

NQI Program and U.S. QIS R&D Coordination

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National Quantum Coordination Office

www.quantum.gov

www.whitehouse.gov/ostp

www.ostp.gov



National Quantum Initiative – Background

Quantum Mechanics + Information Theory

- Einstein, von Neumann, Shannon, Bell, Feynman, Bennet, Shor...
- Nobel Prizes for quantum control (NMR, Lasers, atomic clocks)
- Turing Awards for computation (architecture, complexity theory)
- Quantum algorithms, qubit platforms, entanglement → advantage

1990's Government Activities on Quantum Information Science

- Example Workshops and Studies:
 - 1994 NIST workshop on Quantum Computing
 - 1996 DOD (JASON) study on Quantum Computing
 - 1999 NSF workshop on Quantum Information Science
- Example Funding Programs:
 - NIST ion traps, cold atoms, single electron transistor
 - DOD DARPA SPiNS; AFOSR program on QIS
 - NSF Physics at the Information Frontier



National Quantum Initiative - Background

Quantum Mechanics + Info

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- Nobel Prizes for quantum mechanics
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 - 1999 NSF workshop
- Example Funding Programs
 - NIST ion traps, cold atoms
 - DOD DARPA SPiNS; ARO
 - NSF Physics at the Information Frontier

Quantum Computing

H. Kimble, Chair
C. Callan, Jr.
K. Case
A. Despain
N. Fortson
J. Goodman
S. Koonin
H. Levine
N. Lewis
W. Press
O. Rothaus
P. Weinberger
R. Westervelt

July 1996

JSR-95-115

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JASON
The MITRE Corporation
1820 Dolley Madison Boulevard
McLean, Virginia 22102-3481
(703) 883-6997

Quantum Information Science

*An Emerging Field of Interdisciplinary Research and Education in
Science and Engineering*

NSF Workshop

October 28-29, 1999

Arlington, Virginia



National Science Foundation

Report of the NSF Workshop
October 28-29, 1999
Arlington, Virginia

Steering Committee

C. H. Bennett	IBM
D. P. DiVincenzo	IBM
N. Gershenfeld	MIT
H. M. Gibbs	University of Arizona
H. J. Kimble	Caltech
J. Preskill	Caltech
U. V. Vazirani	UC/Berkeley
D. J. Wineland	NIST
C. Yao	Princeton University



NQI Background + Coordination

2000's U.S. QIS R&D Investment & Coordination

- Academic, Industry, and Government QIS efforts grow
- NIST, NSF, DOE, DOD, IC, NASA all support QIS programs and Labs
- 2009 A Federal Vision for QIS – National Science & Technology Council (NSTC)
- 2016 Advancing QIS: National Challenges and Opportunities (NSTC)

National Quantum Initiative Act (Public Law 115-368)

- 2018 National Strategic Overview for QIS (NSTC)
- Consortia, Centers, Coordination, Core Programs

National Defense Authorization Act (PL 115-232) & (PL 116-92)

