National Nanotechnology Coordinated Infrastructure

The National Nanotechnology Coordinated Infrastructure:

Critical nanotechnology facilities for emerging NSF and US research priorities

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Outline

- NSF Funding History of Nano User Facilities
- NNCI Award Sites and Impact
- Emerging NSF and US Research Priorities
- Quantum Leap
- ENG Interdisciplinary Research Opportunities
- Mid-Scale Research Infrastructure
- National Academies Quadrennial Review of NNI
- NNI Signature Initiatives

NSF Funding History of Nano User Facilities

Initial Award - Single Site >	1977	Cornell	$1M	ENG/ECS	National Research & Resource Facility of Submicron Structures (NRRFSS)
Renew - Single Site >	1987	Cornell	$2M	ENG/ECS	National Nanofabrication Facility (NNF)
Compete - Network >	1993				
	1994	NNUN	$3.55M	ENG, MPS, BIO	National Nanofabrication Users Network (NNUN)
	1999	NNUN Renew	$4.4-6.2M	ENG, MPS, BIO, CISE	
Recompete - Network >	2003		<< National Nanotechnology Initiative (NNI) established 2003		
	2004	NNIN	$14M	ENG, MPS, BIO, CISE, GEO SBE, EHR + OISE	National Nanotechnology Infrastructure Network (NNIN)
	2009	NNIN Renew	$17M	All Directorates + OISE	
[NG NNIN cancelled] >	2013				
Compete - Individual Sites >	2014	NNIN Bridge	$16M	All Directorates + OISE	
	2015	NNCI	$16M	All Directorates + OISE	National Nanotechnology Coordinated Infrastructure (NNCI)
	2020	NNCI Renew	$17M	All Directorates + OISE	
	2024				

Celebration of CNF at 30th Anniversary June 14, 2007

- Symposium on The Future of Nanotechnology

  Opening Presentation: *"Reflecting on 30 Years of NSF Investment in Cornell's National User Facility Leading to the National Nanotechnology Infrastructure Network"*

- Science Friday Podcast recording on the occasion of the 2007 Cornell CNF 30th anniversary symposium

  NanotechCornell2007scifri-2007061523.mp3

  Participants were Larry Goldberg, John Silcox, Barbara Baird, and Roslyn Burns

National Nanotechnology Coordinated Infrastructure (www.NNCI.net)

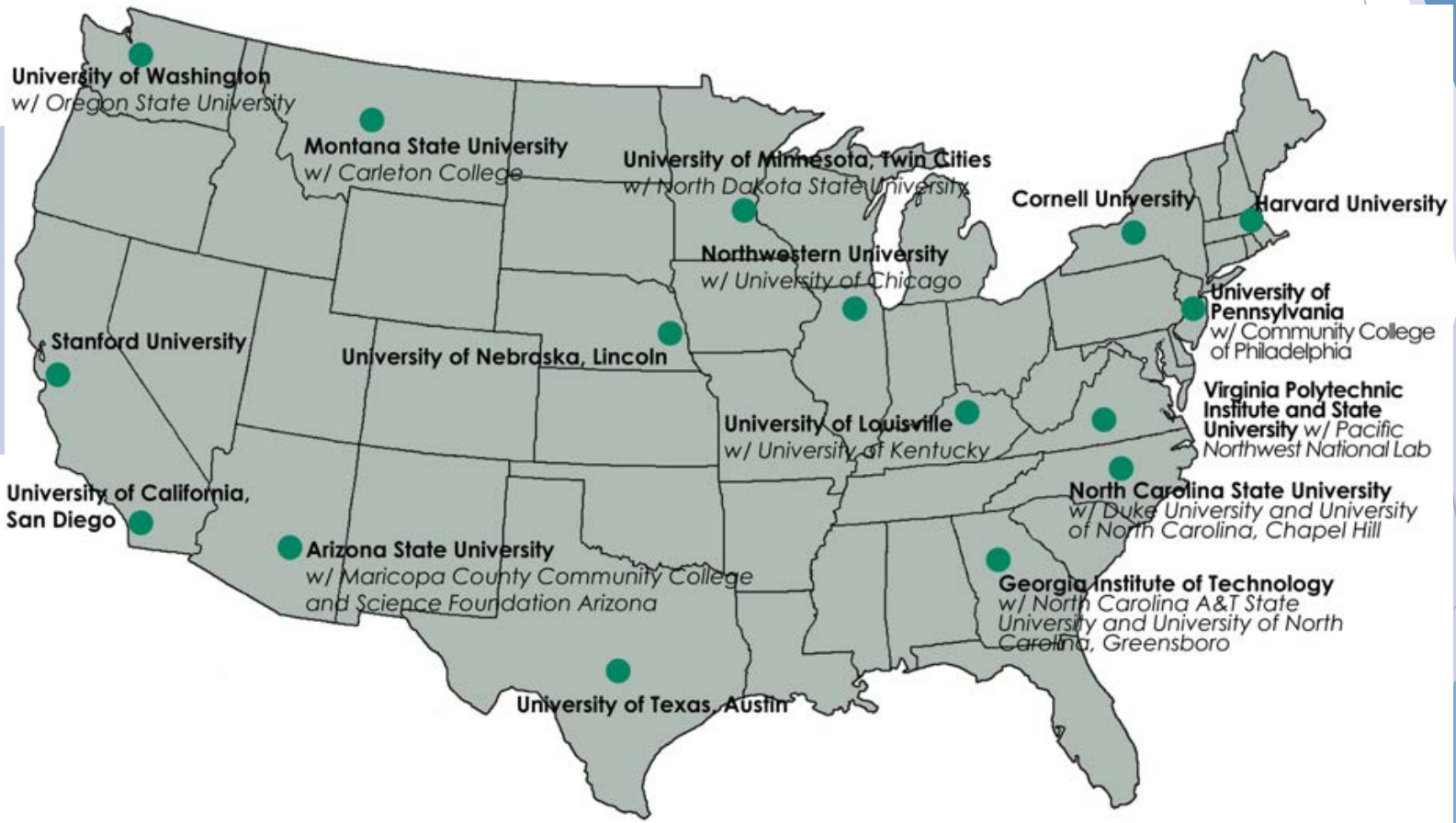
National Nanotechnology Coordinated Infrastructure

