NIST Quantum Plans

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Quantum Information Science in a Nutshell

Quantum information science (QIS) exploits unique quantum properties such as *coherence*, *superposition*, *entanglement*, and *squeezing* to *acquire*, *transmit*, and *process* information in ways that greatly exceed existing capabilities.

QIS is a field of scientific inquiry in its own right, with applications in:

- *sensing and metrology:* precision navigation, timekeeping, magnetic fields, …
- *communication:* secure data transmission and storage, random number generation,
- *simulation:* complex materials, molecular dynamics, QCD, …
- *computing:* cryptanalysis, quantum chemistry, optimization, quantum field theory, …

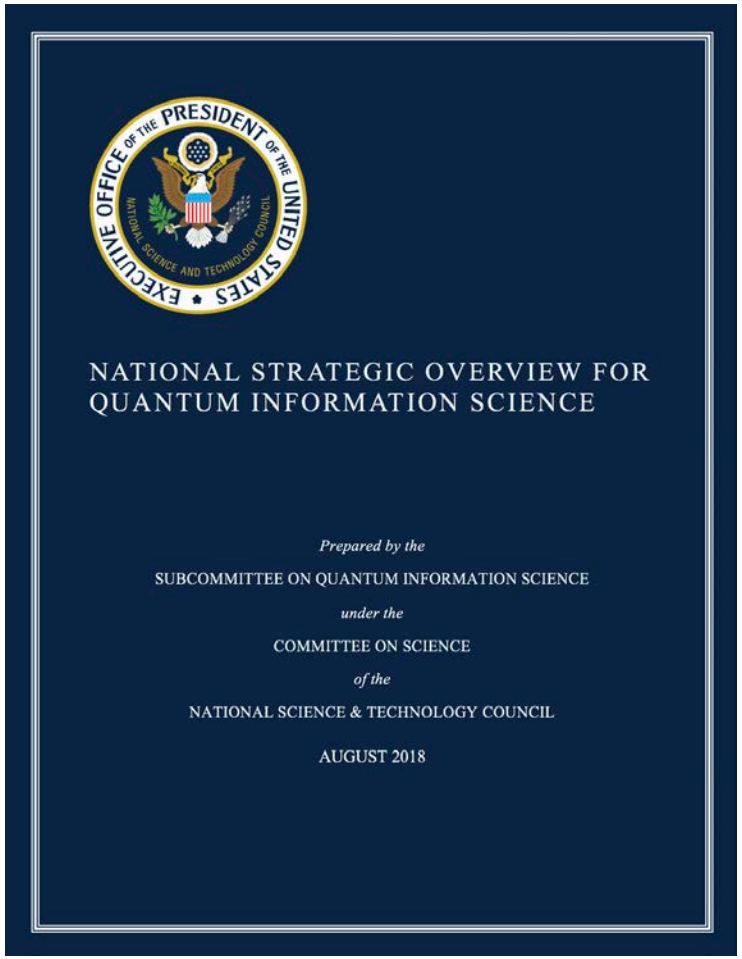
NIST's QIS Program covers all of this

and robust intellectual connections to numerous areas of basic research.

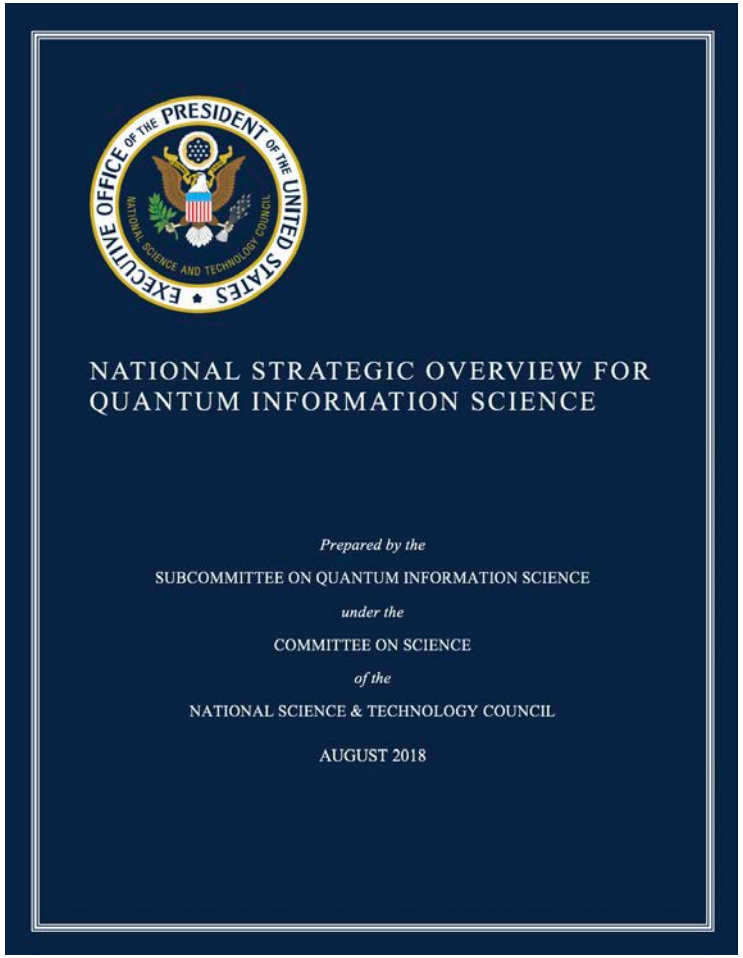
NIST program currently focuses on QIS but our activities already include aspects of quantum engineering which must grow!

