

The Computing and Information Science and Engineering Landscape: A Look Forward

Margaret Martonosi

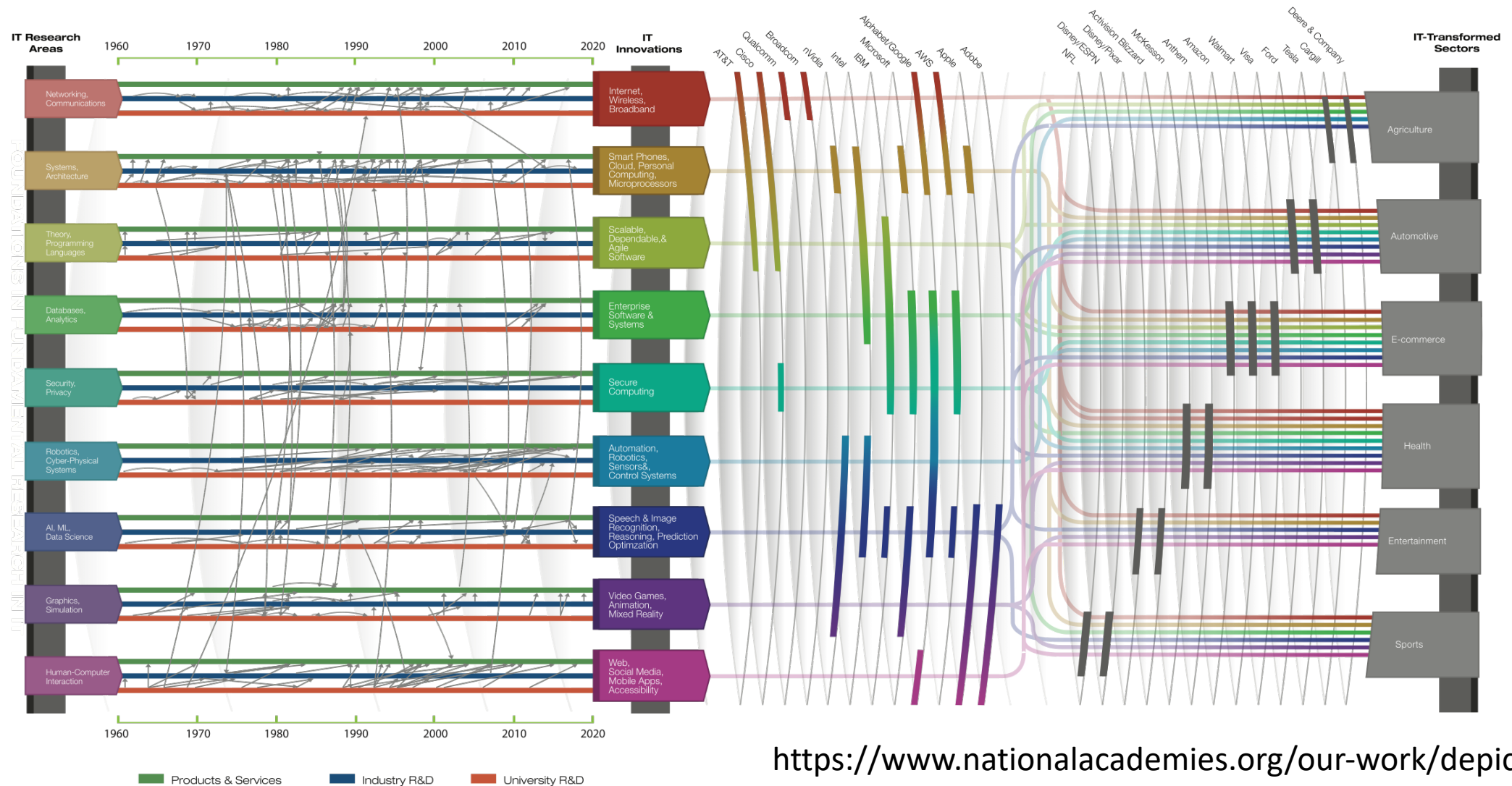
NSF Assistant Director for Computer and Information Science and Engineering (CISE)