- Defense QIS and Technology R&D Program



NQI Background + Coordination

2000's U.S. QIS R&D

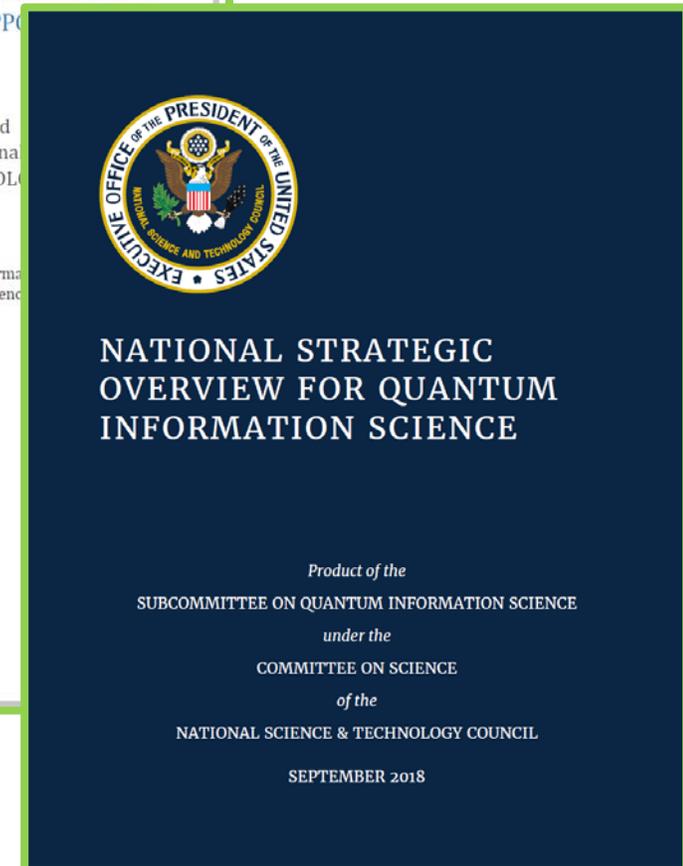
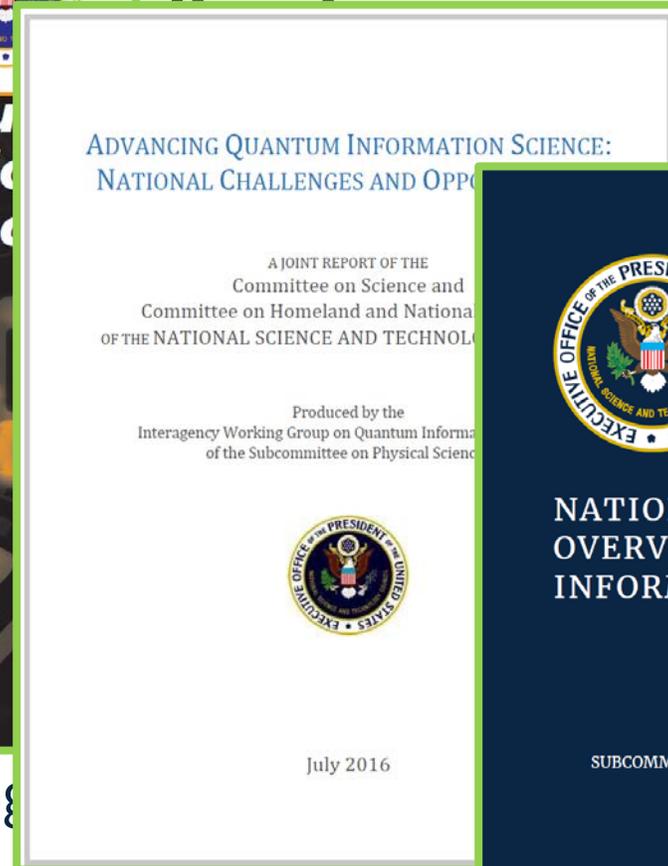
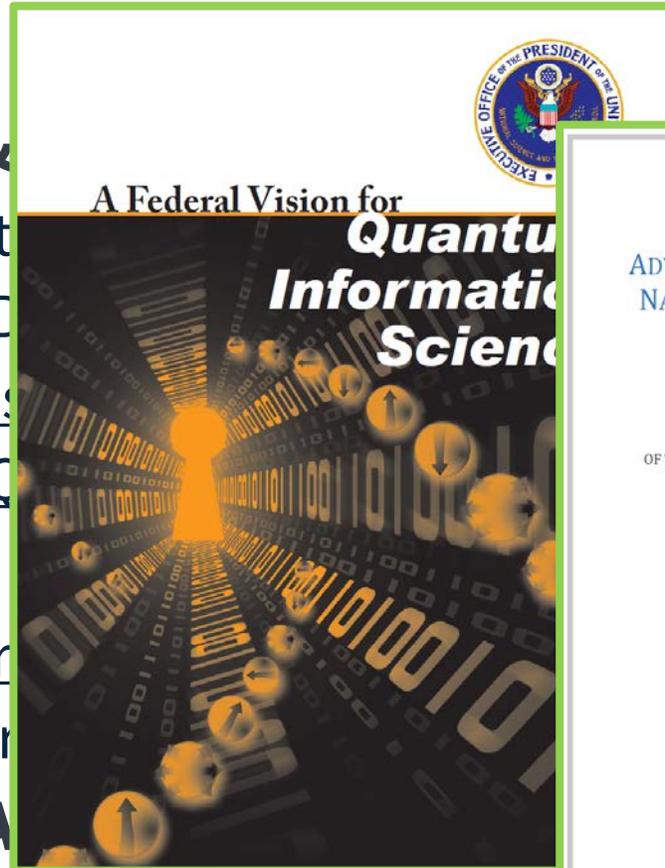
- Academic, Industrial
- NIST, NSF, DOE, DARPA
- 2009 A Federal Vision for Quantum Information Science
- 2016 Advancing Quantum Information Science

