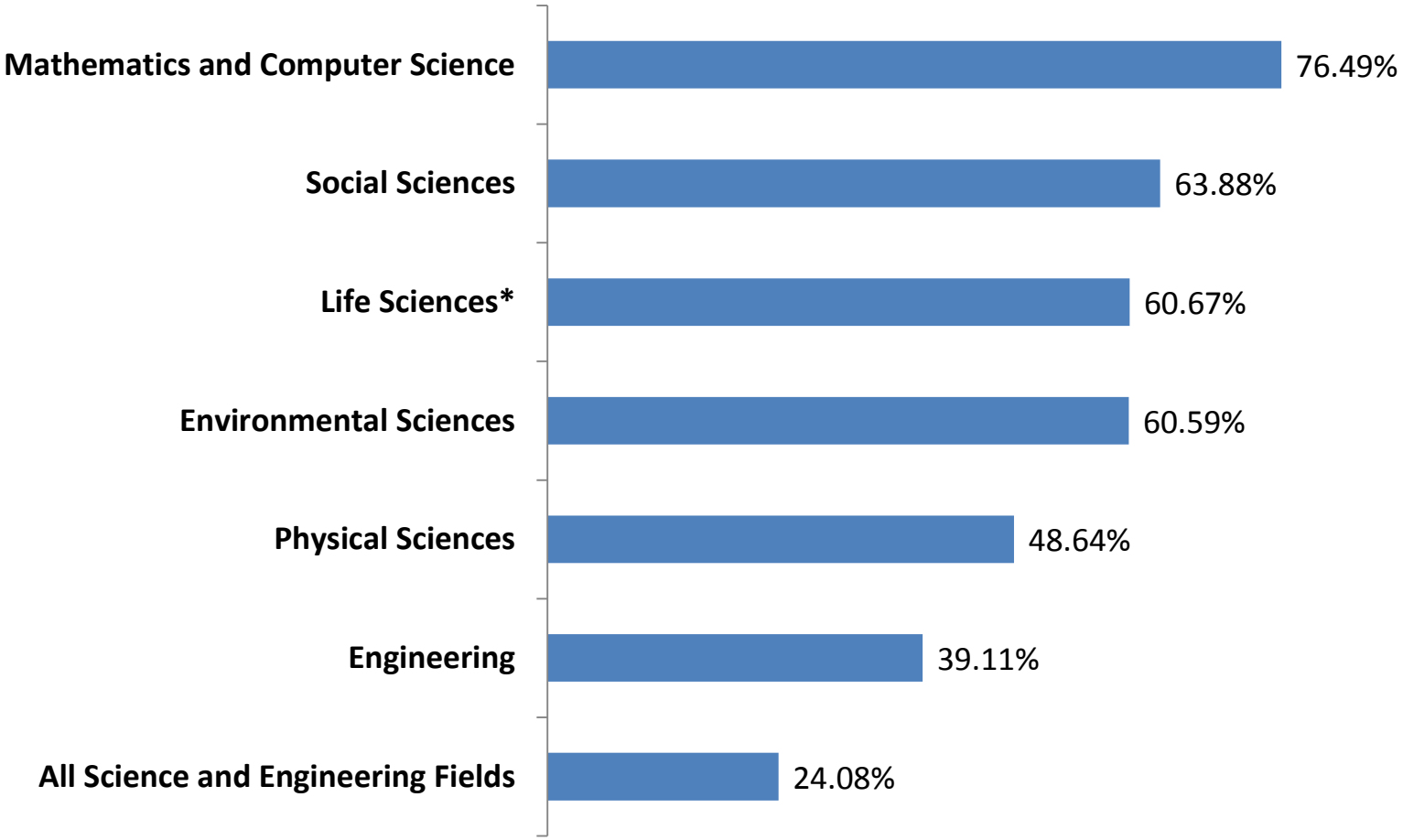
Computer and Information Science and Engineering (CISE)

Exploring the frontiers of computing

http://www.nsf.gov/dir/index.jsp?org=CISE

March 2013

NSF Support of Academic Basic Research in Selected Fields – FY 2009
(as a percentage of total federal support)