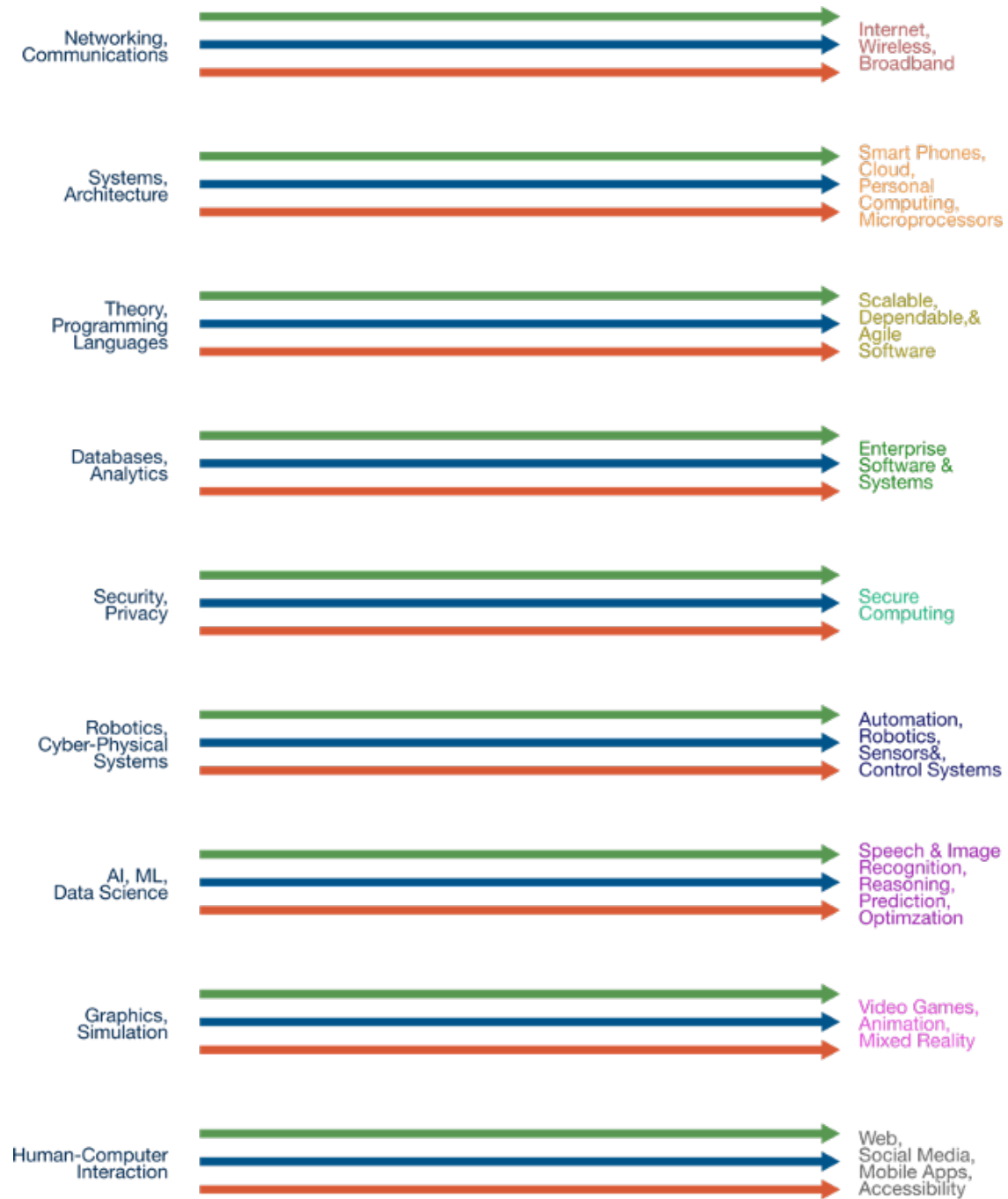


Research:
Planting trees
now,
in order to
have shade in
the future

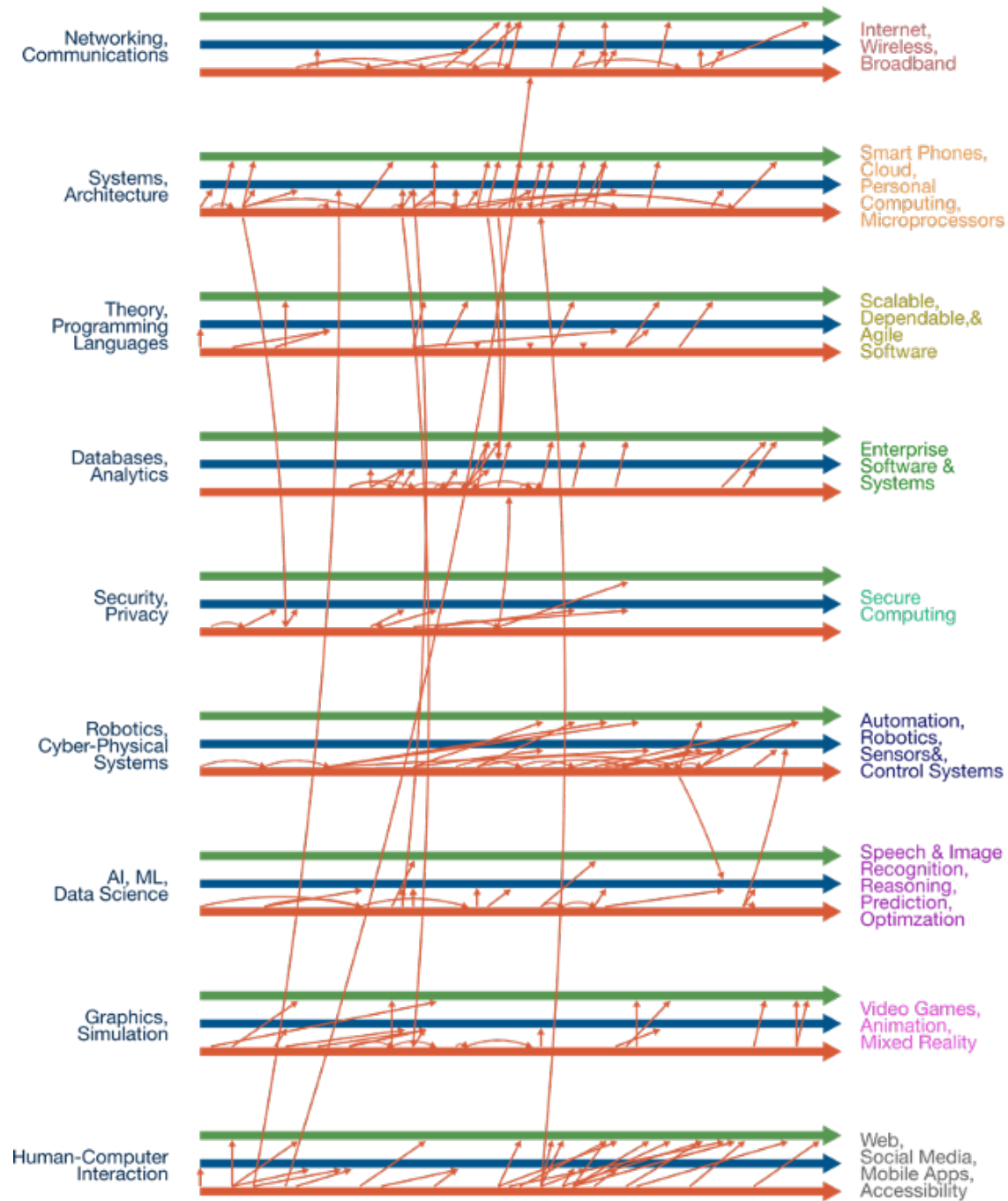
The 2020 "Tire Tracks" Update



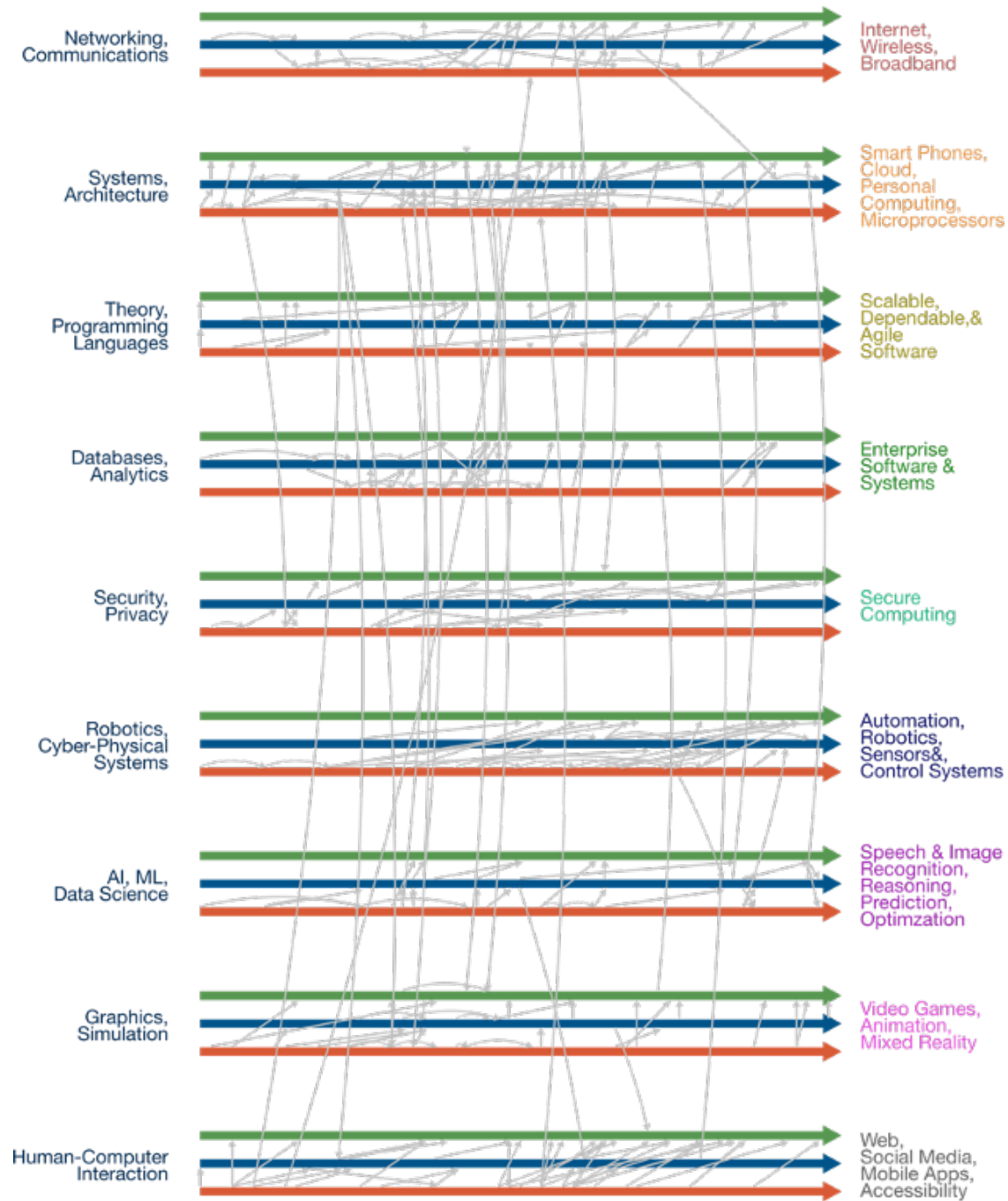
<https://www.nationalacademies.org/our-work/depicting-innovation-in-information-technology>