National Quantum Information Science

- 2018 National Strategic Overview for Quantum Information Science
- Consortia, Centers

National Defense Authority

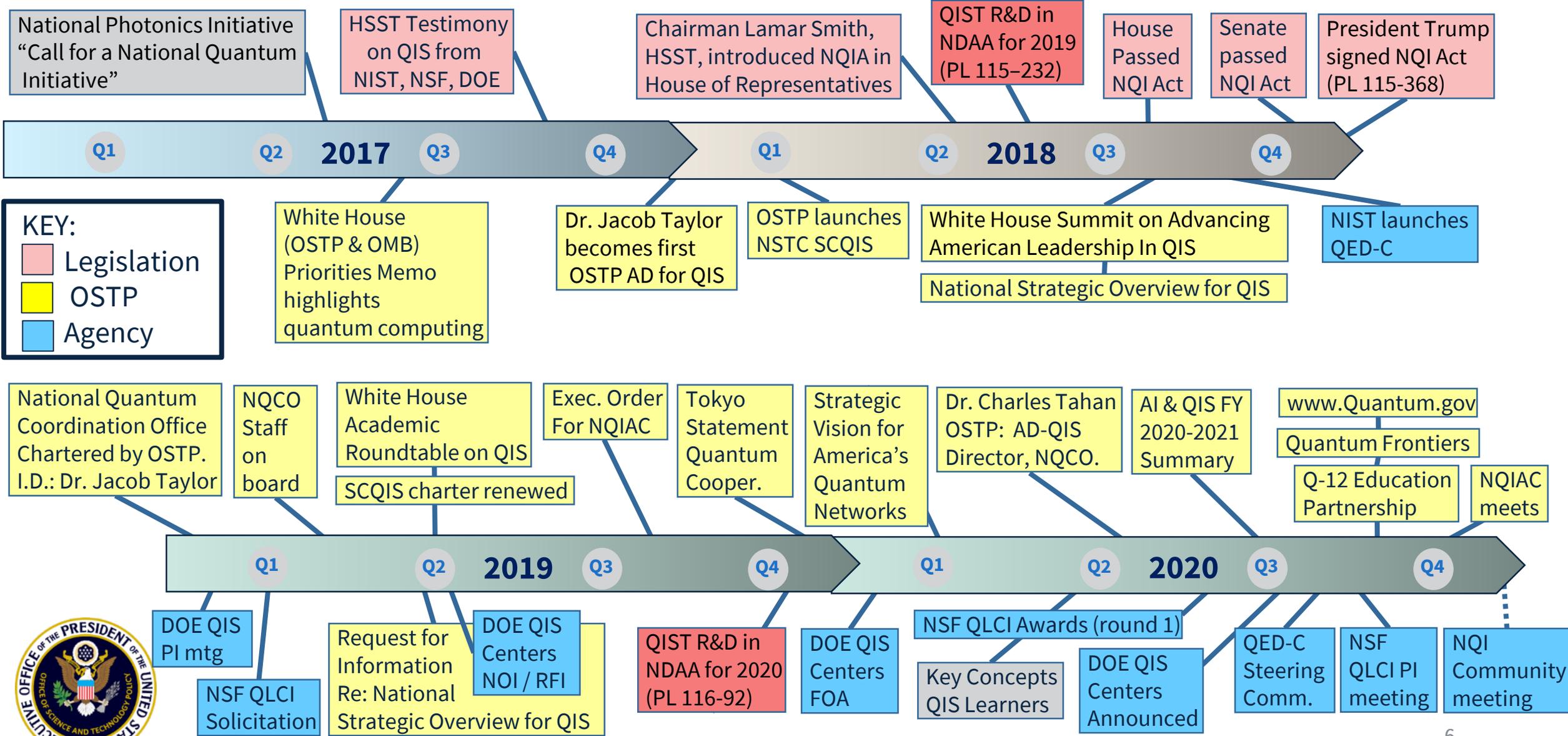
- Defense QIS and Technology R&D Programs



National Science and Technology Council (NSTC)



Establishing and Implementing the NQI



KEY:

- Legislation
- OSTP
- Agency



NQI Program

NQIAC shall advise and make recommendations to consider when reviewing & revising the Program.