A New National Strategy for QIS

- OSTP and its interagency arm, the NSTC, released Sunday September 23, 2018 a new national strategy for QIS. It is consistent with the National Quantum Initiative Act.
- On September 24, 2018, OSTP held a *Summit on Advancing American Leadership in QIS*, that rolled this out with about 100 participants from academy, industry, and the USG.
- Closing remarks were by Lamar Smith



Key QIS Policy Opportunities



- Choosing a science-first approach to QIS
- Creating a quantum-smart workforce for tomorrow
- Deepening engagement with quantum industry
- Providing critical infrastructure
- Maintaining national security and economic growth
- Advancing international cooperation

National Quantum Initiative Act

- Passed the House *unanimously* on September 13, 2018
- Requires OSTP to setup a National Quantum Coordination Office
- Requires NIST to:
  - Continue and expand QIS research and the development of measurement and standards infrastructure
  - Train scientists in QIS
  - Establish or expand existing partnerships or consortia
  - Provides OTA for the NQI related activities
  - Hold within 1 year a workshop that convenes stakeholders on future measurements and standards
  - Report to Congress not later than 2 years the results of that workshop

NIST QIS Programmatic Elements: Review

- NIST has established QIS as one of its programmatic activities
- NIST Programmatic Planning in QIS has three Program Elements:
  - Foundational Quantum (Information) Science and Metrology
    - Quantum many-body, state-of-the-art quantum limited measurements, quantum metrology at the highest level of accuracy, quantum algorithms, quantum information theory
  - Quantum Engineering:
    - Measurement tools to engineer quantum materials, structures, and devices that will be the core building blocks for a broad collection of future quantum technologies
    - Quantum transduction
    - A quantum ecosystem through consortium and multi-disciplinary centers – *external facing*
  - Quantum SI (Système International d'Unités)
    - Quantum breakthroughs to redefine how weights and measures are disseminated, providing improving accuracy and precision while eliminating calibration chains
    - Extend and build on the NIST-on-a-Chip program

Future QIS Activities at NIST

- **Foundational Quantum Metrology:** Create the metrological foundations essential to the future application of technology arising from quantum information science and engineering both for innovation and for future measurement science;
- **Quantum Engineering:** Create the foundation for this new engineering discipline through centers, a QIS consortium, engagement with external partners, and other venues to support innovation and competitiveness;
- **Quantum SI :** Expand the foundations for more ubiquitous dissemination of measurement standards based on this technology, whether at a primary calibration laboratory, on a manufacturing floor, in an airplane, or out in the real world.

Basic R&D

Applied R&D

Mission Based Delivery

NIST Planning Process

- NIST held a 2 day workshop on September 25-27, 2018
  - About 100 NIST principals and managers
  - Briefly summarized NIST activities
  - Research ideas and grand challenges were presented and discussed
  - Discussed organizing principles for potential grand challenges
  - Schedule had sufficient time for team building
- NIST has a call out for white papers – due November 8 – that will be used to create a detailed QIS program plan
- NIST continues to work with SRI to establish a QIS Consortium
  - Held an organizational meeting at SRI International on August 21, 2018
  - Have more than 20 Letters of Intent
  - A 2nd organizing meeting is scheduled for NIST Boulder on October 29-30

Additional NIST Activities

- NIST senior management (Copan, Olthoff, Lin, Romine, Williams) visited the West Coast in July to explore options for future activities in QIS and other areas. Visit included Stanford, SLAC, UC-Berkeley, LBL, and the *venture capital funded startup* Rigetti Computing
- NIST engaged with IEEE around quantum standards
- NIST held a 1-day workshop on October 4th with NRC-Canada and NPL to explore common interests around quantum standards
- NIST continues to meet and interact with professional societies, industry, and academia around QIS
- NIST continues to work with DOC, OSTP, and OMB to support an expanded QIS program

One Concept for a NIST Grand Challenge

Build a prototype few node **Quantum Network** that distributes and stores entangled states of light and maintains the entanglement for sufficient time to support R&D, sensing, and metrology using various technologies

Requires: Quantum memory, quantum repeaters, small quantum processors, transduction, quantum error correction, entanglement purification