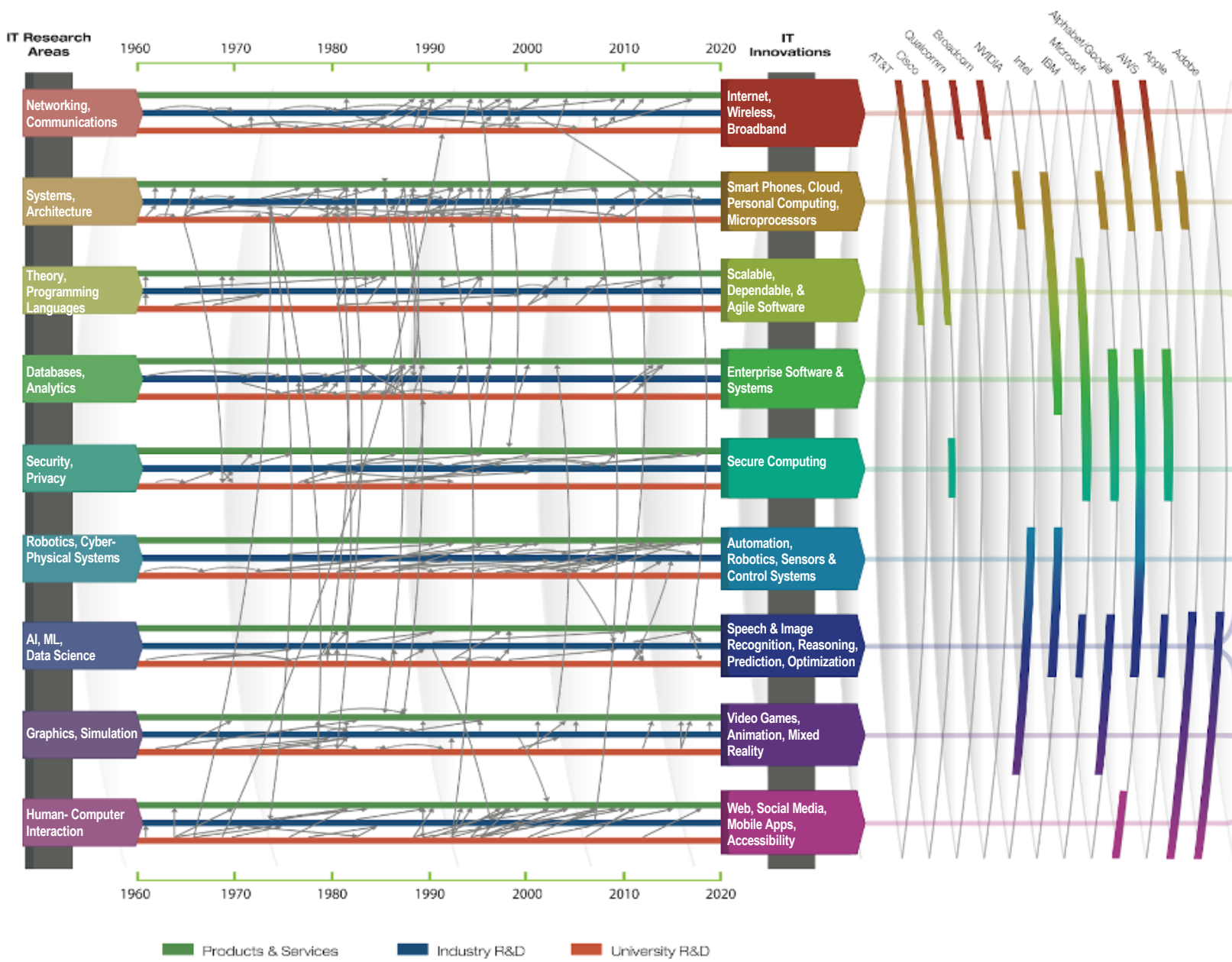


academic research

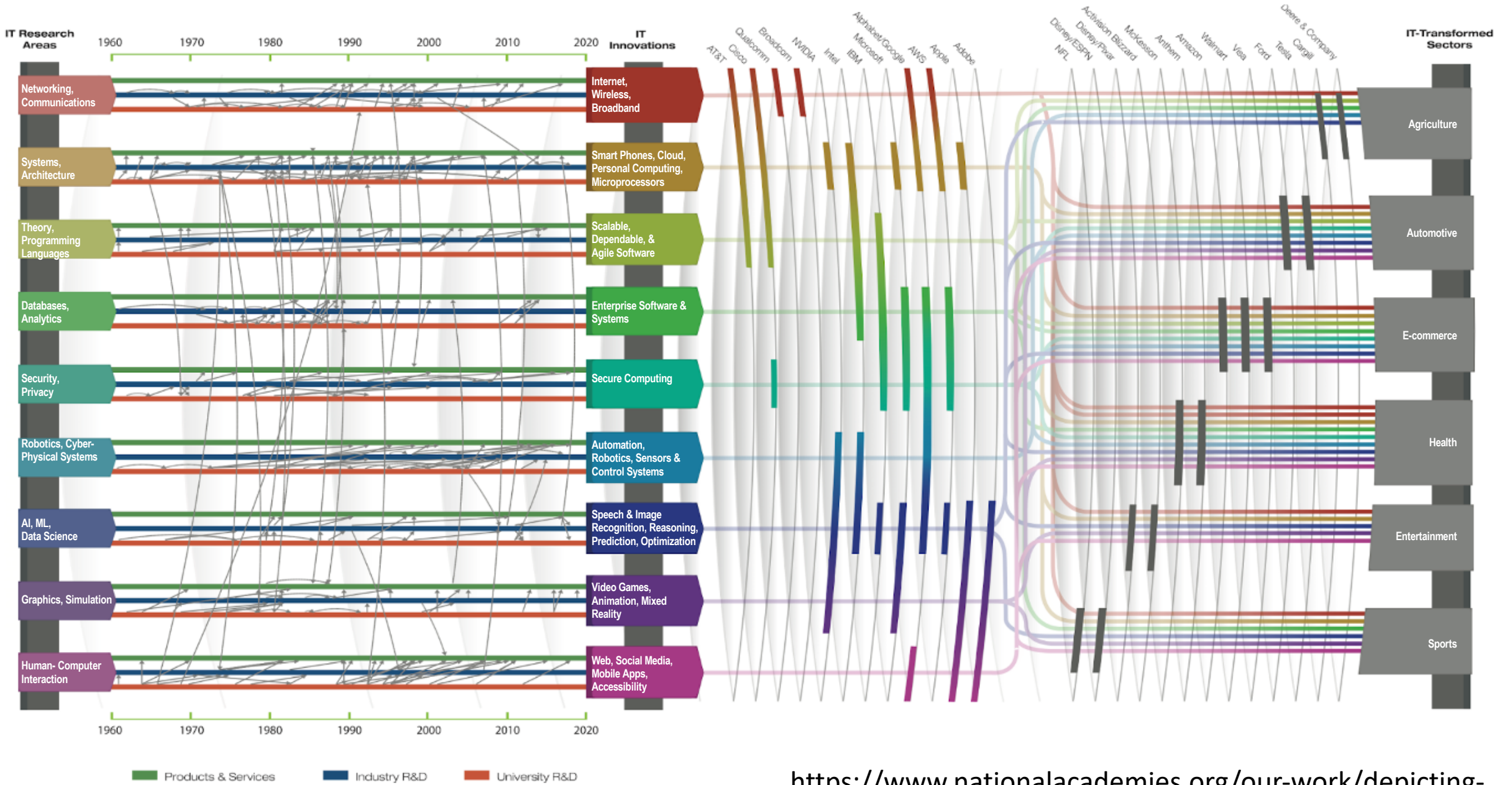


academic research
industry research
products and services





■ Products & Services
 ■ Industry R&D
 ■ University R&D



CISE Organization and “Core” Programs

Office of Advanced Cyberinfrastructure (OAC)

- Data/Software
- Leadership and Advanced Computing
- Networking/Cybersecurity
- Learning and Workforce

Computing & Communication Foundations (CCF)

- Algorithmic Foundations
- Communications and Information Foundations
- Software and Hardware Foundations
- Foundations of Emerging Technologies

CISE Leadership



Margaret Martonosi, Assistant Director



Joydip Kundu, Deputy Assistant Director

- Computer and Network Systems
- Education and Workforce Development

Computer & Network Systems (CNS)

- Human-Centered Computing
- Information Integration and Informatics
- Robust Intelligence

Information & Intelligent Systems (IIS)



Manish Parashar, Office Director



Amy Walton, Acting Deputy Office Director



Gurdip Singh, Division Director



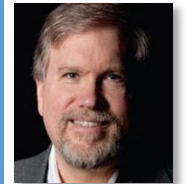
Thyagarajan Nandagopal, Acting Deputy Division Director