“the Program,” means the **NQI Program**, i.e., Activities authorized by the NQI Act, including coordination of U.S. QIST Research, Development, and Demonstration efforts.

NQI Act, Title I, Sec. 101: In carrying out the Program, the President, acting through Federal agencies, councils, working groups, subcommittees, and the Coordination Office... shall:

- (1) establish goals, priorities, & metrics for a 10-year plan to accelerate development of QIST applications;
- (2) invest in fundamental Federal QIST R,D&D, and activities to achieve the goals established in (1);
- (3) invest in activities to develop a QIST workforce pipeline;
- (4) provide for interagency planning and coordination ...;
- (5) partner with industry and universities to leverage knowledge and resources; and
- (6) leverage existing Federal investments efficiently to advance Program goals and priorities.

QIST = Quantum Information Science and Technology
R,D&D = Research, Development, and Demonstration



NQI Act Statutory Requirements

Quantum Coordination Office (NQCO)

- Provide technical support to SCQIS and NQIAC;
- Oversee interagency coordination. Encourage joint agency solicitation;
- Ensure coordination among QIS Consortia & Centers;
- Conduct public outreach and serve as the point of contact on Federal civilian QIST activities;
- Promote access to and early application of the technologies.

NSTC Subcommittee on QIS (SCQIS)

- Coordinate Fed. Agency QIST R&D programs, & information sharing on R&D, standards, education;
- Establish goals and priorities of the NQI Program;
- Assess U.S. QIS workforce, global outlook for QIS R&D, and infrastructure; & make recommendations;
- Propose a budget for the NQI Program that ensures a balanced QIS research portfolio and appropriate effort;
- Strategic Plan and Annual Program Budget Reports.

Advisory Committee (NQIAC)

- Advise and provide recommendations for improving the NQI Program
- Conduct independent assessments of:

- (A) Trends or developments in QIST;
- (B) progress implementing the Program;
- (C) management, coordination, implementation, & activities;
- (D) if activities, goals and priorities maintain U.S. leadership in QIST;
- (E) if need exists to revise the Program;
- (F) if opportunities for international cooperation
- (G) if national security, societal, economic, legal, and workforce concerns are adequately addressed by the NQI Program.



See the National Quantum Initiative Act (PL 115-368) and Executive Order 13885 for more detail

NQI Act Statutory Requirements

Title II: NIST

- **Continue to support and expand basic and applied QIST R&D**
- Measurement and standards to advance commercial development
- Coordinate & use existing programs
- Establish or expand collaborative ventures with public or private sector entities
- **Convene a consortium** to identify future measurement, standards, cybersecurity, & other needs for a robust QIS and technology industry
- assess current research needs;
- identify gaps in the research necessary to meet the needs

Title III: NSF

- **Carry out a basic research and education program on QIS&E**
- Support human resource development
- Coordinate existing programs
- Graduate traineeships
- **Establish Multidisciplinary Centers** that conduct basic research and education activities:
 - advancing QIS & engineering
 - supporting QIS&E curriculum and workforce development
 - fostering innovation by bringing industry perspectives to quantum research and workforce development

Title IV: DOE

- **Carry out a basic QIS research program**
- Leverage the collective body of knowledge from existing QIS research;
- Provide QIS research experiences and training for additional students
- Coordinate research in existing programs
- **Establish and operate National QIS Research Centers** to conduct basic research to accelerate scientific breakthroughs in QIST
- ... serve the needs of the DOE, industry, ... advancing basic research in QIS and improving the competitiveness of the U.S.
- Coordinate with industry.



See the National Quantum Initiative Act (PL 115-368) for more detail on NQI-authorized activities

National Defense Authorization Act

Defense QIS and Technology R&D Program

...develop and manage a portfolio of fundamental and applied quantum information science and technology and engineering research initiatives that is stable, consistent, and balanced across scientific disciplines.

...establish and support appropriate research, innovation, and industrial base, including facilities, workforce, and infrastructure, to support the needs of Department of Defense missions and systems related to QIST.

Requirements:

- Strategic Plans
- Coordination on
 - QIST R&D
 - Training
 - Infrastructure
- QIS Center(s)

Quantum Science is one of DoD's 11 top modernization priority areas

NQIAC should be aware of the entire QIS ecosystem.

