARS
- **Expeditions in Computing**
- Exploiting Parallelism and Scalability, XPS
- High Performance Computing System Acquisition: Continuing the Building of a More Inclusive Computing Environment for Science and Engineering
- Interdisciplinary Research in Hazards and Disasters, Hazards SEES
- Integrative Strategies for Understanding Neural and Cognitive Systems, NSF-NCS
- International Research Network Connections, IRNC
- NSF/Intel Partnership on Visual and Experiential Computing, VEC
- Partnerships for Innovation: Building Innovation Capacity, PFI:BIC
- Petascale Computing Resource Allocations, PRAC
- **Smart and Connected Health, SCH**
- **STEM + Computing Partnerships, STEM +C**
- US Ignite
- United States-Israel Collaboration in Computer Science, USICCS
- US-Japan Big Data and Disaster Research, BDD
- Wireless Innovation between Finland and US, WIFIUS

Cross-cutting Programs

NSF Advanced Cyberinfrastructure

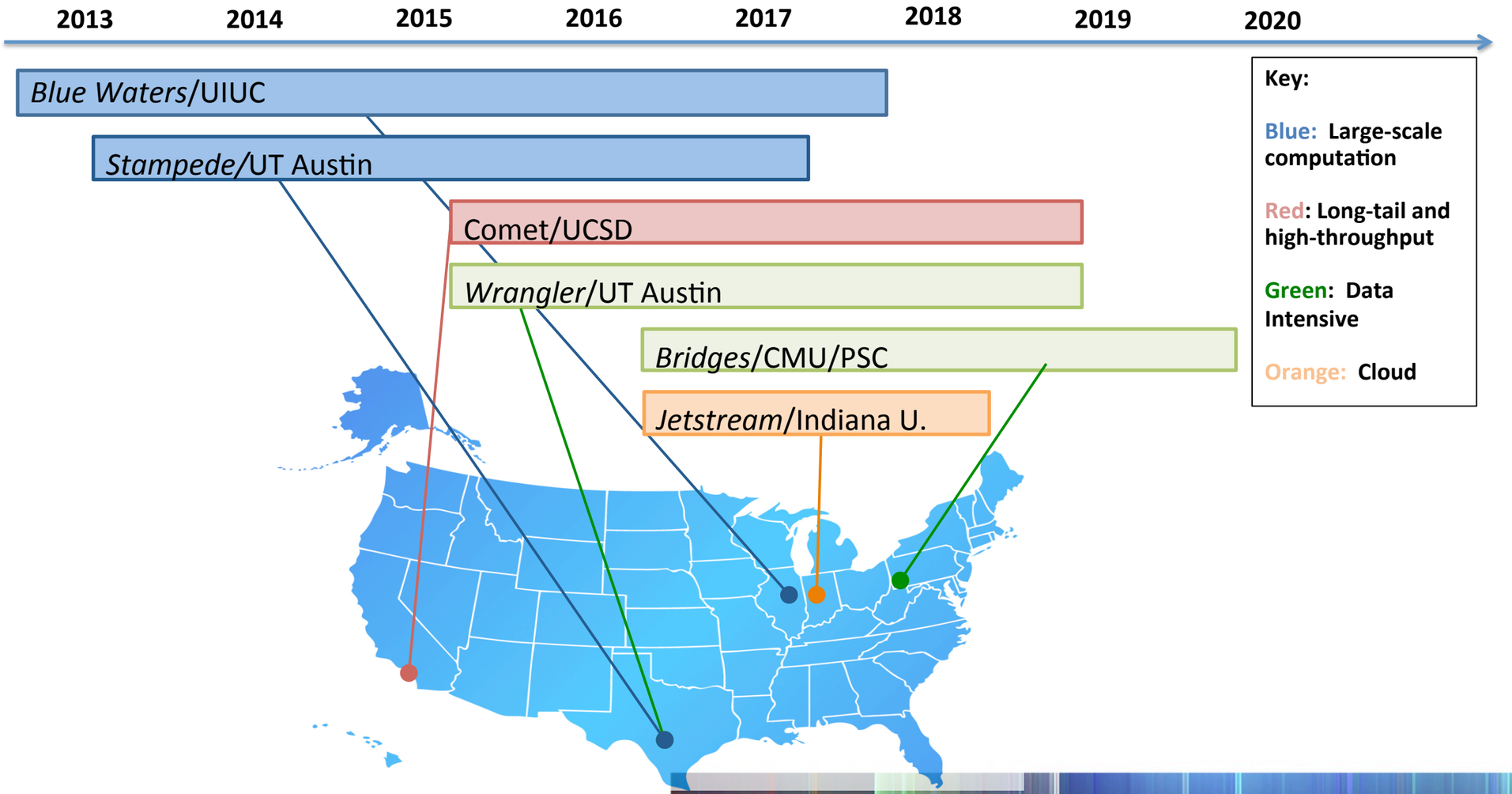
Connecting scientific communities with computational resources and services at all scales