Walter Cleveland II, Division Director



Philip Regalia, Acting Deputy Division Director

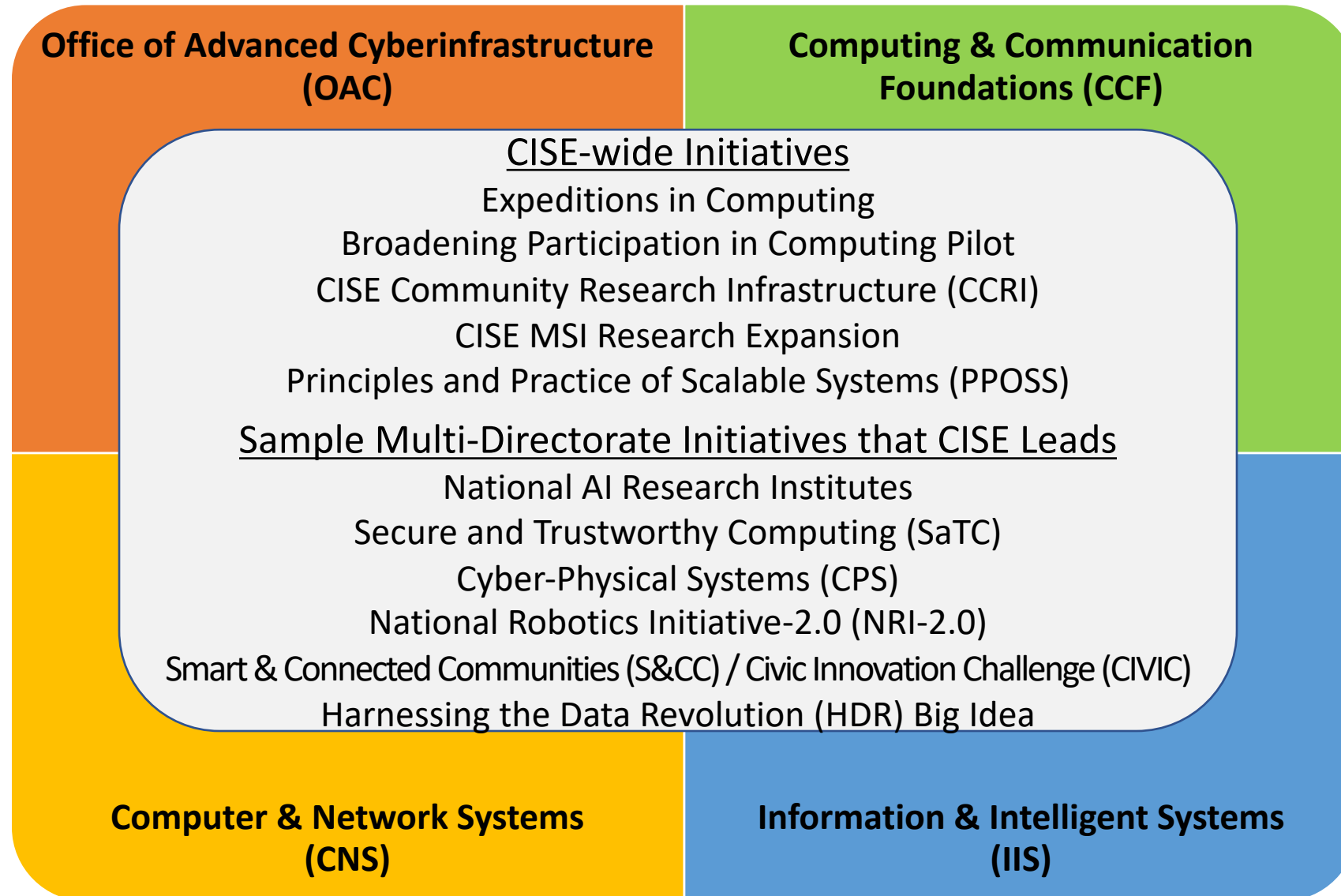


Henry Kautz, Division Director

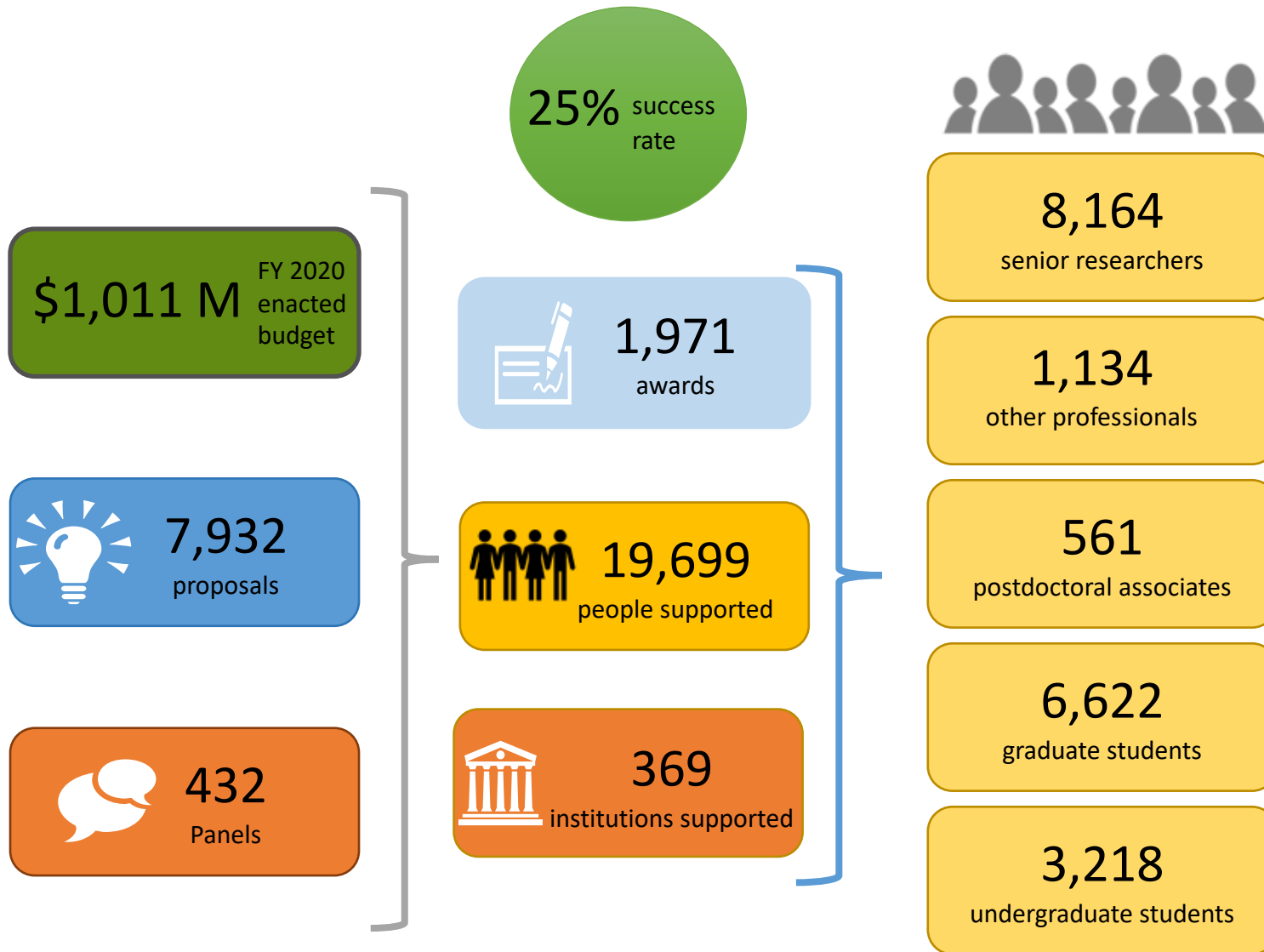


Wendy Nilsen, Acting Deputy Division Director

Major CISE-wide and Multi-Directorate Initiatives



NSF CISE by the numbers, FY 2020



NSF funds **> 85%** of federally-funded academic CS research in the US.
(Source: NCSES)

If you had a billion dollars a year,
what research would you spend it on?

What trees would you plant?

Today...

- Technical Themes
- "How to get there": Programs, Infrastructure, People...
- Q&A

Technical Themes



CISE in a Post-Moore World:
The Seismic Shift



Transcendence of Artificial
Intelligence



CISE's Sociotechnical Frontier

CISE in a Post-Moore World: Seismic Shift...

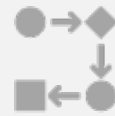
- Principles and Practice of Scalable Systems (PPoSS)
- First Large awards Announced (\$5m / 5 years)
 - ScaleStuds: Foundations for Correctness Checkability and Performance Predictability of Systems at Scale
 - U. Chicago, UC-Davis, U. Michigan, Ohio St.
 - Panorama: Integrated Rack-Scale Acceleration for Computational Pangenomics
 - Cornell, UT-Memphis, U. Washington
 - Principles and Infrastructure of Extreme Scale Edge Learning for Computational Screening and Surveillance for Health Care
 - Stony Brook, Penn St., Rutgers, MIT
 - Unifying Software and Hardware to Achieve Performant and Scalable Frictionless Parallelism in the Heterogeneous Future
 - Northwestern, CMU
- Next Deadline: Jan 24, 2022 for both planning and large grants
 - Intel partnership for machine programming theme



Seismic Shift
→
NSF Programs



Foundations of Emerging Technologies (FET) → New core programs cluster in CCF



Principles & Practice of Scalable Systems (PPOSS)



QCIS Faculty Fellows, Quantum Leap Challenge Institutes (QLCI)



Beyond 5G/Advanced Wireless → PAWR, Resilient and Intelligent NextG Systems (RINGS), Secure 5G and Beyond Act

Tell us what you think!

NSF 21-112

Dear Colleague Letter: CISE RFI on Semiconductor Research and Education

August 6, 2021

Dear Colleagues:

Semiconductor-related research, including underlying supply-chain, business, and economic impacts, are increasingly important to the Nation's long-term competitiveness and security. Through this Request for Information (RFI), the National Science Foundation's (NSF) Directorate for Computer and Information Science and Engineering (CISE) seeks input from those who are directly engaged in, or might potentially benefit from, CISE-related research and education in semiconductor and micro- and nano-electronics.

The computing stack has traditionally been viewed as a hierarchy of layers with devices and circuits comprising the lowest layers, and architectures, software, algorithms, and applications constituting progressively higher layers. Lower layers of the stack (e.g., devices, circuits, architectures) more directly involve semiconductor technologies to the extent that researchers may interact with large-scale fabrication facilities, but all levels of the stack are influenced by microelectronic advances to varying degrees. Thus, although in its entirety CISE research may not directly involve research on semiconductors, per se, the entire computing stack, from circuit design to architectures and on to software and applications such as sensor networks including the Internet of Things (IoT), embedded computing, next-generation wireless systems, large-scale data analytics, artificial intelligence (AI), edge and cloud computing, and high-performance computing, heavily depends on advances in this space.

As a result, much of the CISE directorate's portfolio is dependent upon advances in semiconductor technologies. For one example, tomorrow's AI innovations offer transformative societal impacts, but require advanced hardware capabilities that leverage newer semiconductor technologies. Conversely, the hardware design problem is a large, multi-objective, multiscale optimization problem that stands to benefit from the application of modern AI techniques.

On December 14-20, 2020, CISE funded a workshop focusing on the lowest levels of the computing stack. This workshop considered the scientific frontiers for semiconductor and microelectronics technologies as well as the needs for access to semiconductor foundries. The workshop report is available at: https://nsfedaworkshop.nd.edu/assets/429148/nsf20_foundry_meeting_report.pdf.