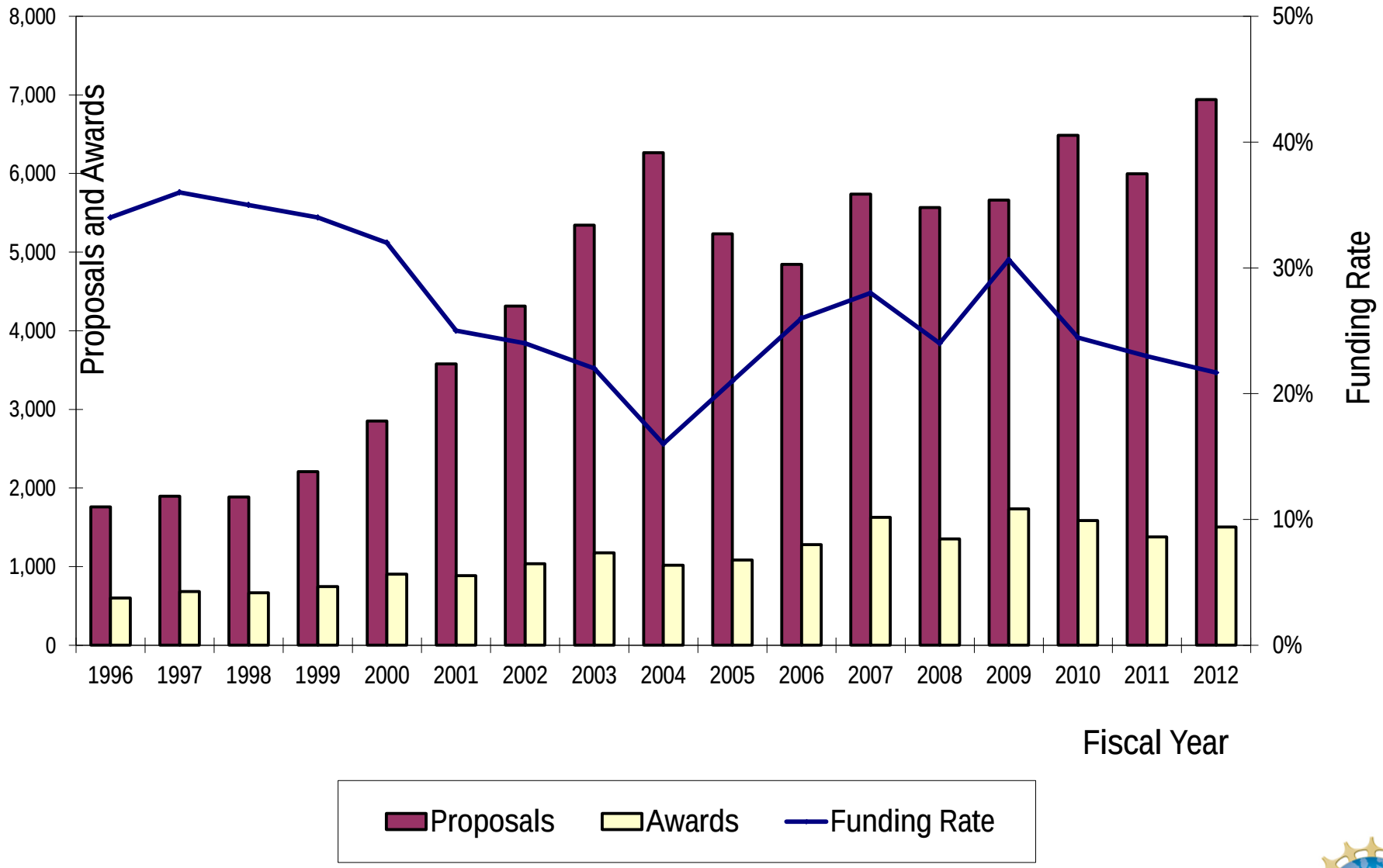


**Excludes the National Institutes of Health*

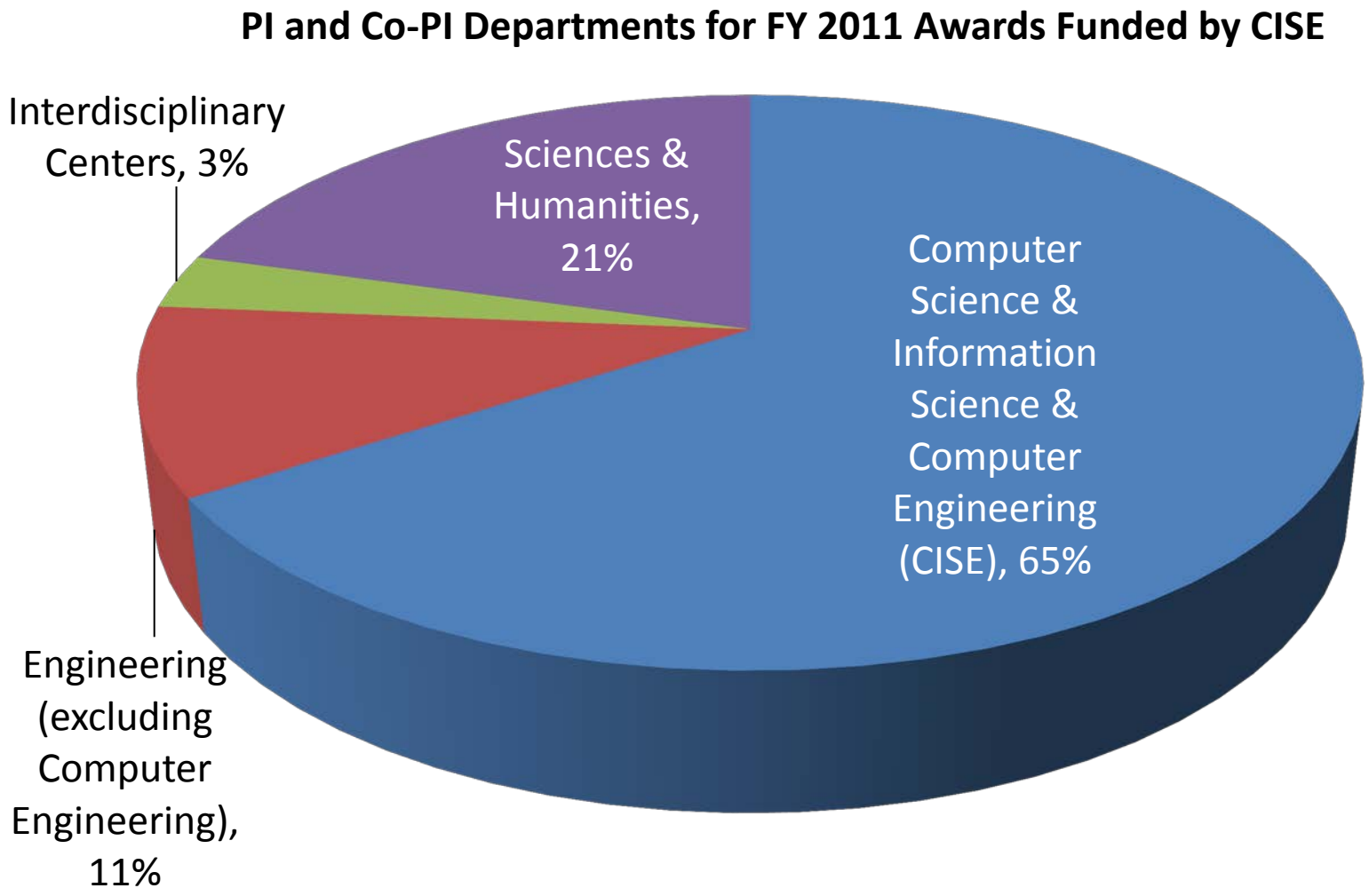
Source: NSF Survey of Federal Funds for Research and Development

Goals of CISE Directorate

- To enable the U.S. to maintain a position of world leadership in computing, communications, and information science and engineering
- To promote understanding of the principles and uses of advanced computing, communications and information systems in service to society
- To contribute to universal, transparent and affordable participation in an information-based society


8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Proposals and Awards
50%
40%
30%
20%
10%
0%
Funding Rate
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Fiscal Year
Proposals
Awards
Funding Rate

Who is the CISE community?