16 Sites, Coordinating Office at Georgia Tech site

NSF Award $81M
FY 2015-2019

Renewal $84M
FY 2020-2024

16 NNCI Sites
11 Partners
67 Facilities
>2000 Tools



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NNCI Impact

National Nanotechnology Coordinated Infrastructure

- Provides open access to **state-of-the-art nano-fabrication & characterization facilities, tools, and staff expertise** across the US
- **Catalyzes new discoveries** in diverse fields and **stimulates technological innovation**
- Supports a rich user base with **broad accessibility** and **affordable user fee** structure
- **NSF funding leverages university and other resources** to grow the numbers of external users, with **emphasis on small companies, startups, and academia**
- Supports **education & outreach (E&O)** and **societal & ethical implications (SEI)** of **nanotechnology**

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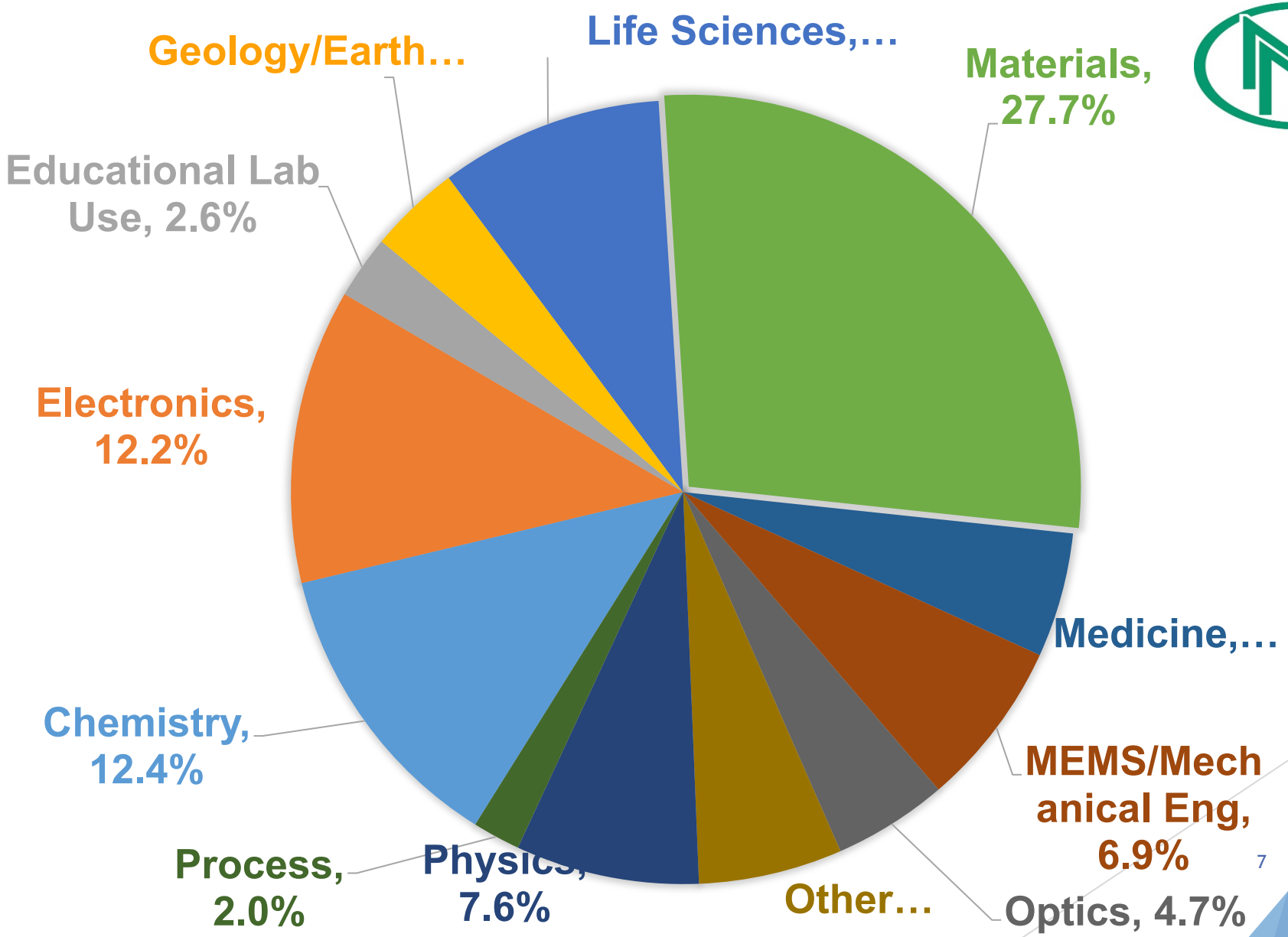
NNCI Users come from all Areas of Science and Engineering



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NNCI Research Funding Sources

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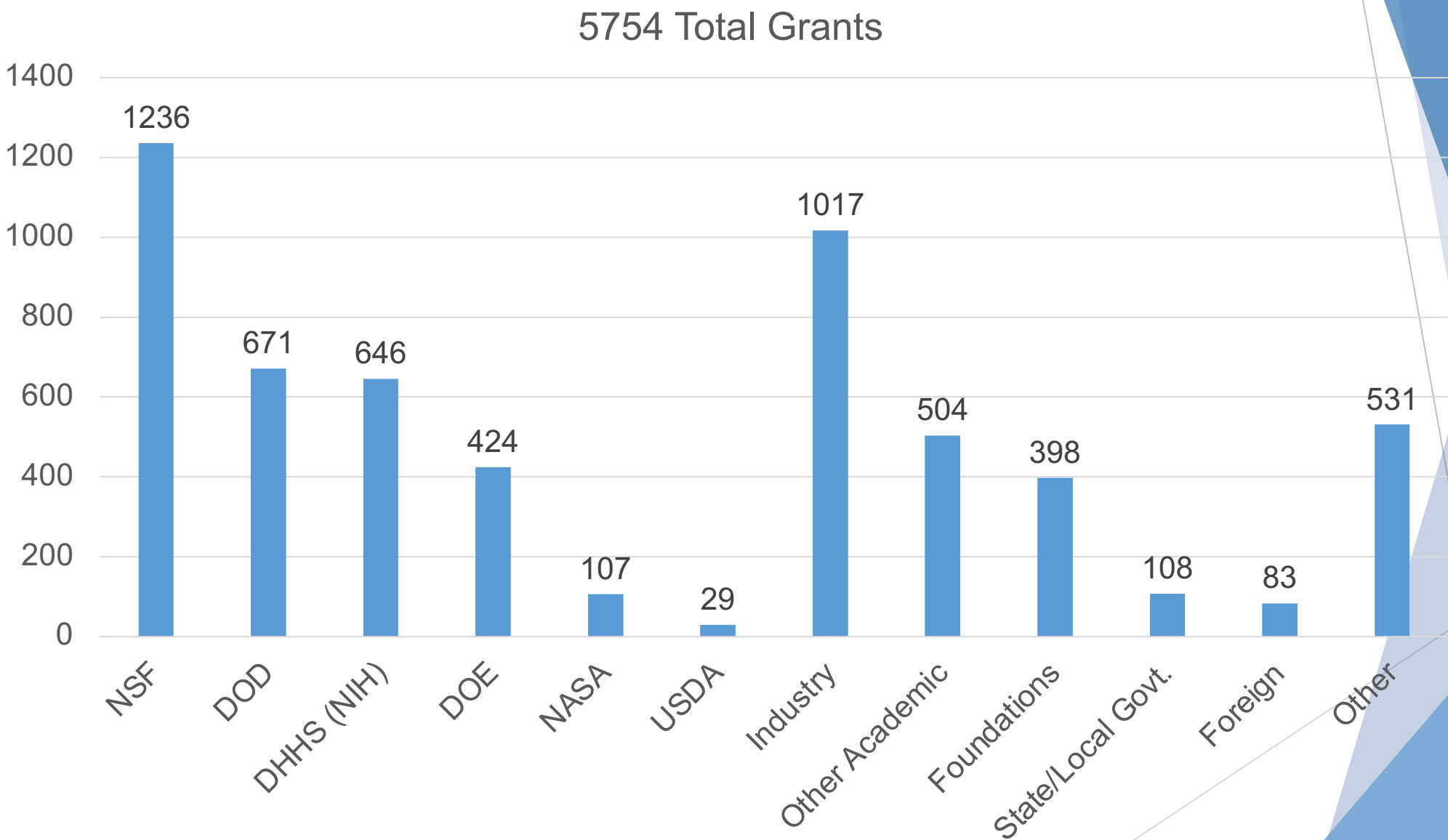