- NSF CISE
Semiconductors RFI
- Responses
requested by **Sept
30**
- <https://www.nsf.gov/pubs/2021/nsf21112/nsf21112.jsp?org=NSF>

Technical Themes



CISE in a Post-Moore World: The Seismic Shift



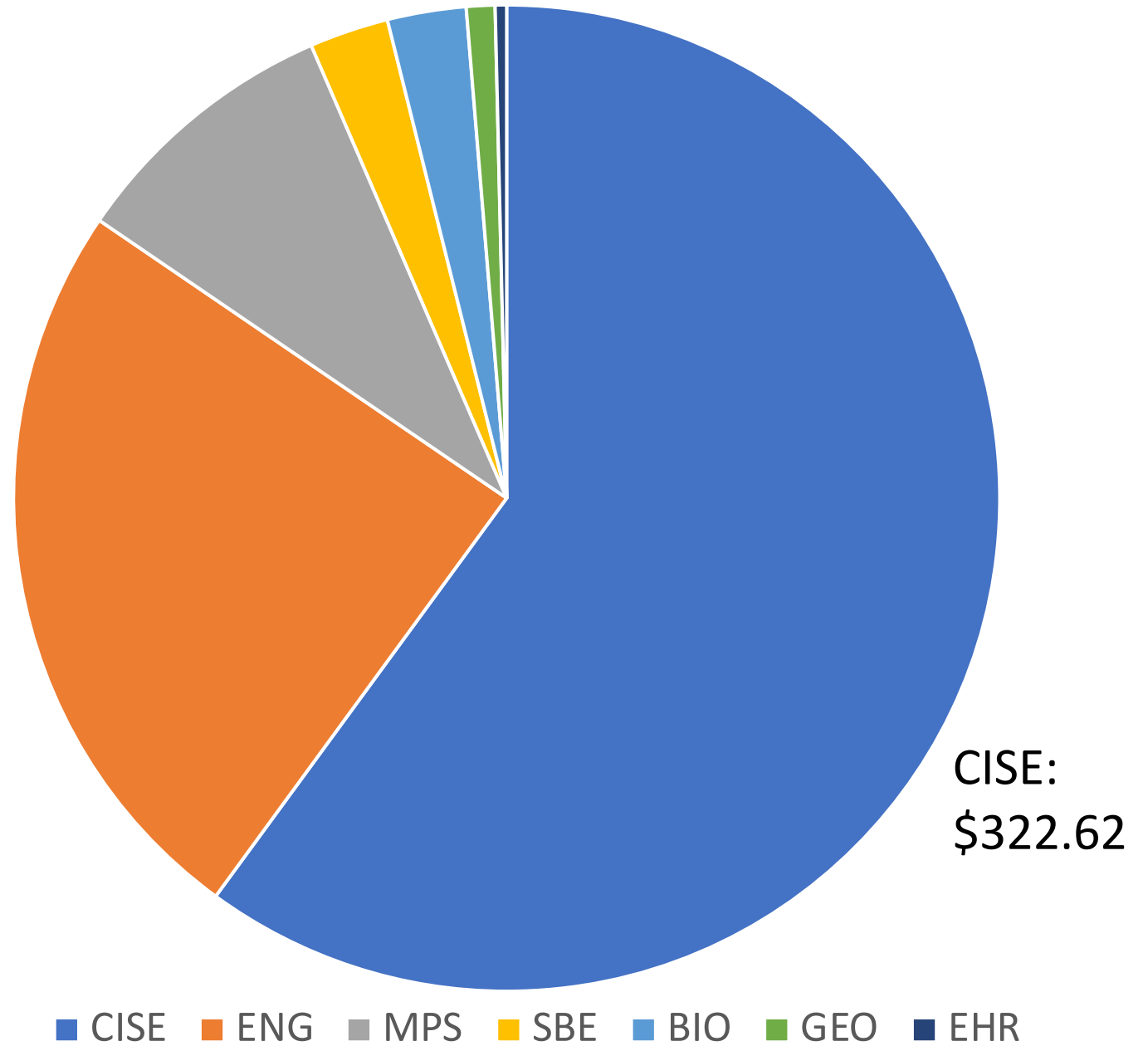
Transcendence of Artificial Intelligence