- Advanced cyberinfrastructure: accelerates pace of discovery, innovation across entire spectrum of science, engineering and education expands each year
- Rich ecosystem: HPC, data, networking & cybersecurity, software



NSF Advanced Cyberinfrastructure

A diversity of resources in the ecosystem



Other CISE Cross-Cutting Programs

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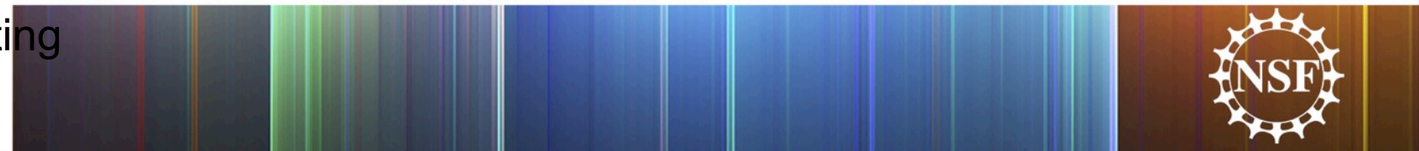

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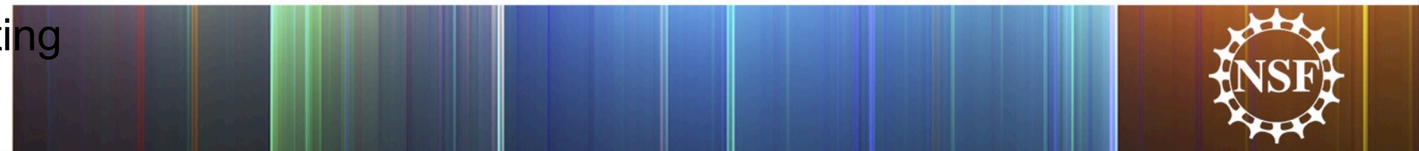
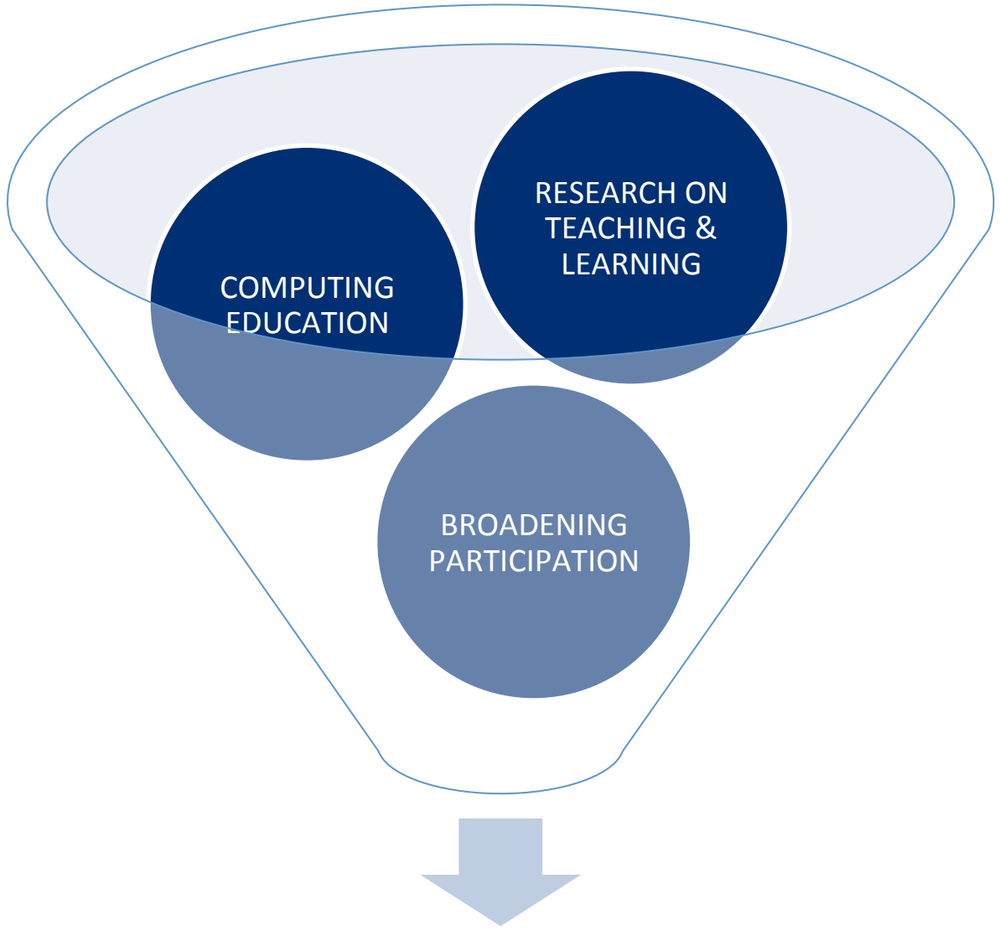