NNCI Impacts NSF Big Ideas

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NNCI sites advance:

- Quantum scale devices and systems based on novel materials design, processing, and analysis – *Quantum Leap*
- High-resolution imaging capabilities – *Windows on the Universe*
- Soft and hybrid materials, in synthesis, functionalization, fabrication and characterization, for solution-processed nanostructures and DNA-assembled complex architectures – *Understanding the Rules of Life*
- Distributed sensing technologies, integrating electronic and photonic functionality at the nanoscale, with embedded communication & networking capabilities – *Navigating the New Arctic*
- Combining micro & nano fabrication processes with advanced 3D printing & additive manufacturing – *Human Technology Frontier*

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Industries of the Future (IotF)

Advanced Manufacturing: Fundamental research in semiconductor design, fabrication and manufacturing to increase competitiveness

Quantum Information Science: Design and fabrication of quantum devices, at scale, for quantum networking and quantum computing

Artificial Intelligence: Highly parallel chip designs to process large datasets for machine learning and AI systems

Advanced Wireless: Low-power processing chips for remote and mobile IoT applications, e.g., “edge” computing and AI at every node

Biotechnology: Biomimetic, integrated and/or smart sensors and decision making; interfaces between the body and artificial materials

Convergence of IotF: Cybermanufacturing, smart systems for agriculture, technologies for aging, energy systems, workforce development, …

NNCI Quantum Leap Research Community (QLRC)

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Lead NNCI Sites in Quantum

- MiNIC - Steve Koester
- SHyNE – Andrew Cleland
- CNS - Bob Westervelt

Other NNCI sites involved in Quantum

- Stanford, CNF, NNI, RTNN, SENIC

AccelNet Global Quantum Leap NSF award

- MiNIC, SHyNE, CNF, GaTech

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NSF Quantum Engineering Group

NSF ENG plans to **organize a workshop series** to **connect** the **NNCI quantum research community (QLRC)** with the **NSF QuantumLeap/QISE awardees.** The intent is to:

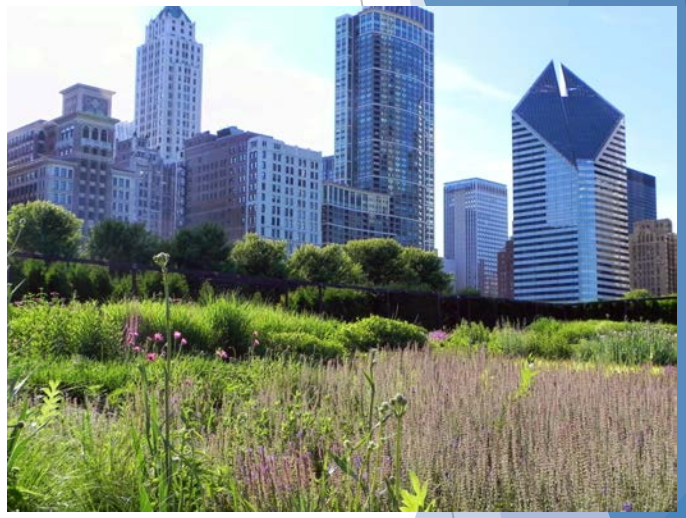
- **Introduce QISE PIs to the NNCI user facility sites'** current instrumentation that they can take advantage of to advance their research.
- **Bring the QISE community infrastructure needs to the NNCI site awardees** to help guide their plans for future instrumentation expansions.
- The **workshop output** would include both a quantum engineering infrastructure assessment and roadmap

ENG Interdisciplinary Research Opportunities

Support integrated, interdisciplinary teams:

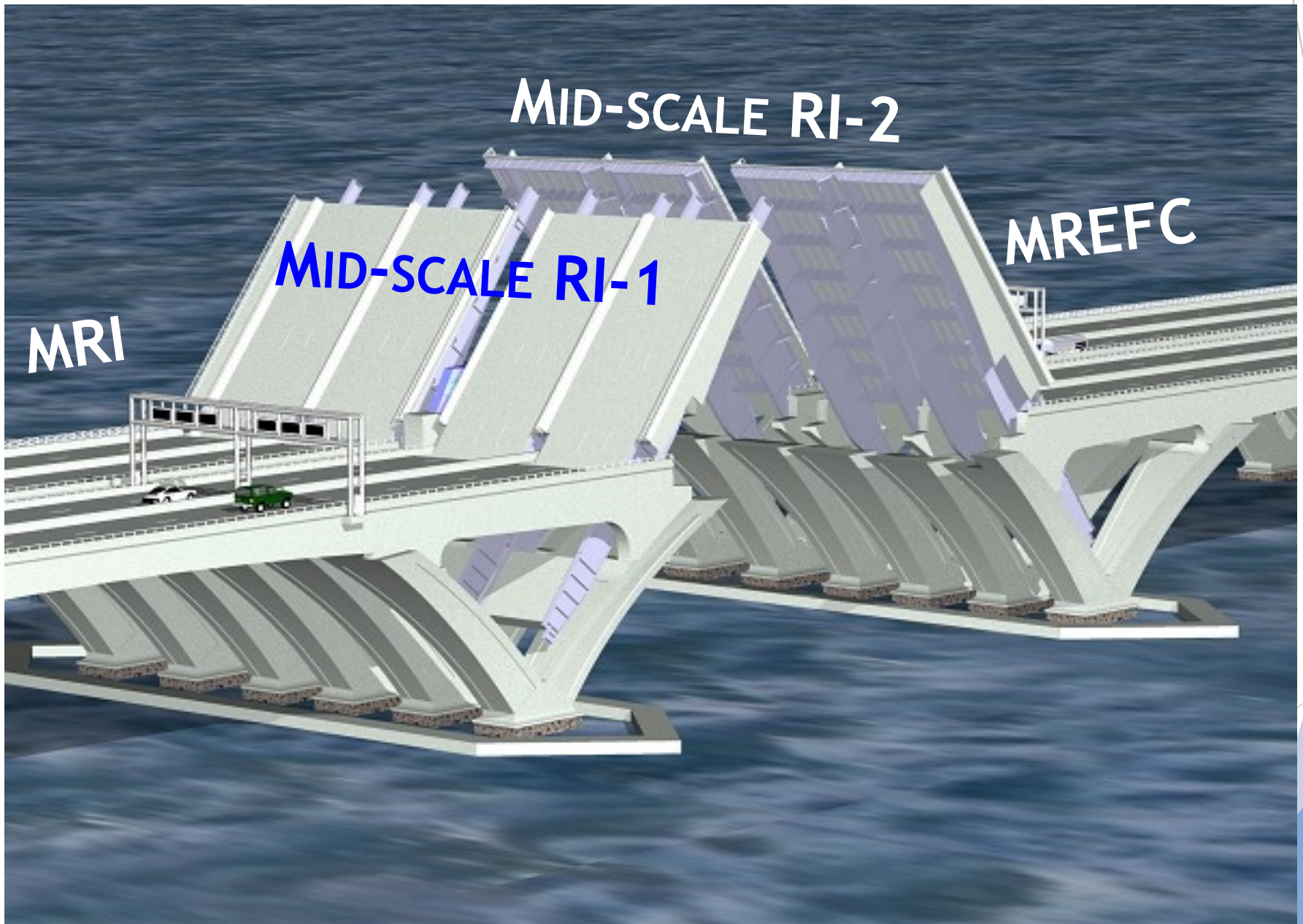
to study **fundamental engineering research** problems with **compelling intellectual challenges** and **significant societal impact**

