The Computing & Information Science & Engineering Landscape: A look forward
Margaret Martonosi
NSF Assistant Director for Computer and Information Science and Engineering (CISE)
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National Science Foundation’s Mission

“To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”
**NSF Champions Research and Education across all Fields of Science and Engineering**

<table>
<thead>
<tr>
<th>Biological Sciences</th>
<th>Engineering</th>
<th>Mathematical &amp; Physical Sciences</th>
<th>Computer &amp; Info Science &amp; Engineering</th>
<th>Geosciences (including Polar Programs)</th>
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<tbody>
<tr>
<td>Integrative Activities</td>
<td>Education &amp; Human Resources</td>
<td>Social, Behavioral &amp; Econ. Sciences</td>
<td>International Science &amp; Engineering</td>
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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

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

Computer & Network Systems (CNS)
- Computer and Network Systems
- Education and Workforce Development

Information & Intelligent Systems (IIS)
- Human-Centered Computing
- Information Integration and Informatics
- Robust Intelligence

CISE directorate
Major CISE-wide and Multi-Directorate Initiatives

Office of Advanced Cyberinfrastructure (OAC)  Computing & Communication Foundations (CCF)

CISE-wide Initiatives
- Expeditions in Computing
- Broadening Participation in Computing Pilot
- CISE Community Research Infrastructure (CCRI)
- CISE MSI Research Expansion

Sample Multi-Directorate Initiatives that CISE Leads
- National AI Research Institutes
- Secure and Trustworthy Computing (SaTC)
- Cyber-Physical Systems (CPS)
- National Robotics Initiative-2.0 (NRI-2.0)
- Smart & Connected Communities (S&CC) / Civic Innovation Challenge (CIVIC)
- Harnessing the Data Revolution (HDR) Big Idea

Computer & Network Systems (CNS)  Information & Intelligent Systems (IIS)

NSF CISE by the numbers, FY 2020

- **$1,011 M** FY 2020 enacted budget
- **7,932** proposals
- **1,971** awards
- **19,699** people supported
- **8,164** senior researchers
- **1,134** other professionals
- **561** postdoctoral associates
- **6,622** graduate students
- **3,218** undergraduate students

25% success rate

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...

- CISE Overview and Technical Themes
- "How to get there": Programs, Infrastructure, People... -> Focusing on People
- Broaden from CISE to NSF as a whole
- Q&A
CISE: Inflection Points -> Technical Themes

CISE in a Post-Moore World: The Seismic Shift

End of Moore/Dennard Scaling impacts all aspects of computing: Hardware, Software, Security, Reliability, Curriculum... Opportunity to reinvent!

Transcendence of Artificial Intelligence

AI today draws from all-of-CISE inflection Point: Algorithms, data, systems. Likewise, AI broadly fuels advances across our field and society.

CISE’s Sociotechnical Frontier

More so than ever, our field is shaped by integrated perspectives on our technologies and on how humans use them and are shaped by them.
NSF invests over $500M in AI annually

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. 26, 2020
  - Launched seven new Institutes nationwide ($140 million)
2020 AI Research Institutes

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    - Launched seven new Institutes nationwide ($140 million)
  - FY 2021 solicitation (NSF 20-604). Deadline Dec 4!
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...
- Responsibility Meets Opportunity
  - Reshape computation to “bake in” notions of equity, fairness, security, trust, verifiability, privacy, ...
- Example: 2020 Economics Nobel (Milgrom/Wilson) reflects long track record of SBE AND CISE funding

### Highlights

- CIVIC Innovation Challenge
- Project Overcome
- CISE/SBE workshops look ahead toward future investments
- NASEM Study Launched: Responsible Computing Research: Ethics and Governance in our Research and its Applications
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

2020-2021: Rural Broadband Platform Bakeoff

Technical Themes

- CISE in a Post-Moore World: The Seismic Shift
- Transcendence of Artificial Intelligence
- CISE’s Sociotechnical Frontier
How to advance on those themes?
How to get there?

Budget and Program Portfolio
Infrastructure
People
Partnerships

CISE and BPC

- Women: 20.3% of US CS PhD graduates
- African-Americans, Hispanics, Native Americans: 3.1% of US CS PhD graduates

=> CS research is missing ~70% of US population’s talents.