STEM + Computing (STEM+C) Partnerships

Integrating computing into STEM

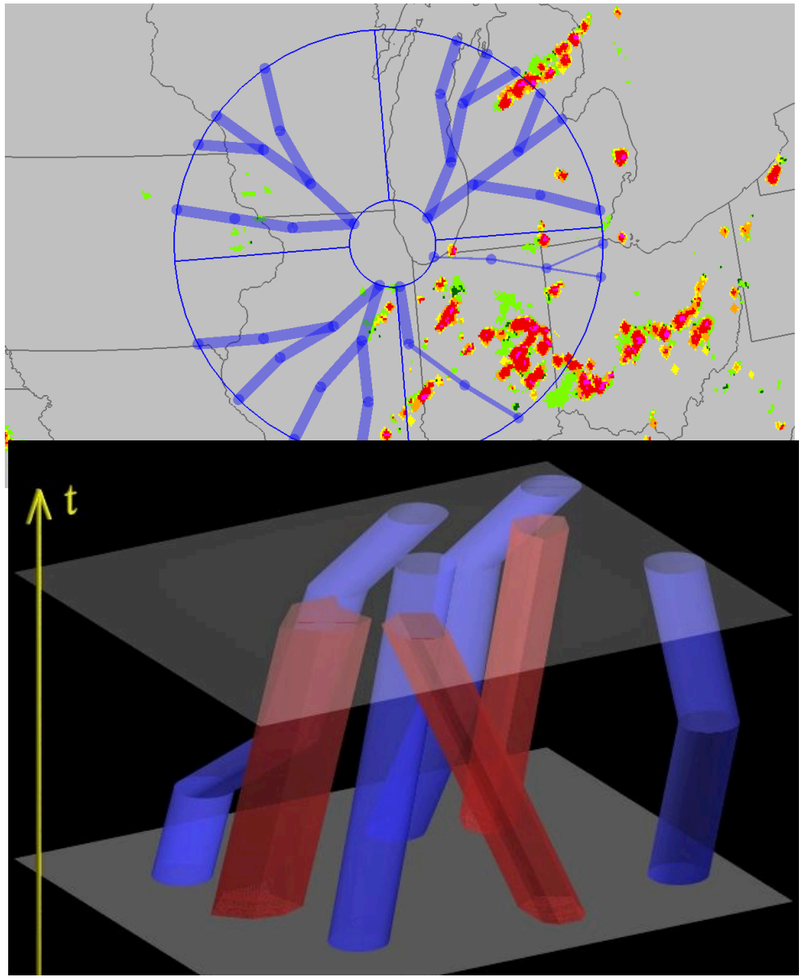


CISE Investment: $12.50 M

- Partnerships:
  - CISE and EHR
  - Deep community partnerships
- Also aims to increase number, diversity of K-14 students, teachers who develop, practice computational competencies
- Transforms the computing education pipeline through CS10K

Algorithms in the Field (AitF)

Advancing algorithmic design and the application area to which the algorithms are being deployed



Images courtesy of *Joseph Mitchell, SUNY at Stony Brook*

- Encourages closer collaboration between theoretical computer science and applied researchers
- Bridges gap between theory, practice in design, analysis, implementation, evaluation of algorithms

Cyberlearning and Future Learning Technologies

Improving learning by integrating technologies with knowledge about how people learn

- Participation among CISE, EHR, and ENG
- Program foci:
  - Advancing understanding of how people learn in technology-rich learning environments
  - Close collaboration with teaching community

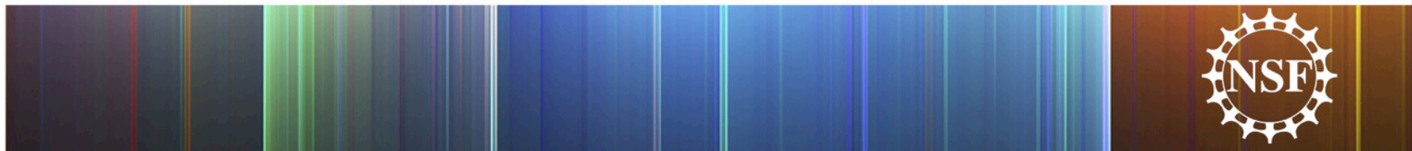