- Addressing Systems Challenges through Engineering Teams **(ASCENT-ECCS)**
- Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems **(ECO-CBET)**
- Leading Engineering for America's Prosperity, Health, and Infrastructure **(LEAP HI-CMMI)**



Resilient urban infrastructure that integrates the natural and built environments

NSF Mid-Scale Research Infrastructure



NSF Mid-Scale Research Infrastructure Program

- **Mid-Scale** is an agile program for funding important research projects and facilities that could not be funded by prior NSF programs
  - Major Research Instrumentation (**MRI**) projects are limited to less than $6M (with cost sharing)
  - Major Research Equipment and Facilities Construction (**MREFC**) have a minimum of $70M
- This gap results in missed opportunities that leave essential research undone
- **New solicitation coming in FY2021** for Mid-Scale RI-1 ($6M – $20M)

Types of Mid-Scale Research Infrastructure Projects

- Infrastructure that **supports high-priority research**
- **Cyberinfrastructure** that addresses community and national-scale computational and data-intensive science and engineering
- Major shared community infrastructure and resources that **enable community-scale research.**
- Upgrades of infrastructure for existing and major new infrastructure **for existing facilities**

2020 NASEM Quadrennial Review: Recommendations identify 3 priorities for shaping the future of NNI

Committee Members: Harold Craighead (Cornell), Oliver Brand (GaTech)

- **Priority 1**: The NNI should improve ***alignment with the stated national priorities*** for R&D and ***focus on strategically selected*** environmental and other societal challenges.
- **Priority 2**: The NNI should ***partner broadly*** to improve the ***efficiency of translation*** of nanoscience/nanotechnology research and development into economic, environmental, security, health etc. (i.e. societal) benefits.
- **Priority 3**: The NNI should expand the nation's nanotechnology ecosystem via increased ***recruitment*** and ***training*** of future scientists and engineers, with an intentional focus on accelerated technology translation, and with robust investments in ***next-generation infrastructure*** to support both basic science and commercialization.

The goals of the NNI are unchanged since its inception in 2000

1. Advance a **world-class nanotechnology R&D program.**
2. Foster the **transfer of new technologies into products** for commercial and public benefit.
3. Develop and sustain educational resources, a **skilled workforce**, and a dynamic **infrastructure and toolset** to advance nanotechnology, and
4. Support **responsible development** of nanotechnology

NNI Review Findings - selected

- Several countries have followed the U.S. lead and are investing heavily into underlying infrastructure to support nanotechnology efforts, placing continued U.S. leadership in doubt.
- The US, as an early investor in nanotechnology infrastructure, is consequently now facing the challenges of an aging toolset.
- Easy access to core facilities has been a critical enabler to start-up companies and researchers. These facilities allow researchers to try out new ideas and develop prototypes and are of vital importance for training students.
- A state-of-the-art infrastructure helps the United States to attract the best talent, including students, researchers, and entrepreneurs.
- The U.S. nanotechnology infrastructure has played an important role in the technology transfer ecosystem, particularly at the initial stages.

Maintaining and constantly updating a state-of-the-art infrastructure is critical to support a world leadership position in science and technology

Current networks of world-class user facilities:

- DOE Nanoscale Science Research Centers (NSRCs)
- NSF National Nanotechnology Coordinated Infrastructure (NNCI)
- NSF Network for Computational Nanotechnology (NCN)
- NIH Nanotechnology Characterization Laboratory (NCL)
- NIST Center for Nanoscale Science and Technology (CNST)

National Nanotechnology Initiative (NNI)
Nanotechnology Signature Initiatives: FY2020

Areas identified for significant advances through close and targeted program-level interagency collaboration

Sustainable Nanomanufacturing
www.nano.gov/NSINanomanufacturing

Nanoelectronics for 2020 and Beyond
www.nano.gov/NSINanoelectronics

Water Sustainability through Nanotechnology
www.nano.gov/nsiwater

Nanotechnology for Sensors
www.nano.gov/SensorsNSIPortal

Thank you

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