Overview of CISE Support

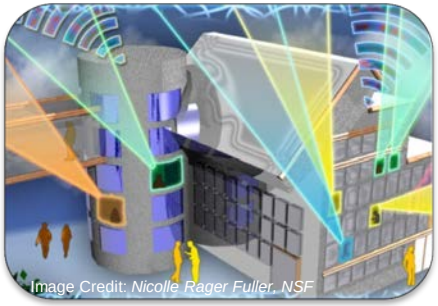
CISE Supports:

- Investigator-initiated **research** in all areas of computer and information science and engineering
- Cutting-edge national computing and information **infrastructure** for research and education
- **Education and training** of the next generation of computer scientists and engineers

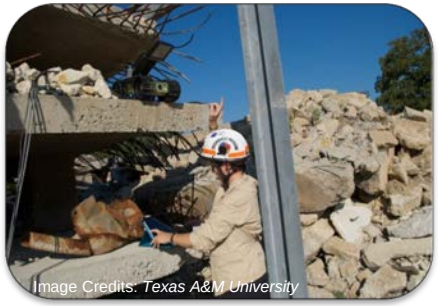
Through:

- CISE Core programs
- CISE Cross-cutting programs
- NSF Cross-cutting programs

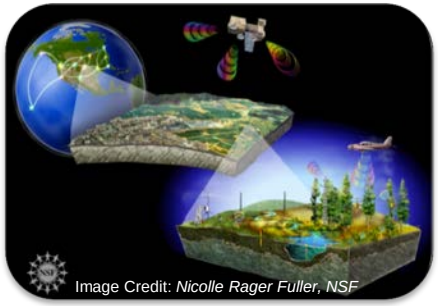
CISE and National Priorities



Broadband & Universal Connectivity



Emergency Response & Disaster Resiliency



Environment & Sustainability

Health & Wellbeing

Manufacturing, Robotics, & Smart Systems

Secure Cyberspace

Transportation & Energy

Education and Workforce Development

CISE Organization

Office of the Assistant Director for CISE
Assistant Director: Dr. Farnam Jahanian
Deputy Assistant Director: Dr. C. Suzanne Iacono

Advanced Cyberinfrastructure

Division Director
Mr. Alan Blatecky

Computing and Communications Foundations

Division Director
Dr. Rao Kosaraju

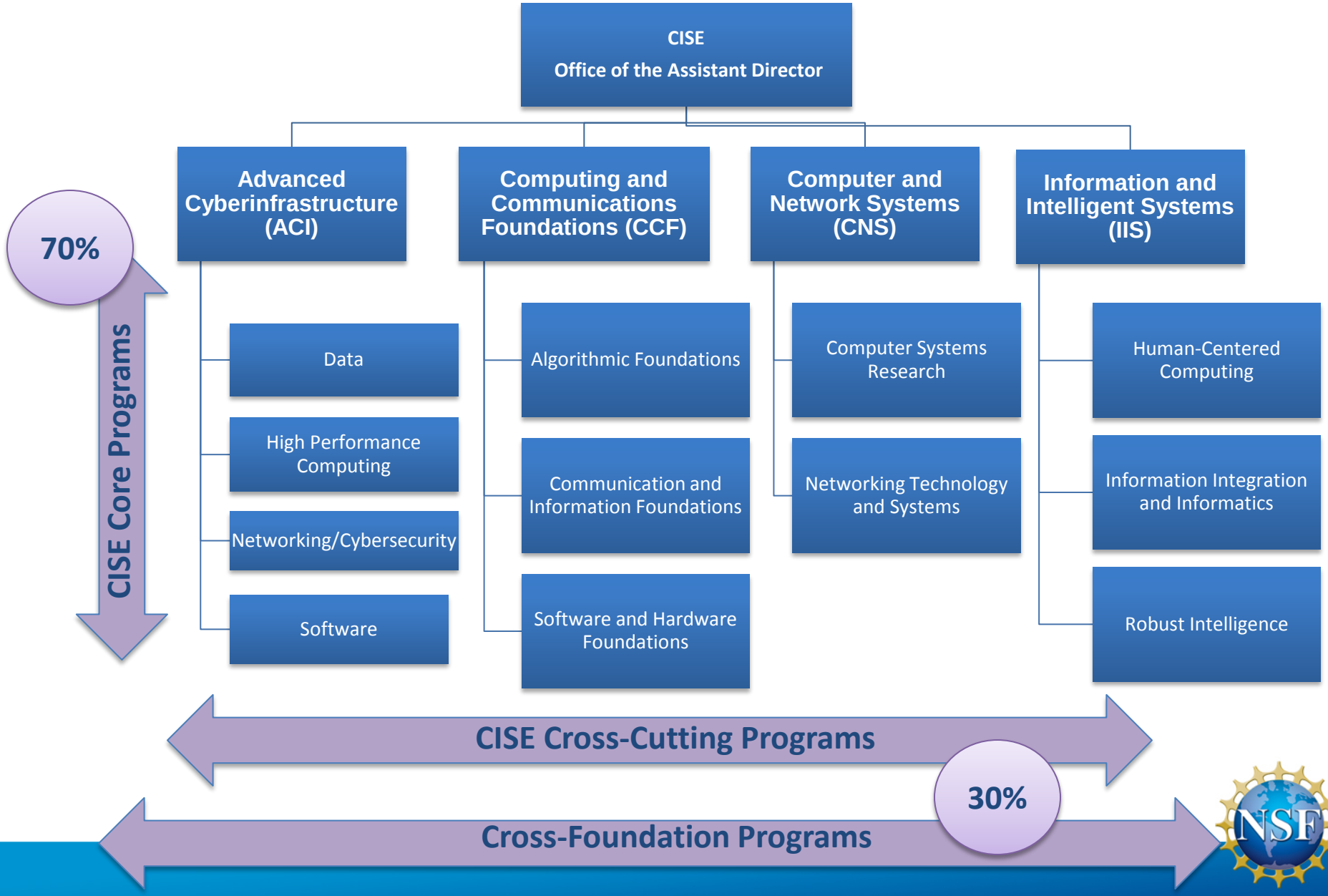
Computer and Network Systems

Division Director
Dr. Keith Marzullo

Information and Intelligent Systems

Division Director
Dr. Deborah Lockhard (acting)

CISE Organization and Core Research Programs



Advanced Cyberinfrastructure (ACI)

Supports the acquisition, development, and provision of state-of-the-art cyberinfrastructure resources, tools, and services essential to the conduct of 21st century science and engineering research and education

- *Data:* Support scientific communities in the sharing and archiving of, as well as computing with data by creating building blocks to address common community needs in data infrastructure.
- *High Performance Computing:* Enable petascale computing; provide open-science community with state-of-the-art HPC assets ranging from loosely coupled clusters to large scale instruments; develop an integrated scientific HPC environment.
- *Networking and Cybersecurity:* Invest in campus network improvements and re-engineering to support a range of activities in modern computational science. Support transition of cybersecurity research to practice.
- *Software:* Transform innovations in research and education into sustained software resources that are an integral part of cyberinfrastructure.

Computing & Communication Foundations (CCF)

http://www.nsf.gov/div/index.jsp?org=CCF

Supports research and education projects that explore the foundations of computing and communication devices.