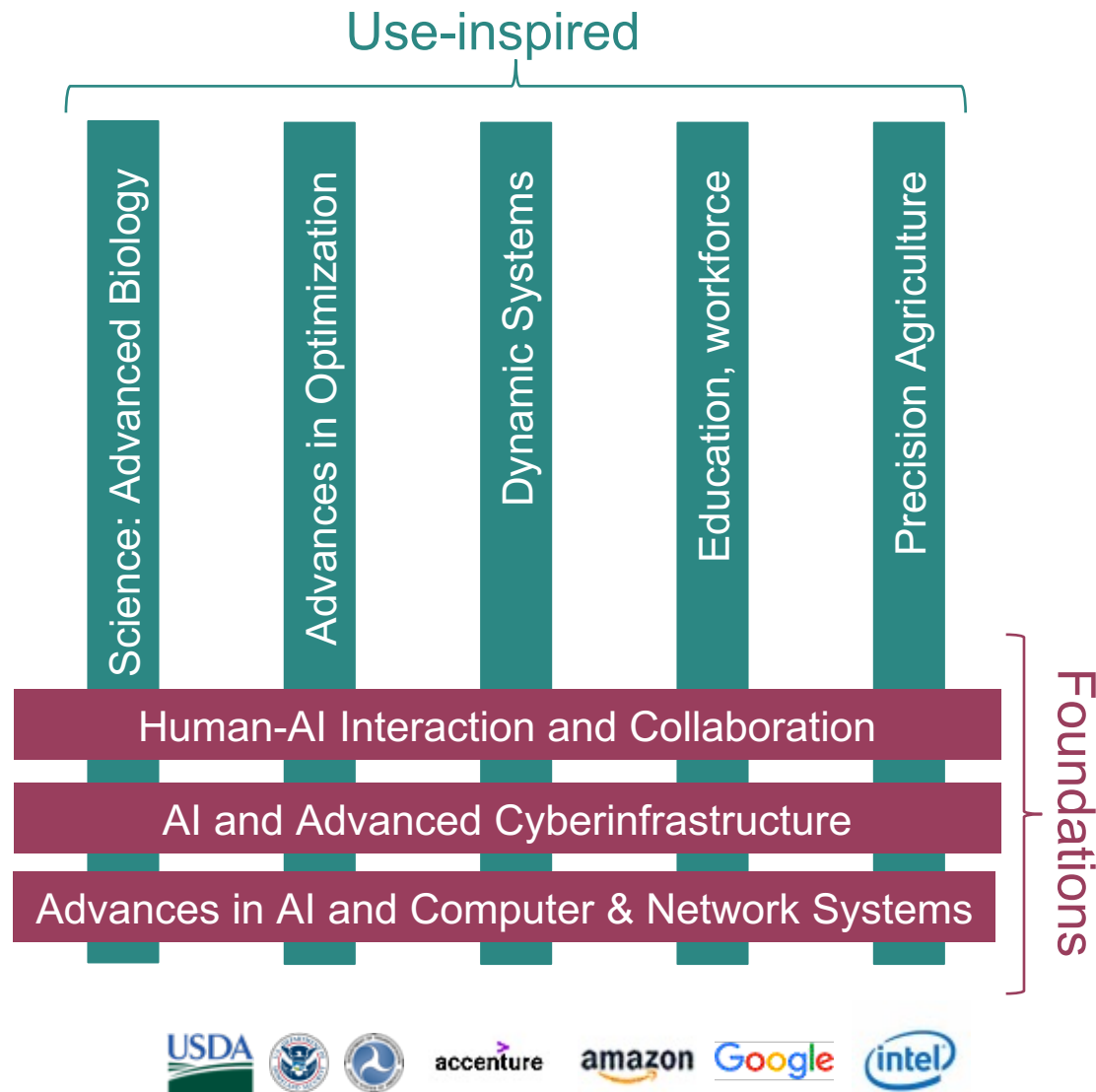
CISE's Sociotechnical Frontier

FY2020 AI Plan

NSF invests
over \$500M
in AI annually



2021 AI Research Institutes



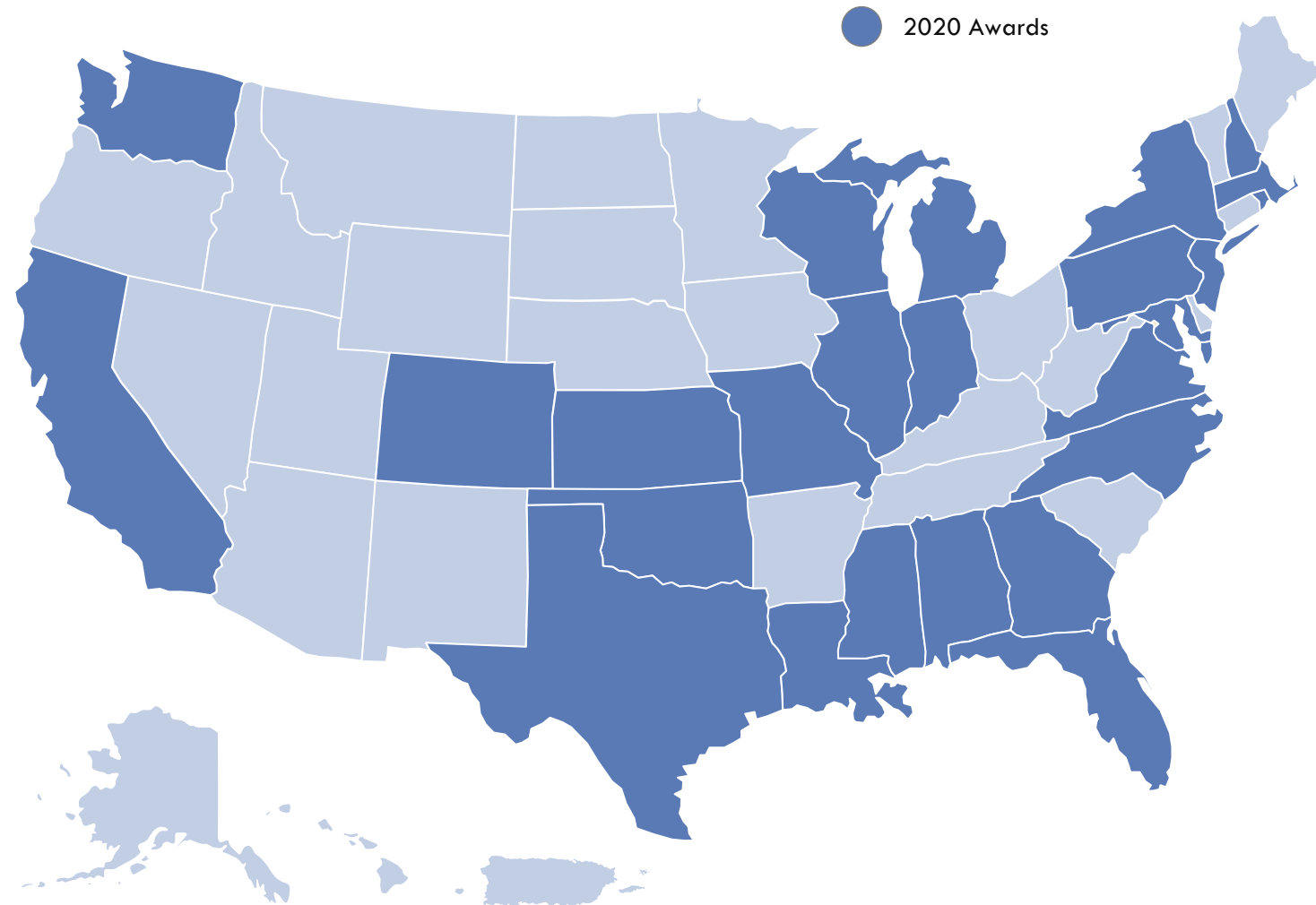
National hubs for universities, government, industry and nonprofits to advance AI research and education

- \$20M over five years per Institute
- First round of awards announced Aug 2020
 - Launched seven AI Institutes nationwide
- Second awards announced July 2021
 - 11 new AI Institutes

AI Research Institutes

2020 AWARDS

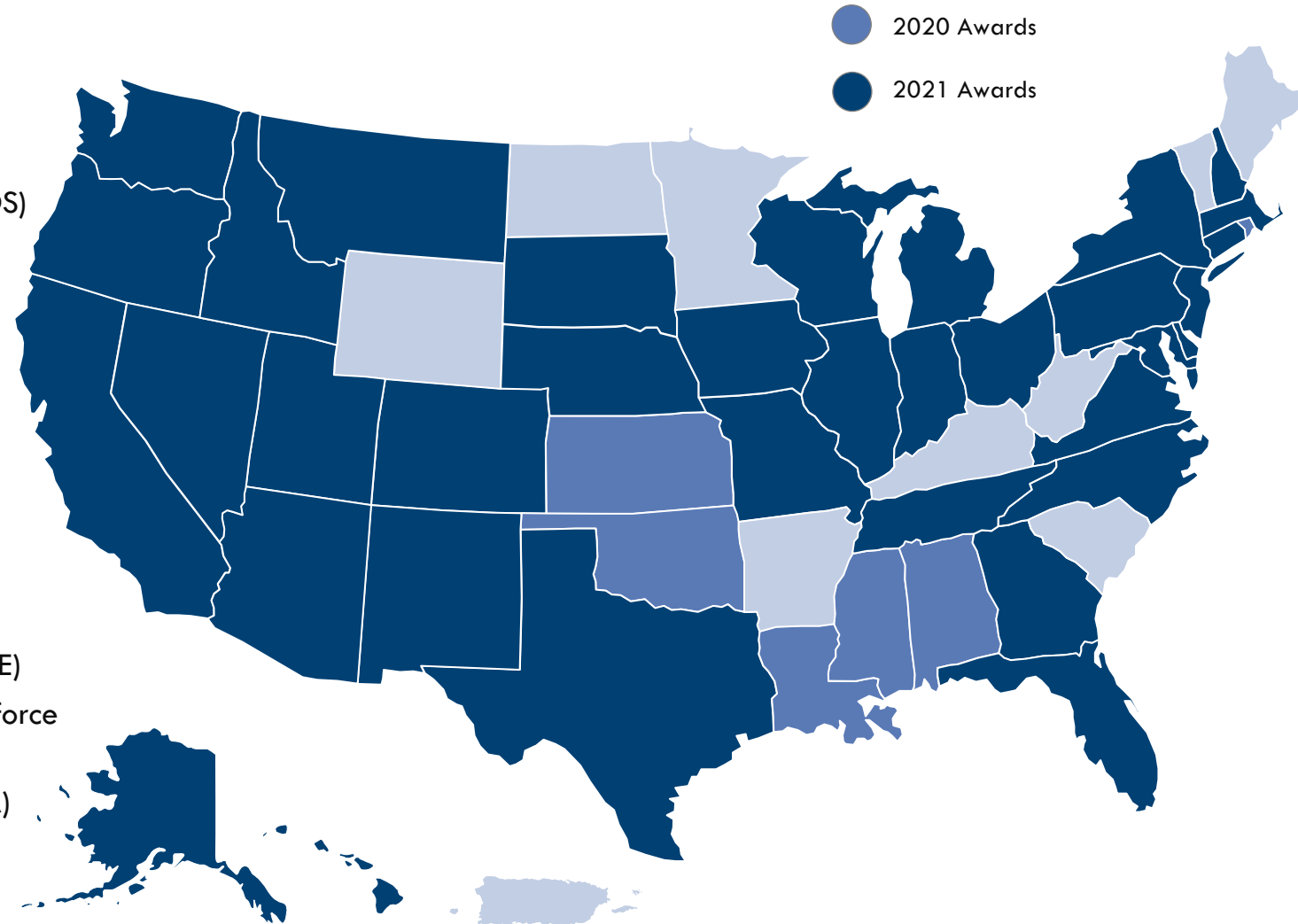
- NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography
- NSF AI Institute for Foundations of Machine Learning
- USDA-NIFA AI Institute for Next Generation Food Systems
- USDA-NIFA AI Institute for Future Agricultural Resilience, Management, and Sustainability (AIFARMS)
- NSF AI Institute for Student-AI Teaming
- Molecule Maker Lab Institute (MMLI): NSF AI Institute for Molecular Discovery, Synthetic, and Manufacturing
- NSF AI Institute for Artificial Intelligence and Fundamental Interactions



AI Research Institutes

2021 AWARDS

- NSF AI Institute for Collaborative Assistance and Responsive Interaction for Networked Groups (CARING)
- NSF AI Institute for Learning-enabled Optimization at Scale (TILOS)
- NSF AI Institute for Optimization
- NSF AI Institute for Intelligent Cyberinfrastructure with Computational Learning in the Environment (ICICLE)
- NSF AI Institute for Future Edge Networks and Distributed Intelligence (AI-EDGE)
- NSF AI Institute for Edge Computing Leveraging Next-generation Networks (Athena)
- NSF AI Institute for Dynamic Systems
- NSF AI Institute for Engaged Learning
- NSF AI Institute for Adult Learning and Online Education (ALOE)
- USDA-NIFA AI Institute: Agricultural AI for Transforming Workforce and Decision Support (AgAID)
- USDA-NIFA AI Institute: AI Institute for Resilient Agriculture (AIIRA)



National AI Research Resource (NAIRR)



- Vision: A shared computing and data infrastructure that would provide AI researchers and students across scientific fields with access to a holistic advanced computing ecosystem. This would include:
 - Secure, high-performance, privacy-preserving computing frameworks;
 - High-quality, representative datasets; and
 - Appropriate educational tools and user support mechanisms.
- Why: Democratize access to the cyberinfrastructure that fuels AI research and development, enabling all of America's diverse AI researchers to participate in exploring innovative ideas for advancing AI, including communities, institutions, and regions that have been traditionally underserved
- The National AI Initiative Act of 2020 (became law on January 1, 2021) establishes the National AI Research Resource (NAIRR) Task Force (TF) to:
 - Explore feasibility/advisability of a NAIRR
 - Develop roadmap & implementation plan

Technical Themes



CISE in a Post-Moore World: The Seismic Shift



Transcendence of Artificial Intelligence



CISE's Sociotechnical Frontier

CISE's Sociotechnical Frontier

- Cyber-Physical and Cyber-Human interactions increasingly shape our society and economy, at all levels and in many forms: Health, connectivity, community, fair access to trustworthy information...
- Reshape computation to “bake in” equity, fairness, security, trust, privacy, ...