Image Credit: *Georgia Computes! Georgia Tech*

CISE Research Infrastructure: Mid-Scale Infrastructure - NSFFutureCloud

Enabling novel cloud architectures

- Program foci:
  - Resource sharing in clustered computing
  - Virtualization with software-defined networking technologies
  - Interplay between applications and cloud computing architectures

Images: Logos from the NSF Cloud projects funded in FY2014



Exploiting Parallelism and Scalability (XPS)

Leading to a new era of parallel computing

- Establishes *new* collaborations combining expertise cutting across abstraction, software, hardware layers
- Program foci:
  - Foundational Principles
  - Cross-layer and Cross-cutting Approaches
  - Scalable Distributed Architectures
  - Domain-specific Design

Image Credit: CCC and SIGACT CATCS

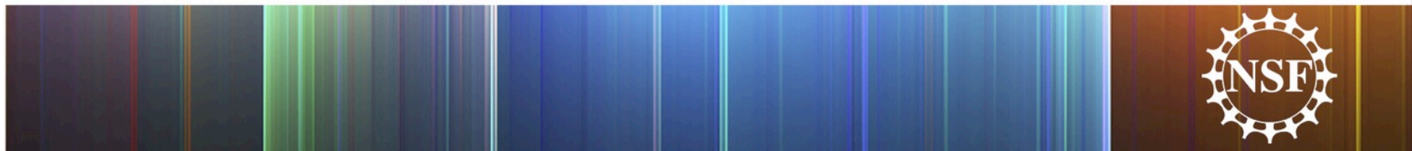
Smart and Connected Health

Transforming healthcare knowledge, delivery, and quality of life through IT

- CISE, ENG, SBE partnership with NIH
- Fundamental technical, scientific advances that transform healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, person-centered and focused on wellbeing rather than disease.