- *Algorithmic Foundations (AF):* Innovative research characterized by algorithmic thinking and algorithm design, accompanied by rigorous mathematical analysis.
- *Communications and Information Foundations (CIF):* Transformative research addressing the theoretical underpinnings and current and future enabling technologies for information acquisition, transmission, and processing in communication and information networks.
- *Software and Hardware Foundations (SHF):* Foundational research essential to advance the capability of computing systems, including software and hardware components, systems, and other artifacts.

Computer and Network Systems (CNS)

http://www.nsf.gov/div/index.jsp?div=CNS

Supports research and education activities inventing new computing and networking technologies and exploring new ways to make use of existing technologies.

- *Computer Systems Research (CSR):* Transformative research on fundamental scientific and technological advances leading to the development of future generation computer systems, including new architectures; distributed real-time embedded devices; pervasive, ubiquitous and mobile computing; file and storage systems; operating systems; reliable, fault-tolerant and secure hard/middle/software.

- *Networking Technology and Systems (NeTS):* Transformative research on fundamental scientific and technological advances leading to the understanding, development, engineering, and management of future-generation, high-performance computer networks.

Information and Intelligent Systems (IIS)

http://www.nsf.gov/div/index.jsp?div=IIS

Supports research and education activities that study the inter-related roles of people, computers, and information.

- *Human Centered Computing (HCC):* Research that explores creative ideas, novel theories, and innovative technologies that advance our understanding of the complex and increasingly coupled relationships between people and computing.

- *Information Integration and Informatics (III):* Information technology research on the processes and technologies involved in creating, managing, visualizing, and understanding diverse digital content in circumstances ranging from individuals through groups, organizations, and societies, and from individual devices to globally-distributed systems, and that can transform all stages of the knowledge life cycle.

- *Robust Intelligence (RI):* Research that encompasses all aspects of the computational understanding and modeling of intelligence in complex, realistic contexts to advance and integrate the traditions of artificial intelligence, computer vision, human language research, robotics, machine learning, computational neuroscience, cognitive science, and related areas.

Applying to Core Programs

- Program Solicitations:
  - CCF: NSF 12-581
  - CNS: NSF 12-582
  - IIS: NSF 12-580

  Coordinated Solicitations
- Project Types:
  - Large: $1,200,001 to $3,000,000; up to 5 years, collaborative teams
  - Medium: $500,001 to $1,200,000; up to 4 years, multi-investigator teams
  - Small: up to $500,000; up to 3 years, one or two investigator projects
- CISE-wide Submission Windows:
  - Large: November 1 - 30, annually
  - Medium: September 15 – 30, annually (2013 and beyond)
  - Small: December 3 – 17, annually
- PI Limit:
  - **Participate in no more than 2 "core" proposals/year**

For a comprehensive list of CISE funding opportunities, visit:
http://www.nsf.gov/funding/pgm_list.jsp?org=CISE

Sample of CISE Cross-Cutting Programs

For a comprehensive list of CISE funding opportunities, visit:
http://www.nsf.gov/funding/pgm_list.jsp?org=CISE

- Cross-Directorate
  - *Secure and Trustworthy Cyberspace (SaTC)*

    Securing our Nation's cyberspace from malicious behavior, while preserving privacy and promoting usability.
  - *Cyber-Enabled Sustainability and Science (CyberSEES)*

    Sustainability enabling by new advances in computing
  - *Computing Education for the 21st Century (CE21)*

    Increasing number and diversity of students and educators in computing education and learning.
  - *Cyberlearning: Transforming Education (CTE)*

    Designing and implementing technologies to aid and understand learning.
  - *Cyber-Physical Systems (CPS)*

    Integrating computation, communication, and control into physical systems.
  - *Enhancing Access to the Radio Spectrum (EARS)*

    Enhancing access to wireless service and/or efficiency with which radio spectrum is used.

Sample of CISE Cross-Cutting Programs

For a comprehensive list of CISE funding opportunities, visit:
http://www.nsf.gov/funding/pgm_list.jsp?org=CISE

- Cross-Division
  - *Expeditions in Computing*
    Exploring new frontiers in computing and information science.
  - *Exploiting Parallelism and Scalability (XPS)*
    Groundbreaking research leading to a new era of parallel computing
  - *Campus Cyberinfrastructure – Network Infrastructure and Engineering (CC-NIE)*
    Improvements at campus level to support computational science and systems research.
- Cross-Agency
  - *Core Techniques and Technologies for Advancing Big Data Science & Engineering (BIG DATA)*
    Developing tools to manage and analyze data in order to extract knowledge from data.
  - *National Robotics Initiative (NRI)*
    Developing and using robots that work alongside, or cooperatively with, people.
  - *Smart & Connected Health (SCH)*
    Transforming healthcare knowledge and delivery, and improving quality of life through IT.

Expeditions-in-Computing

Exploring scientific frontiers that promise transformative innovations in computing

- $10M total per project
  - $2M/year per award for 5 years
- 14 awards to date

Credit: Jason Dorfman, CSAIL/MIT

Beyond Moore's Law

- ***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**
- ***The Molecular Programming Project*, CalTech, U Washington, 2008**

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**

Healthcare & Wellbeing

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

Robotics

- ***RoboBees: A Convergence of Body, Brain and Colony – Harvard, Northeastern, 2009***
- ***An Expedition in Computing for Compiling Printable Programmable Machines, MIT, U Penn, Harvard, 2011***

Image Credit: Harvard University

Limits of Computation

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

Formal Modeling and Verification

- ***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***
- ***Expeditions in Computer Augmented Program Engineering, U Penn, UC Berkeley, UMD, Rice, Cornell, U of Michigan, U of Illinois-UC, UCLA, MIT, 2011***

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**

Secure and Trustworthy Cyberspace (SaTC)

Securing our Nation's cyberspace

- Aims to support fundamental scientific advances and technologies to protect cyber-systems (including host machines, the Internet and other cyber-infrastructure) from malicious behavior, while preserving privacy and promoting usability.
- Proposals must address cybersecurity from one or more of three perspectives:
  - Trustworthy Computing Systems
  - Social, Behavioral and Economics
  - Transition to Practice
  - Cybersecurity Education (special requirements)

Image Credit: *ThinkStock*

Project Types:

- **Small**
  Submission window:
  Dec 1-15 annually
  up to $500,000
  over 3 years
- **Medium**
  Submission window:
  September 15-30, 2013
  $500,001 to $1,200,000
  over 4 years
- **Frontier**
  Submission window:
  early Nov
  $1,200,001 to $10,000,000
  over 5 years