Why now?
CS BS Degrees
(Just one example)

More Broadly Across STEM

Legend
- 100,000 people in 2020 S&E workforce
- 100,000 additional people needed in 2030 for the S&E workforce to be representative of the U.S. population
More Broadly Across STEM

Legend

- x 100,000 people in 2030 in the S&E workforce representative of the U.S. population

THE CHRONICLE OF HIGHER EDUCATION

Diversity Without Dollars
You think you can’t afford to transform your faculty? The University of Houston begs to differ.
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42% increase in tenure/tenure-track faculty of color between 2014 and 2019

$3.3M NSF Advance Award, plus local action and engagement

Pathways to Opportunity

NSF + Community working together
K-12: AP CS Principles Exam

• 2012: CISE funded The College Board to create framework for new exam
  • No specific programming language and stresses principles rather than programming
• 2012-present: CISE funded curricular efforts such as UC Berkeley “Beauty and Joy of Computing”
• 2017: New Exam Launched
• 2017-present: Significant increases in number and diversity of test takers

Dramatic Increase in Number, Diversity of Test Takers

<table>
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<th>Female students</th>
<th>Underrepresented students</th>
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<td>38,200</td>
<td>29,000</td>
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Includes both AP CS-A and AP CSP
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CSP students are more than three times as likely to major in computer science than similar students who did not take CSP (16.9% vs. 5.2%), and differences are even larger for female and Hispanic students.

https://www.washingtonpost.com/education/2020/12/13/advanced-placement-computer-science/


Pathways to Opportunity

NSF + Community working together
Vision: Broadening Participation in Computing

- Goal: Measurable progress towards diversifying the CISE Research Community
- Goal: CISE research proposals include a meaningful plan to broaden participation in computing
- **Approach:** Individual PIs offer BPC plans for Medium (and larger) proposals in Core, CPS, SaTC
  - Currently in Year 3 of 3-year BPC Pilot
- Key Concept: Individual PIs plug into departmental and national plans and expertise
- Increase collaboration, coordinate efforts, broaden expertise
BPCnet provides resources for CISE PIs

- [https://bpcnet.org](https://bpcnet.org)
- Developed and curated by CRA, NCWIT
- Best and promising practices: Evidence-based and vetted resources
  - Not just *What* but *How*
- Departmental and Individual BPC Plan Workshops
  - July - October, 2020
  - + Ongoing 1-1 Consulting Office Hours
  - Vetting, Hosting Departmental Plans in a Single Library

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Pathways to Opportunity

NSF + Community working together
NSF CISE MSI Convenings: 2019-2020

• Goal: CISE BPC Efforts should be inclusive of Minority-Serving Institutions
• To increase MSI attendee awareness about CISE Core Programs, as well as proposal submissions & CISE engagement
• Take steps to enhance engagement of HBCUs, HSIs and Tribal/Native Serving Institutions in NSF CISE Core programs

4 Initial convenings/hosts:
• HBCUs: May 2019, Hampton Univ.
• HSIs: July 2019, NSF CASHI
• TCUs: Sept 2019, American Indian Science and Engineering Society (Native/Tribal Colleges)
• Broad MSI Community: Feb. 2020

MSI Convenings -> Next Steps

• Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program (CISE-MSI Program)
  • Deadline: April 15, 2021
• Faculty: Capacity Building and Proposal-writing workshops ("Mini-Labs")
• Infrastructure: Collaborative Multi-MSI opportunities
• Undergrad Students: Enhanced undergraduate research opportunities
  • Fellowships to encourage transition to grad programs

https://msi-cise.asee.org/

Division of Materials Research (DMR)  
Partnership for Research and Education in Materials (PREM)

- To broaden participation in materials research and promote the retention of URMs in STEM fields.
- Award to a Minority Serving Institution (HBCU, HSI, TCU, etc) to partner with a DMR-supported Center or National Facility.

- Since 2004, 38 awards training to date
  - 123 postdocs
  - 498 MS and PhD students
  - 991 BS students
  - 80% of whom pursued careers/higher education in STEM after graduation

University of Puerto Rico, Humacao and UPenn

Sabrina Rosa (PREM 2010)  
BS Physics, UPRH 2016  
PhD Candidate, EE, USF

Adriana Santiago (PREM 2011)  
BS Chemistry, UPRC 2018  
Grad Student Bio Chem, PENN

- Partnership with a local high school allows students to begin their materials research careers as early as high school
- 33% of current PREM UGs began their materials research careers while in High School
- UPRH has become a Top 20 Institution for producing Hispanic women doctorates in physics (NCSES data)

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- Recent Events: Impacts and Responses
- Q&A

CISE COVID-19 Impact & Response

The COVID-19 High Performance Computing Consortium

Addressing the need for advanced computing for COVID-19 research

NSF-funded resources: Frontera, XSEDE, and more

Connected cities with municipal broadband programs by state

OVERCOME – deploy novel broadband technology solutions to underserved communities, supporting virtual learning

Virtual Organization for Computing Research in Pandemic Preparedness and Resilience

Coordination across COVID-19 RAPIDs and related research

Fellowships for graduating doctorate students impacted by hiring reductions at IHEs

CISE REU Expansion: 1.7X REU Supplements compared to FY19

Community Building Activities include:
- Semi-annual events (virtual conferences, workshops, etc.), and meetings
- Final Meeting in Year 3 of collaborators from academia, government and industry
Join Us!

**Students**
- Research Experiences for Undergraduates (REU)
- 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!