Research Thrusts

Digital Health Information Infrastructure	Data to Knowledge to Decision	Empowered Individuals	Sensors, Devices, and Robotics
Informatics and Infrastructure	*Reasoning under uncertainty*	*Energized, enabled, educated*	*Sensor-based actuation*



Expeditions-in-Computing

Exploring scientific frontiers that promise transformative innovations in computing

Beyond Moore's Law

- *The Molecular Programming Project*, CalTech, U Washington, 2008; & Harvard, UCSF, 2013
- *Variability-aware Software for Efficient Computing with Nanoscale Devices*, UCSD, UCLA, UIUC, Stanford, Michigan, 2010
- *Customizable Domain-Specific Computing*, UCLA, UCSB, Rice, Ohio State, 2009

Sustainability & Environment

- *Understanding Climate Change: A Data Driven Approach* – Minnesota, Northwestern, NC State, NC A&T State, 2010
- *Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, and Society* – Cornell, Oregon State, Bowdoin, 2008

Wireless & Internet

- *Open Programmable Mobile Internet 2020,* Stanford, 2008

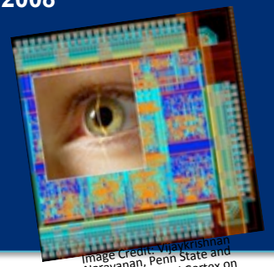


Image Credit: Vijaykrishnan Narayanan, Penn State and members of Visual Cortex on Silicon Team

Healthcare & Wellbeing

- *Socially Assistive Robots,* Yale, USC, MIT, Stanford, Willow Garage, 2011
- *Computational Behavioral Science: Modeling, Analysis, and Visualization of Social and Communicative Behavior,* Georgia Tech, MIT, Boston U, UIUC, USC, *Carnegie Mellon, 2010*

Robotics and Vision

- *Visual Cortex on Silicon*, Penn State, USC, Stanford, York College, UCSD, UCLA, Pitt, MIT, 2013
- *An Expedition in Computing for Compiling Printable Programmable Machines,* MIT, U Penn, Harvard, 2011
- *RoboBees: A Convergence of Body, Brain and Colony* – Harvard, Northeastern, 2009

Image Credit: Harvard University

Limits of Computation

- *Understanding, Coping with, and Benefiting from Intractability* – Princeton, Rutgers, NYU, Institute for Advanced Study, 2008

Image Credit: UC San Diego Jacobs School of Engineering

Formal Modeling and Verification

- *Expeditions in Computer Augmented Program Engineering,* U Penn, UC Berkeley, UMD, Rice, Cornell, U of Michigan, U of Illinois-UC, UCLA, MIT, 2011
- *Next-Generation Model Checking and Abstract Interpretation with a Focus on Embedded Control and Systems Biology,* Carnegie Mellon, Stony Brook, NYU, UMD, Pitt, Lehman College, JPL, 2009

Big Data

- *Algorithms, Machines, and People,* UC Berkeley, UC San Francisco, 2011
- *(Understanding Climate Change: A Data Driven Approach* – Minnesota, Northwestern, NC State, NC A&T State, 2010)