Core Techniques and Technologies for Advancing Big Data Science & Engineering (BIG DATA)

Foundational research to extract knowledge from data

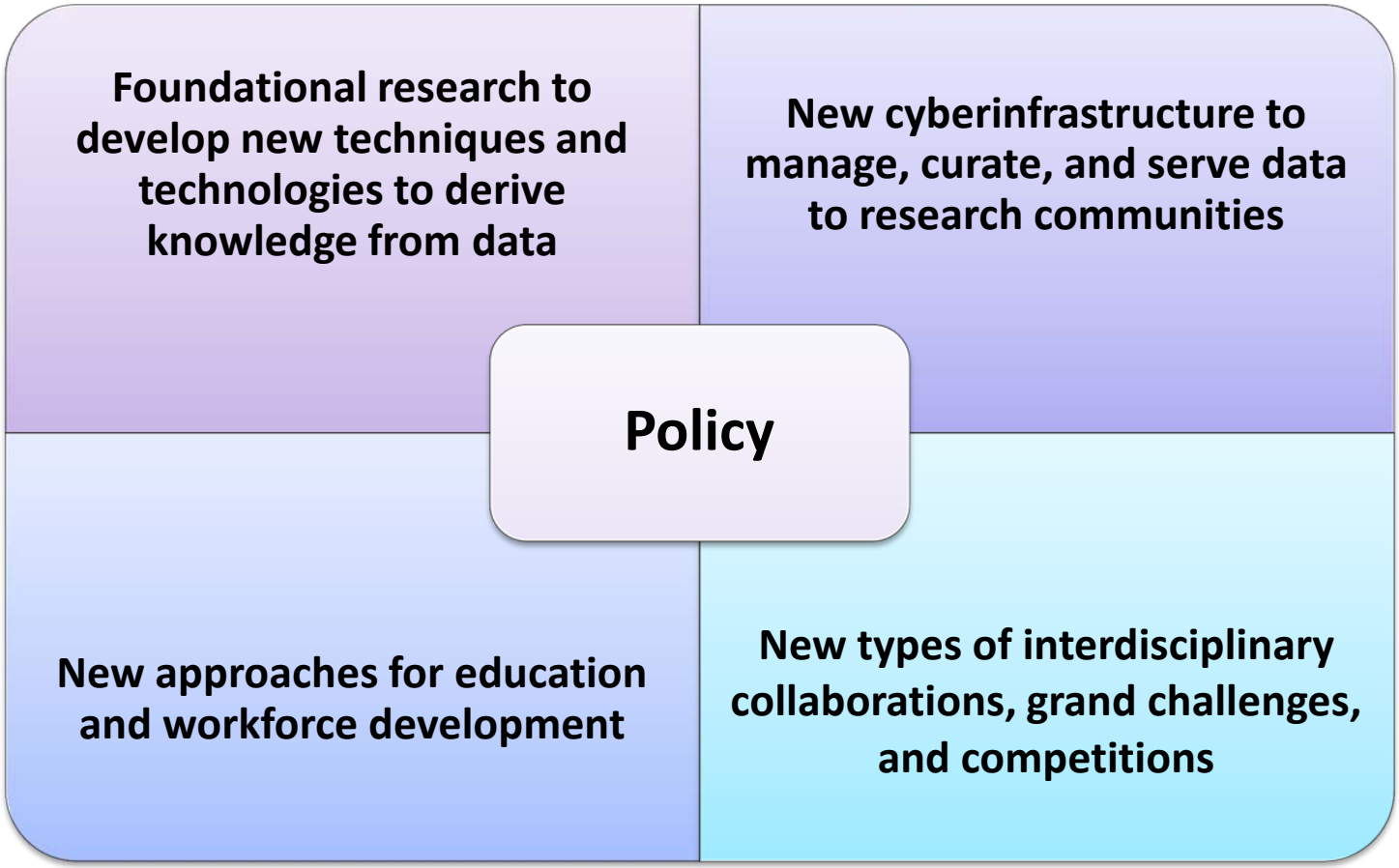
- Foundational research for managing, analyzing, visualizing, and extracting useful information from large, diverse, distributed, and heterogeneous data sets.
- New solicitation to be issued for FY 2013

Collection, Storage, and Management of "Big Data"	Data Analytics	Data Sharing and Collaboration
•Data representation, storage, and retrieval •New parallel data architectures, including clouds •Data management policies, including privacy and access •Communication and storage devices with extreme capacities •Sustainable economic models for access and preservation	•Computational, mathematical, statistical, and algorithmic techniques for modeling high dimensional data •Learning, inference, prediction, and knowledge discovery for large volumes of dynamic data sets •Data mining to enable automated hypothesis generation, event correlation, and anomaly detection •Information infusion of multiple data sources	•Tools for distant data sharing, real time visualization, and software reuse of complex data sets •Cross disciplinary information and knowledge sharing •Remote operation and real time access to distant data sources and instruments

Cross-Directorate Program: NSF Wide

Multi-agency Commitment: NSF and NIH

NSF Strategy to Address Big Data

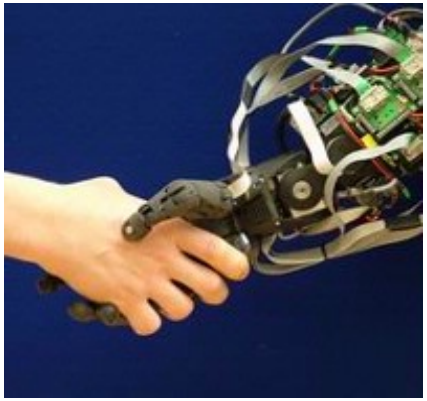


More to come: Policy on data management and open access

National Robotics Initiative (NRI)

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

- A nationally concerted cross-agency program to provide U.S. leadership in science and engineering research and education aimed at the development and use of cooperative robots that work alongside people across many sectors.
- Deadlines:
  - Small Projects: due in November
  - Large Projects: due in January



Credit: *Bristol Robotics Lab*

Research Thrusts

- **Fundamental research in robotics science & engineering**
- **Understanding the long term social, behavioral, and economic implications across all areas of human activity**
- **Use of robotics to facilitate and motivate STEM learning across the K-16 continuum**

Cross-Directorate Solicitation: CISE, EHR, ENG, and SBE

Multi-agency Commitment: NSF, NASA, NIH, USDA

Cyber-Physical Systems (CPS)

Deeply integrating computation, communication, and control into physical systems

- Aims to develop the core system science needed to engineer complex "smart" cyber-physical systems.
- Serves multiple key national priorities.
- Coordinated across NSF and with other government agencies.
- Submission Window: January