National Defense Authorization Acts for FY 2019 and FY 2020 (PL 115-232) & (PL 116-92)
Describe the Defense QIS and Technology R&D Program



NQI Coordinating Structure

SCQIS – NSTC Subcommittee on QIS

- Chaired by: NIST, NSF, DOE, OSTP
- Rep. from: NASA, DOD, ODNI, OMB & DHS, DOI, NIH, NSA, State, USDA, USPTO
- Working Groups on:
 - Science
 - Quantum Networking
 - Workforce Development, Industry, & Infrastructure
 - End Users

ESIX – NSTC Subcommittee on Econ. & Security Implications of QIS

Chaired by: DOD, DOE, NSA, OSTP

NQIAC – NQI Advisory Committee

- Chaired by: OSTP and DOE designees
- Rep. from: Industry, Academic, & Gov.
- Convened by DOE. Tech. and Admin Support from DOE & NQCO

NQCO – Quantum Coordination Office

- OSTP staff from: NIST, NSF, NSA



Highlighted QIS R&D Actions

NIST

- Joint Institutes & R&D activities
- QED-Consortium

NSF

- Core & Quantum Leap programs
- QLCI Institutes

DOE

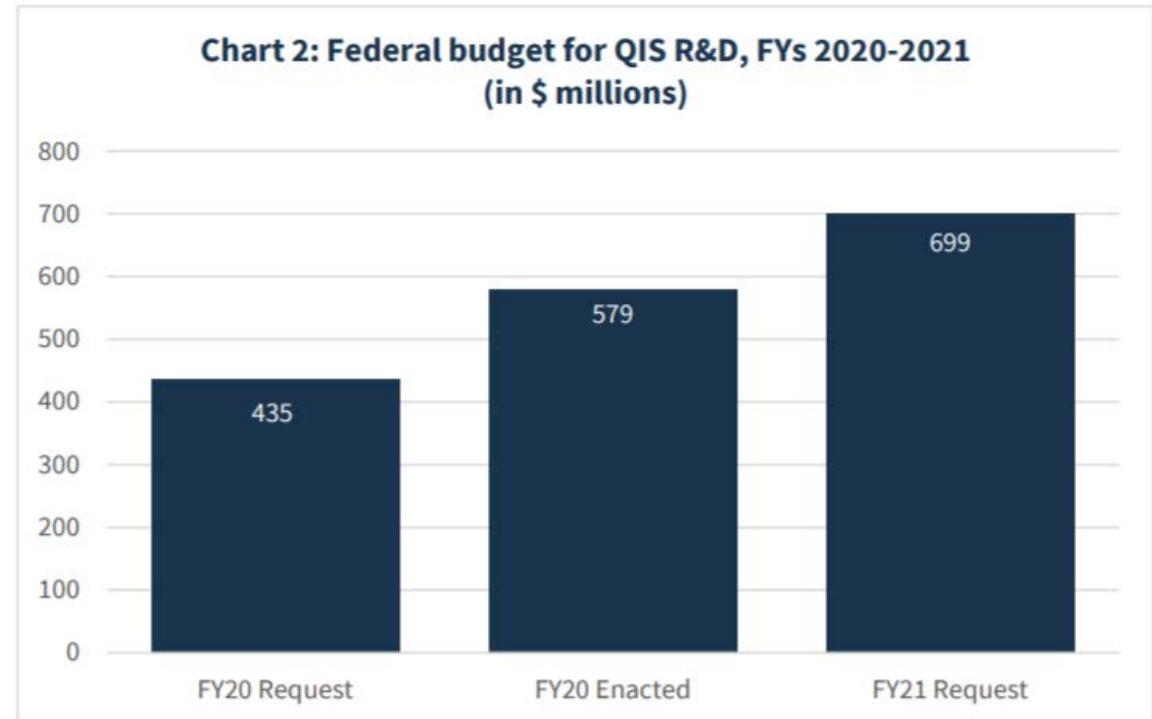
- QIS programs in Office of Science
- National QIS Research Centers

+ Other Federal Agencies

- Ongoing activities supporting the QIS ecosystem



Chart 2: Federal budget for QIS R&D, FYs 2020-2021
(in \$ millions)



Preliminary budget data in OSTP Report, “Artificial Intelligence and Quantum Information Science R&D Summary Fiscal Years 2020-2021” aggregates data from NIST, NSF, DOE and DOD.