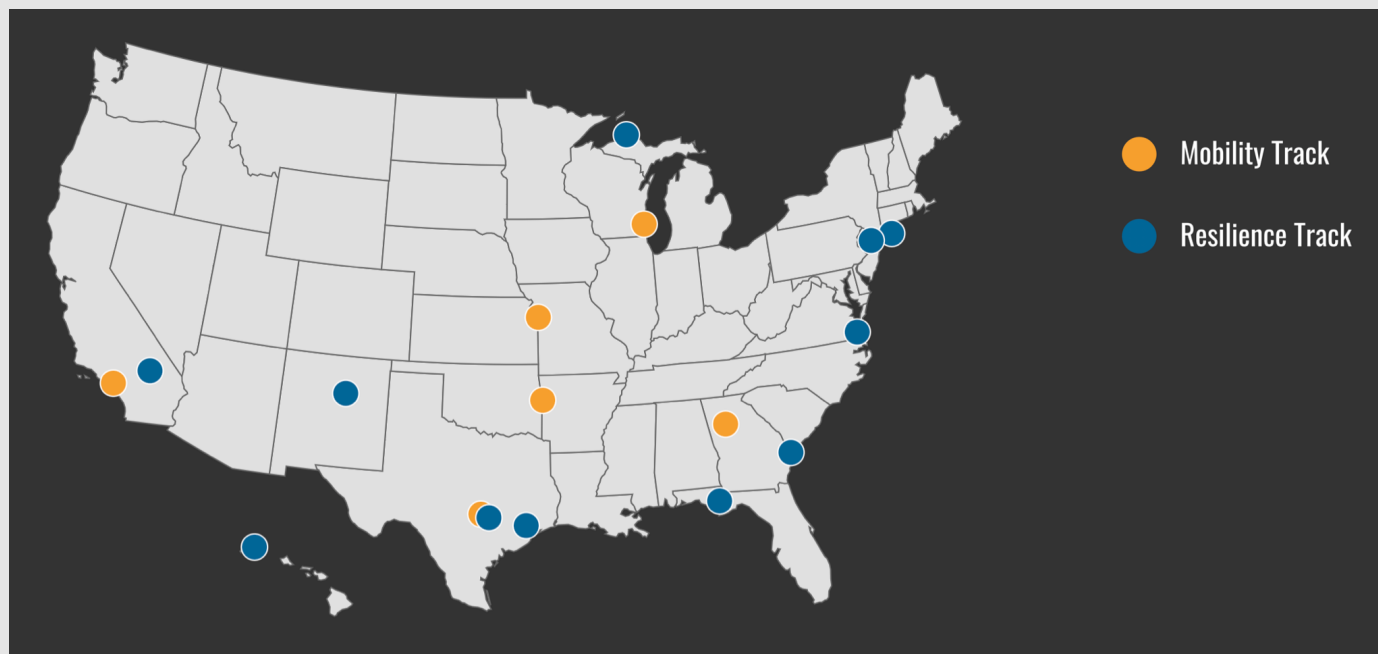
Highlights

- DASS: Designing Accountable Software Systems
CIVIC Innovation Challenge: 400+ proposals -> 52 Stage 1 Awards -> 17 Stage 2 awards
- Project Overcome: Novel Broadband for Virtual Learning
- CISE/SBE workshops look ahead toward future investments
- NASEM Study on Ethics and Governance in Computing Research and Applications

<https://vimeo.com/404649740>

<https://nscivicinnovation.org/stage-1-awardees/>

2021 CIVIC Innovation Challenge Awards



\$15.9 million in awards
to

17 teams

to

conduct and evaluate pilot
projects that address
community-identified
challenges in

12 months

CIVIC Innovation Challenge Awards Tracks

Track A

Funded by NSF and DOE, focuses on communities and mobility, specifically offering better mobility options to solve the spatial mismatch between affordable housing and jobs, as well as access to services like food and childcare.

Track B

Funded by NSF and DHS, focuses on resilience to natural disasters in the context of equipping communities for greater preparedness to and response after disasters such as floods, hurricanes and wildfires.

CIVIC Innovation Challenge

Track A: Mobility

- Connecting Underrepresented Youths with Employment Opportunities. University of Kansas
- Piloting On-Demand Multimodal Transit in Atlanta. Georgia Tech Research Corporation
- Co-Creating a Community Hub for Smart Mobility. The University of Texas at Austin
- User-Centered Mobility Solutions: A New Vision to Connect Jobs and the Labor Force. University of Wisconsin Milwaukee,
- Civic Bicycle Commuting, or CiBiC. UCLA
- Community-based framework on Shared Micromobility for affordable-accessible housing, or SMILIES. University of Arkansas

Track B: Resilience to Natural Hazards

- AI-based Decision Support for Equitable and Resilient Food Distribution during Pandemics and Extreme Weather Events. University of Houston
- Community-Centric Pre-Disaster Mitigation with Unmanned Aerial and Marine Systems. Texas A&M University
- Hoomalu Halelea - Community-led Innovation for Integrated Flood Resilience. University of Hawai'i
- Unification for Underground Resilience Measures. New York University,
- Visualizing Resilience: BIPOC Youth Advocacy through Mapmaking. Georgia Tech
- Helping Rural Counties to Enhance Flooding and Coastal Disaster Resilience and Adaptation. Michigan Technological University
- Low-Cost Efficient Wireless Intelligent Sensors for Greater Preparedness and Resilience to Post-Wildfire Flooding in Native American Communities. University of New Mexico
- Rural Resiliency Hubs: An Integrated, Community-Centered Approach to Addressing the Resiliency Divide through Rural Public Libraries. Florida State University
- CaReDeX: Enabling Disaster Resilience in Aging Communities via a Secure Data Exchange. University of California, Irvine
- Convergence, Inventory, Matching, and Assignment to Optimize Post-event Housing Repair for Displaced Vulnerable Populations. Old Dominion University,
- Inclusive Insurance: Improving the Post-Flood Financial Resiliency of Low- and Moderate-Income Households. University of Pennsylvania

Technical Themes



CISE in a Post-Moore World:
The Seismic Shift



Transcendence of Artificial
Intelligence



CISE's Sociotechnical Frontier

Priorities:
AKA How to
Get There?



Budget and Program Portfolio



Infrastructure



People



Partnerships

Platforms for Advanced Wireless Research (PAWR): Enabling At-scale Experimentation



POWDER

Salt Lake City, UT
Software defined
networks and massive
MIMO



COSMOS

West Harlem, NY
Millimeter wave and
backhaul research



AERPAW

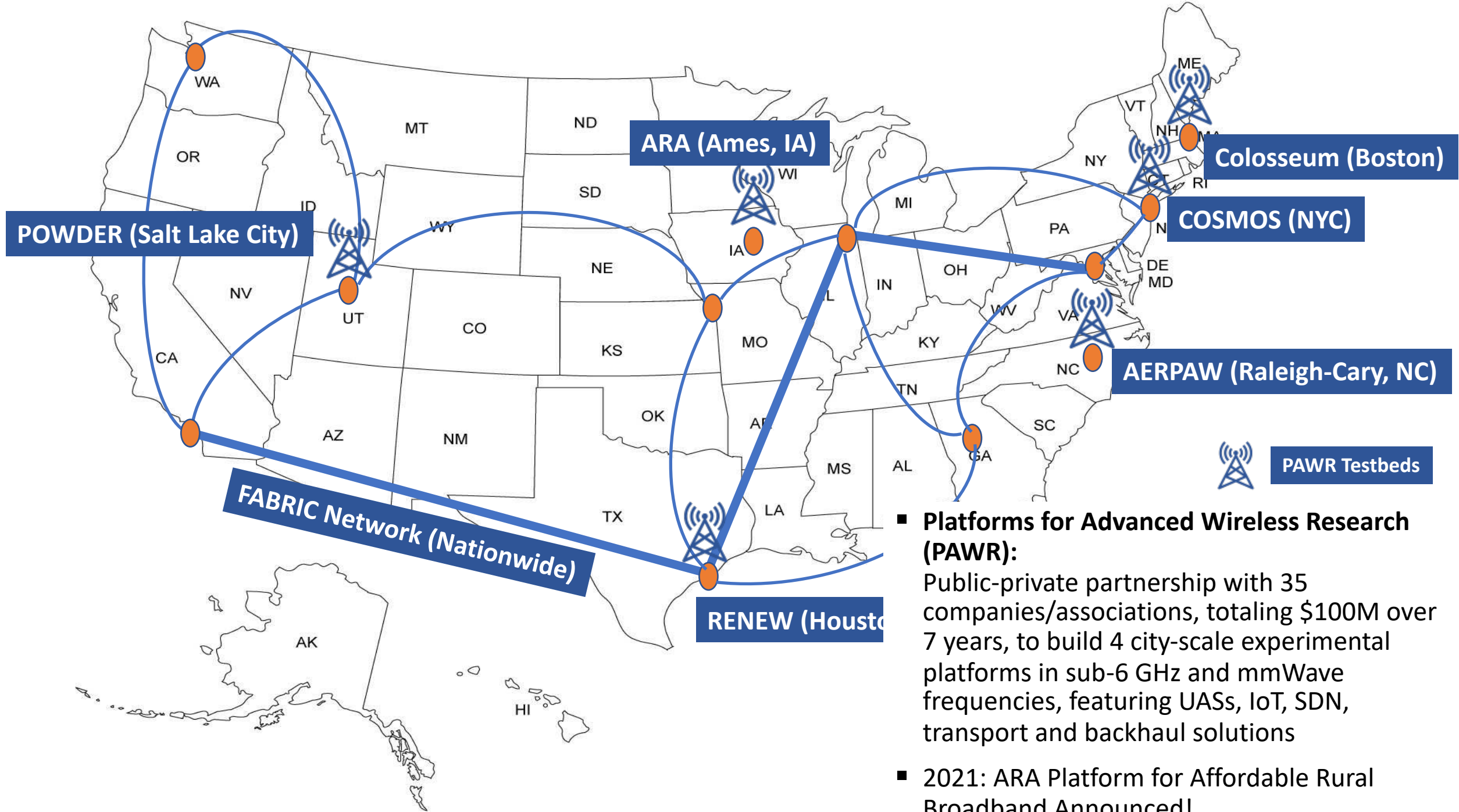
Raleigh, NC
Unmanned aerial
vehicles and mobility