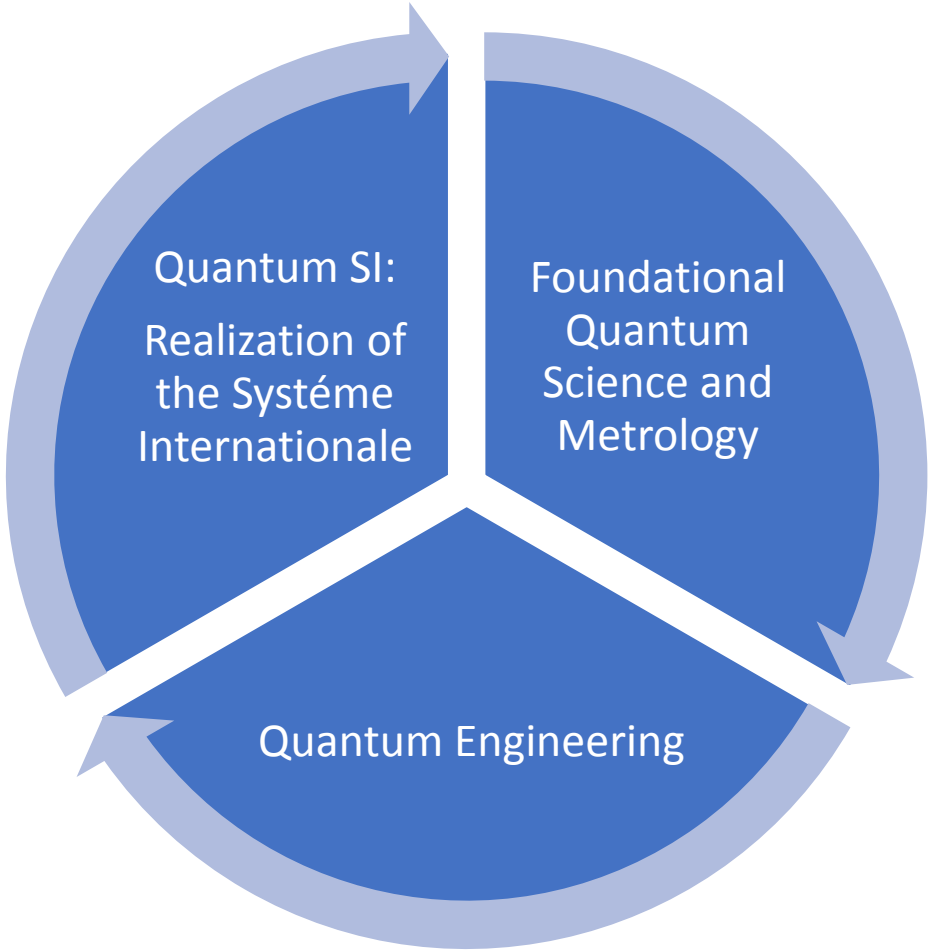
Provides: A testbed for system components and standards and supports basic R&D

Allows: Development of improved components, entanglement of distant clocks or sensors, exploration of quantum enhanced long baseline interferometry

NIST QIS Strategic Vision

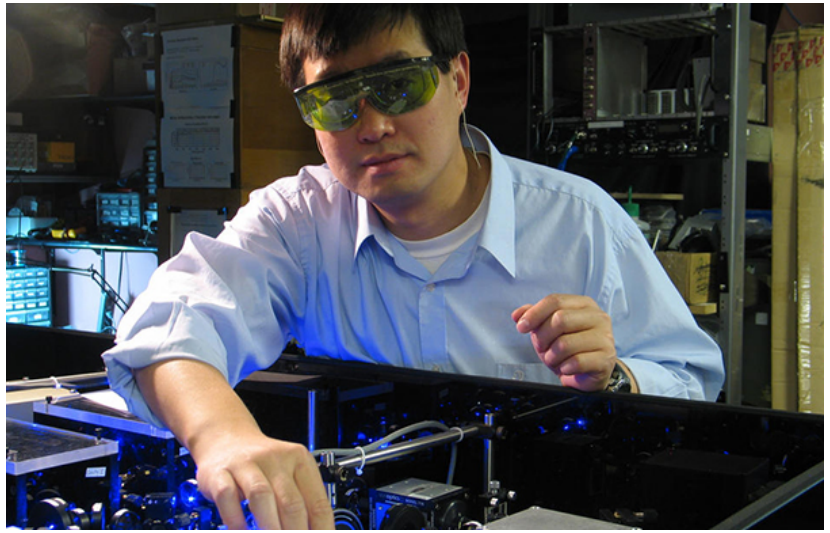
NIST will fulfill its mission in QIS through three coordinated efforts:

- Foundational research emphasizing QIS and Metrology
- Applied research to engineer and improve the robustness of prototypes: Q. Engineering
- Realization and Dissemination of the units of measure: The Quantum SI
- *These activities form an interrelated and self-reinforcing system in which, for example, next-generation atomic clocks are engineered to be smaller and more robust and thereby enable tomorrow's measurement services.*



NIST Mission

To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life



Potential Questions for Discussion

- Do you see any gaps in our QIS plans?
- If NIST were to create a new Quantum Engineering based center is there a focus area that in your opinion would be more important, or conversely one that NIST should avoid?
- Are there other mechanisms in addition to the Quantum Consortia that NIST should consider to maximize engagement between government, academia, and industry?
- Any advice about the balance between basic research, applied research, and dissemination that NIST should consider?

QUESTIONS?