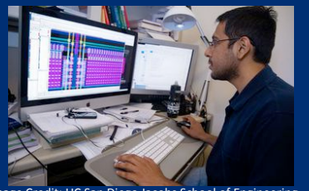
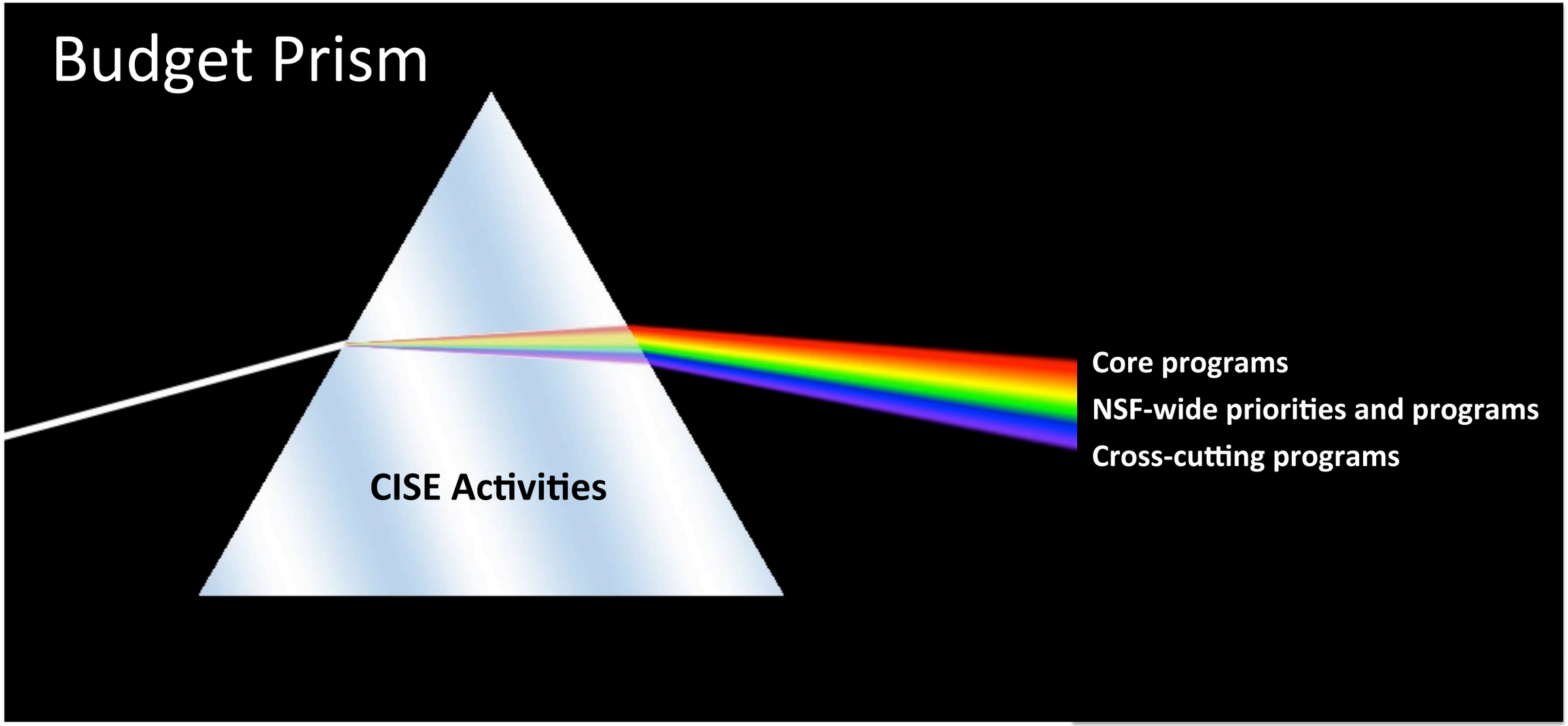


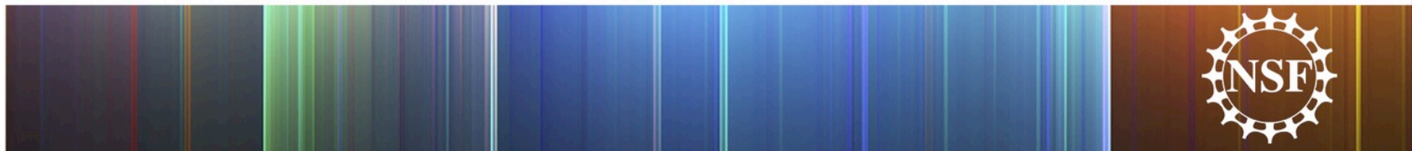
Image Credit: UC San Diego Jacobs School of Engineering

Budget Prism



CISE's Commitment to Research and Education

- CISE: **rich intellectual agenda** – highly creative, highly interactive, with enormous possibilities for changing the world!
- Balanced portfolio of activities
- Thriving basic research community foundational for long-term **discovery** & **innovation**, **economic prosperity**, **national security**
- Growing investment in **cyberinfrastructure** is crucial to accelerating scientific discovery and engineering innovation across all disciplines
- Investments in **research**, **education**, **and infrastructure** have returned exceptional dividends to our Nation



Thanks!