ARA

Ames, IA
Rural broadband

**\$100M public-private partnership with DOD, USDA NIFA, and >35 companies
accelerating beyond-5G wireless research**



- Platforms for Advanced Wireless Research (PAWR):**
 Public-private partnership with 35 companies/associations, totaling \$100M over 7 years, to build 4 city-scale experimental platforms in sub-6 GHz and mmWave frequencies, featuring UASs, IoT, SDN, transport and backhaul solutions
- 2021: ARA Platform for Affordable Rural Broadband Announced!**

RINGS program: Resilient & Intelligent NextG Systems

- \$40M effort in Phase 1
- Augments current investments in networking and computing research
- Resilience-motivated designs
- Diverse partnerships
- Ready-to-use city-scale testbeds
- Awards in early 2022



RINGS Program: Towards Full-Stack, Edge-to-Cloud, Resilient Secure Networks

Resilient NextG Systems			
Applications: Augmented Reality and others that merge physical/virtual	Adaptability	End-to-End Security	Autonomy
Algorithms: Spectrum sharing, Resource optimization and management			
Device-to-Edge-to-Cloud			
Hardware: RF and Mixed Signal Circuits, Antennas and Components			

National Research Resource Building Blocks

Computing

- Leadership-Class: Frontera
- Innovation:
 - Comet, Expanse, Voyager (San Diego)
 - Delta (Urbana-Champaign)
 - Anvil (West Lafayette)
 - Bridges, Bridges 2, Neocortex (Pitt)
 - Jetstream, Jetstream-2 Bloomington
 - Ookami (Stony Brook)
- Services: XSEDE 2 (Urbana-Champaign)

Cloud Access and Testbeds

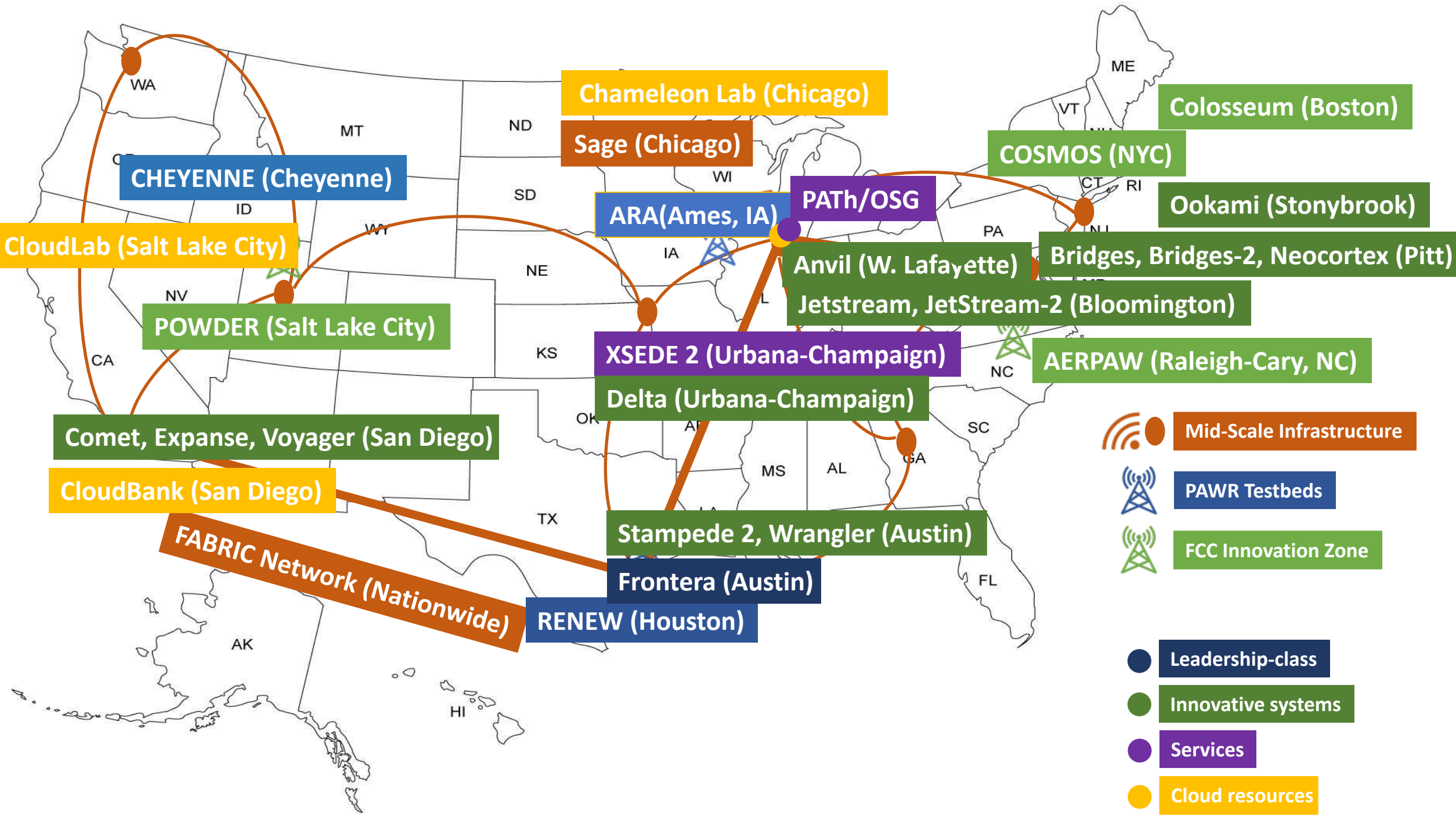
- CloudBank (San Diego)
- CloudLab (Salt Lake)
- Chameleon Lab (Chicago)

Advanced Systems Testbeds

- Fabric Network Infrastructure
- Sage Internet-of-Things PAWR Testbeds
- POWDER (Salt Lake City) (FCC Innov. Zone)
- AERPAW (Raleigh-Cary) (FCC Innov. Zone)
- Colosseum (Boston) (FCC Innov. Zone)
- COSMOS (NYC) (FCC Innov. Zone)
- RENEW (Houston)
- ARA (Ames, Iowa)

Data as a Resource

- Convergence Accelerator: Open Knowledge Networks themes
- BD Hubs: National Network of Big Data Regional Innovation Hubs
- Opportunities for Data Researcher in Residence



CHEYENNE (Cheyenne)

CloudLab (Salt Lake City)

POWDER (Salt Lake City)

Comet, Expanse, Voyager (San Diego)

CloudBank (San Diego)

FABRIC Network (Nationwide)

Chameleon Lab (Chicago)

Sage (Chicago)

ARA (Ames, IA)

PATH/OSG

Anvil (W. Lafayette)

Jetstream, JetStream-2 (Bloomington)

XSEDE 2 (Urbana-Champaign)

Delta (Urbana-Champaign)

Stampede 2, Wrangler (Austin)

Frontera (Austin)

RENEW (Houston)

Colosseum (Boston)

COSMOS (NYC)

Ookami (Stonybrook)

Bridges, Bridges-2, Neocortex (Pitt)

AERPAW (Raleigh-Cary, NC)

Mid-Scale Infrastructure

PAWR Testbeds

FCC Innovation Zone

Leadership-class

Innovative systems

Services

Cloud resources

NSF CISE Searches

- Division Director: DD position provides great decision-making authority over a \$200M+ annual budget
- Deputy Division Director / Deputy Office Director: SES-level position working in coordination with DD or OD to lead unit
- Program Director: Lead award and review processes, envision future programs.

Join Us!

Students

- Research Experiences for Undergraduates (REU)
- CSGrad4US Fellowships
- NSF Graduate Fellowships

Faculty

- Send us your great proposals
- Proposal Writing Workshops
- Tell us your research triumphs
- Be an NSF Panel Reviewer
- Be an NSF Rotator!