Project Types:

- **Breakthrough Projects**
  up to $500,000
  over 3 years
- **Synergy Projects**
  $500,001 to $1,000,000
  over 4 years
- **Frontiers Projects**
  $1,000,001 to $7,000,000
  over 4 to 5 years

Transportation

- Faster and safer aircraft
- Improved use of airspace
- Safer, more efficient cars

Energy and Industrial Automation

- Homes and offices that are more energy efficient and cheaper to operate
- Distributed micro-generation for the grid

Healthcare and Biomedical

- Increased use of effective in-home care
- More capable devices for diagnosis
- New internal and external prosthetics

Critical Infrastructure

- More reliable power grid
- Highways that allow denser traffic with increased safety

Cross-Directorate Solicitation: CISE & ENG

Research to Expand the Limits of Computation

Exploiting Parallelism and Scalability: XPS (NSF 13-507)

Happening now

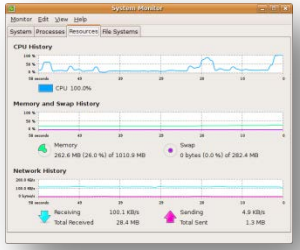
- Architectural innovations with multi-core and many-core
- Domain-specific integrated circuits
- Energy-efficient computing and new processor architectures

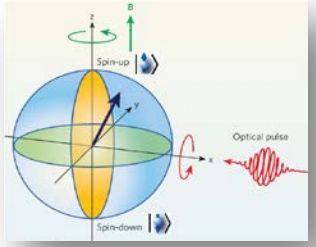
Mid-term solutions

- Research agenda based on parallelism, concurrency, and scalability
- Algorithmic innovations exploiting parallelism
- Software systems leading to improved performance

Long-term solutions

- New materials (e.g., carbon nano-tubes, graphene based devices)
- Non-charge transfer devices; (e.g., electron spin)
- Bio, nano, and quantum devices





Exploiting Parallelism and Scalability (XPS)

- **Aims to support groundbreaking research that will lead to a new era of parallel computing**.
  - *Seeks "clean-slate"* approaches that re-imagine and possibly re-design the traditional hardware and software stack.
- **Goal is to establish *new* collaborations combining expertise cutting across abstraction, software, hardware layers**.
  - Each proposal must have two, or more, PIs providing different and distinct expertise (described in a collaboration plan)
- **Four Focus areas**
  - Foundational Principles, Cross-layer approaches, Scalable distributed architectures, Domain-specific design
- **Proposal deadline**: February 20, 2013 (could be earlier next year)

Cyber-Enabled Sustainability Science and Engineering (CyberSEES)

NSF 13-500

Type 1 Awards: for proof-of-concept, capacity building, or exploratory research and education projects (up to $300K, 2 yrs)

Type 2 Awards for integrative research and education projects (up to $1.2M, 4 yrs)

Letters of Intent : Dec 4, 2012

Proposal deadline: Feb 5, 2013

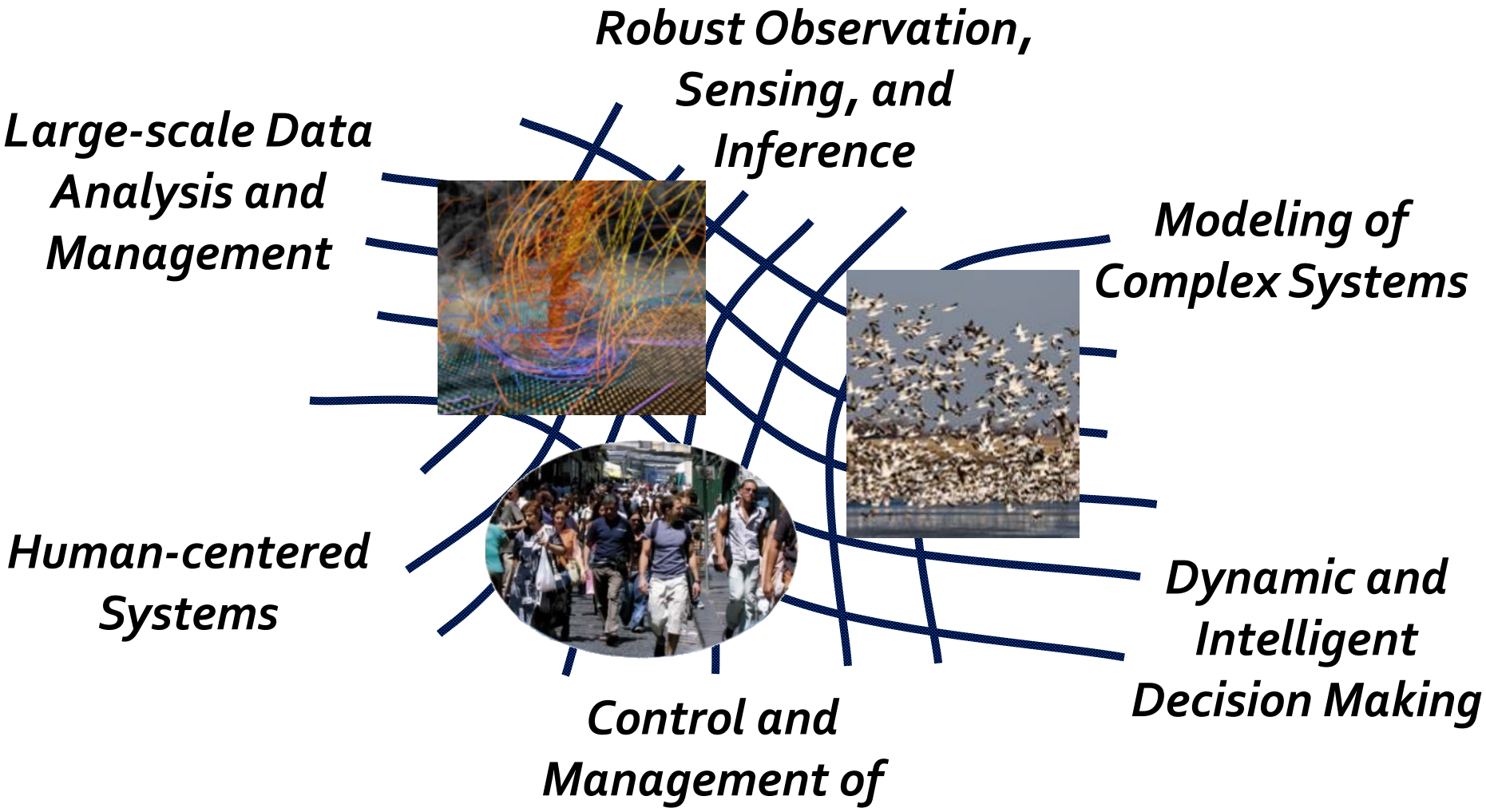
Co-funding with **Semiconductor Research Corporation** in areas of smart infrastructure

CyberSEES aims to

advance interdisciplinary research in which

- the science and engineering of sustainability are enabled by **new advances in computing**, and
- where computational innovation is grounded in the **context of sustainability problems**

Computational challenges are woven into many areas of sustainability research



Smart & Connected Health (SCH)

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

- Address fundamental technical and scientific issues to support the transformation of healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, person-centered and focused on wellbeing rather than disease.
- Must relate to a key health problem and must make a fundamental contribution to ENG, CISE, or SBE domains.
- New solicitation for FY 2013 joint with NIH
- Proposals due May 28/June 3, 2013

Project Types:

- **Type I: Exploratory**
  Up to $250,000 / year for 1-3 years
- **Type II: Integrative**
  Up to $500,000 / year for up to 4 years

Research Thrusts

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

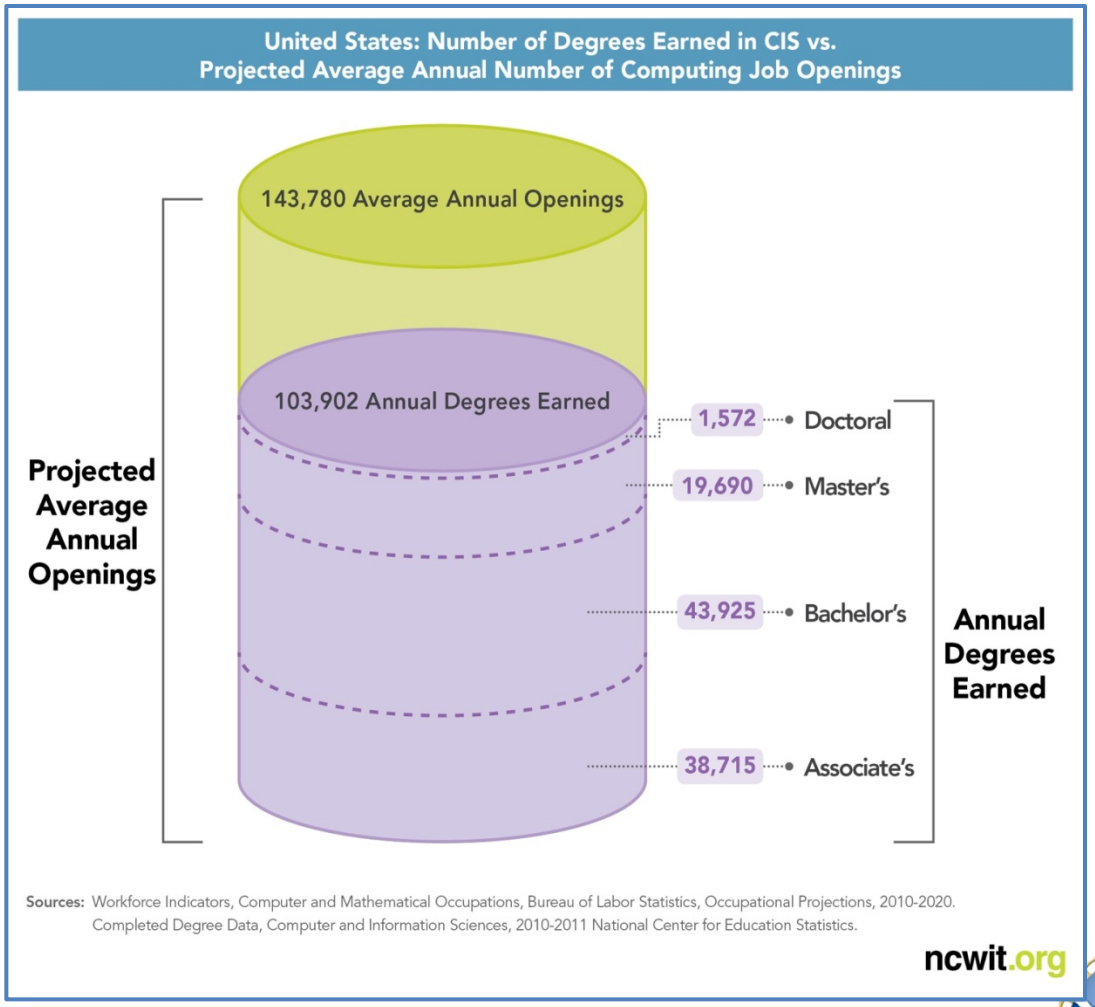
Cross-Directorate Solicitation: CISE, ENG, and SBE

The computing community faces three significant and interrelated challenges in workforce development

Underproduction of degrees

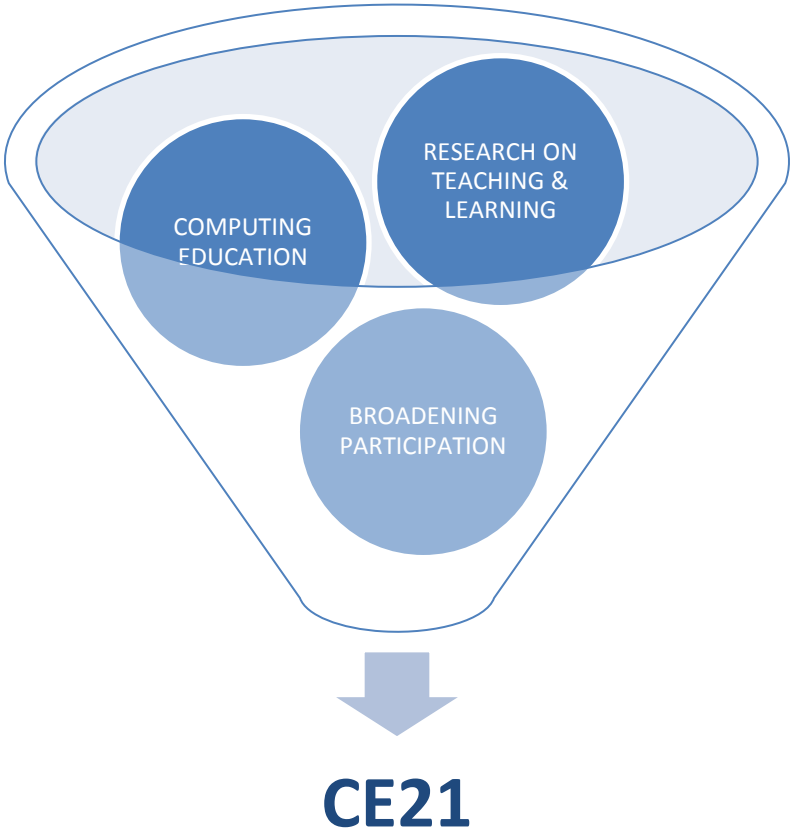
Under-representation

Lack of a presence in K-12



Computing Education for the 21st Century (CE21)

Enhancing computational competencies



Goals:

- Increase number and diversity of K-14 students and teachers who develop and practice computational competencies.
- Increase number of postsecondary students who have background necessary to pursue degrees in computing and computationally-intensive fields.
- Proposal deadline: March 18, 2014

Cross-Directorate Solicitation: CISE, EHR, OCI

Cyberlearning

Improving learning by integrating emerging technologies with knowledge from research about how people learn

- Computer science is both the **enabling discipline** for the development of technologies that enhance learning and a discipline with an **immediate and critical need** for cyberlearning technologies as it aims to scale K-16 educational transformations at the national scale

Goals:

- Understand how people learn in technology rich environments
- Design and study ways in which innovative technologies and tools can promote learning and support assessment
- Prototype new technologies and integrate them into learning environments

Cyberlearning: Transforming Education

Improving learning by integrating emerging technologies with knowledge from research about how people learn

Goals:

- Design ways that innovative tools can be effectively integrated into learning,
- Understand how people learn with technology, and
- Implement new technologies into learning environments in ways so that their potential is fulfilled.

Image Credit: *Georgia Computes! Georgia Tech*

Cross-Directorate Solicitation: CISE, EHR, OCI, SBE

Campus Cyberinfrastructure – Network Infrastructure and Engineering (CC-NIE)

- NSF 13-530 – solicitation released January 4, 2013

http://www.nsf.gov/pubs/2013/nsf13530/nsf13530.htm

- 1st area: Data Driven Networking Infrastructure for the Campus and Researcher
- 2nd area: Network Integration and Applied Innovation
- Proposals due April 3, 2013

CISE Research Initiation Initiative (CRII)

Goal: to enable immediate head start to new/aspiring research faculty.

Eligibility: support untenured faculty or research scientists (or equiv.) in their first 2 years in an academic position after the PhD. One may not yet have received any other grants as a PI.

Support: 2 years up to $170,000 student support.

Estimated Number of Awards: 25 to 30.

Innovation Corps (I-Corps)

Accelerating innovations from the laboratory to the market

- Aims to develop and nurture a national innovation ecosystem that builds upon fundamental research to guide the output of scientific discoveries to the development of technologies, products and processes that benefit society.
- Seeks to identify NSF-funded researchers to receive additional support - in the form of mentoring and funding.
- Must consult with a program director before submission.

Award Information:

- 25 awards in FY11
- 100 awards in FY12

NSF-wide Initiative

NSF-wide Opportunities for the CISE Community

- Faculty Early Career Development (CAREER)
- Grants for Rapid Response Research (RAPID)
- EArly-concept Grants for Exploratory Research (EAGER)
- Graduate Research Fellowship Program
- Research Experiences for Undergraduates (REU)
- Conferences, Summer Schools, and Workshops
- International Collaborations

For a comprehensive list of NSF funding opportunities, visit:
http://www.nsf.gov/funding/

Faculty Early Career Development (CAREER) Program

- The National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through:
    - outstanding research,
    - excellent education, and
    - the **integration of education and research** within the context of the mission of their organizations.

CISE CAREER Proposal Writing Workshops

- Temple University, Philadelphia, PA: March 15, 2013
- University of Texas at Arlington, Arlington, TX: May 17, 2013

RAPID and EAGER Proposals

- ***Grants for Rapid Response Research (RAPID)*:**
  - Supports quick-response research on natural or anthropogenic disasters and similar unanticipated events.
  - Up to $200K and one year duration.
  - Project descriptions are expected to be brief (two to five pages) and include clear statements as to why the proposed research is of an urgent nature.
- ***EArly-concept Grants for Exploratory Research (EAGER)*:**
  - Supports high-risk, exploratory and potentially transformative research.
  - Up to $300K and two years duration.
  - Project description is expected to be brief (five to eight pages) and include clear statements as to why this project is appropriate for EAGER funding.
- See Grant Proposal Guide (GPG) (NSF 13-1) for more details.

Support for Graduate and Undergraduate Students

- ***Graduate Research Fellowship Program***
  - Foundation-wide programs with substantial CISE participation
  - Deadlines in mid-Nov but differ for each Directorate
- ***Research Experiences for Undergraduates (REU)***
  - **REU Sites**
    - Typically in summer, but not strictly necessary
    - 8-10 students in a cohort environment
    - Deadline in August
  - **REU Supplements**
    - Support for 1-2 students to work on existing project
    - Best to submit request by March but no strict deadline

Stay informed and get involved!

- Subscribe to get NSF updates by email at www.nsf.gov.
- Subscribe to receive special CISE announcements:
  - Send a message to: join-cise-announce@lists.nsf.gov with no text in the subject or message body.
- Visit the CISE website often: http://www.nsf.gov/dir/index.jsp?org=CISE.
- Talk to Program Directors: http://www.nsf.gov/staff/staff_list.jsp?org=CISE&from_org=CISE

Get NSF Updates by Email

Opportunities for Community Engagement!

- Volunteer to be a reviewer.
- Visit NSF, get to know your program(s) and program director(s).
- Develop transformational ideas and send your best ideas to NSF.
- Participate in NSF-funded and hosted activities (e.g., workshops, COVs, ACs).
- Participate in the CCC/CRA visioning activities.
- Develop transitional ideas for how to move from ideas and prototypes to systems deployed on testbeds to technology transfer.
- Work within your institution to support and reward interdisciplinary research.
- Work within your institution to support service to the larger computing community around the globe.
- Send us your accomplishments; advertise your research to other citizens through local radio or TV, blogs, newspaper articles, etc.
- Join NSF to serve as program officers or division directors.

CISE Needs Good People

- Quality of program directors:
  - ✓ Affects quality of reviewers chosen for panels and ad hoc reviews
  - ✓ Affects quality of reviews PIs receive
  - ✓ Affects funding decisions
  - ✓ Affects the nature and content of our research
  - ✓ Affects the frontiers of our discipline!

Credits

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