Quantum Economic Development Consortium (QED-C)

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SRI International

• The Quantum Landscape
• Federal Action: National Quantum Initiative
• Government-Industry Action: Quantum Economic Development Consortium
Quantum Science & Technology Landscape

- S&T advances across many disciplines (“supply”, “push”)
  - Materials (e.g. topological insulators; atomically precise doping); devices (aka qubits) and components; coherence; error correction; algorithm development
  - Reports highlighting opportunities and applications (e.g. NSF, DOE, AFSB)

- Technology need (“demand”, “pull”)
  - Post Moore’s Law
  - More precise technology for communications, navigation, etc.
  - Post quantum cryptography (see 2018 NRC report on feasibility and implications of quantum computing)

- Industry investing heavily in R&D
Industry Making Big Bets...

Google thinks it’s close to “quantum supremacy.” Here’s what that really means.

Merlame Berboucha
Science Laser Physicist

IBM's First Commercial Quantum Computer

Microsoft predicts five-year wait for quantum computing in Azure

Industry experts predict it will take 10 years for quantum computing to become a reality, but Microsoft believes it has the research edge, with systems, software and technology to get there in five
Birth and Development of an Industry

First Transistor, 1947
Shockley, Bardeen, and Brattain

FROM LAB TO FAB

Wafer processing
- Wet cleans
- Photolithography
- Ion implantation
- Dry etching
- Wet etching
- Plasma ashing
- Thermal treatments
- Chemical vapor deposition (CVD)
- Physical vapor deposition (PVD)
- Molecular beam epitaxy (MBE)
- Electrochemical deposition (ECD)
- Chemical-mechanical planarization (CMP)
- Wafer testing
- Wafer backgrinding

Die preparation
- Wafer mounting
- Die cutting

IC packaging
- Die attachment
- IC bonding
- IC encapsulation
- IC testing

Moore’s Law

2018, IC (12”, < 10 nm)
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- International competition
  - EU Quantum Flagship = €1B
  - China plans to invest $10B+
Government Actions

- NSF Big Ideas included Quantum Leap (2016)
- Govt-wide research spending ~$200M-$250/yr
- Solicitations by NSF, DOE, DARPA et al.
- National Strategic Overview for Quantum Information Science released (Sept 2018)
- Quantum Economic Development Consortium (QED-C) established; partnership with NIST and industry (Oct 2018)
- National Quantum Initiative Act signed (Dec 2018)
NQI Act* Establishes a Multi-agency Program

- Support research, development, demonstration and application of QIS&T
- Grow researchers, educators, and students (= “Quantum workers”)
- Improve QIS&T interagency planning and coordination (interagency group, coordination office, strategic plans, annual budget reports)
- Facilitate collaboration among government agencies, national labs, industry and universities
- Promote development of standards for QIS&T security
- Establish an outside advisory committee
- Terminate 11 years after enactment (unlike NNI)
- NSF and DOE to fund research centers
- NIST to convene a quantum consortium

*Modeled after the National Nanotechnology Initiative
Quantum Enabling Device Development Continuum

STAGE & TRL:

<table>
<thead>
<tr>
<th>Basic R&amp;D</th>
<th>Application R&amp;D</th>
<th>Device Prototypes</th>
<th>Enabling Component Development</th>
<th>Prototype Components and Subsystems</th>
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ACTIVITY:

- Understanding Physical Phenomena
- Exploiting & Controlling Phenomena
- Create First of a Kind Devices
- Create Key Sub-Components & Devices/ T&E/ Performance Stds.
- Develop Efficient Common Purpose-Driven Device Designs/ T&E/ Stds.

EFFICIENCIES:

- Public/Private Support: Funding & Collaboration
- Introduce New Common Enabling Devices Performance Standards

ENGAGED DISCIPLINES:

- Physics / Comp Sci & Math / Materials
- T&E / Engineering Design & Development

MATURE INDUSTRY

- De-risked components
- Robust infrastructure
- Common standards
- Testbeds

Competitive R&D And Industry Activities:

- Production Equipment Fabrication & Sales
- COTS Device Manufacturing & Sales
- Full Quantum Systems
- Deploy Quantum Systems at Utility Scale

Create Device Production Equipment Standards
COTS Device & Systems Performance Standards
SRI: At the intersection of Discovery and Innovation

LEGACY: Founded by Stanford University in 1946
GLOBAL: 63-acre headquarters in Silicon Valley and 21 locations worldwide
- 1900 staff members
- $483M in annual revenues

INNOVATE: >$4B in research investment over last 10 years
- 4,000 total patents, 500 disclosures per year
- 1,000 R&D projects per year
- >25,000 total final reports

LAB to MARKETPLACE: helped create hundreds of billions of marketplace value
- 60+ spin-off companies

MANAGING THE QED-C
QED-C Mission and Goals

MISSION

• Strengthen U.S. leadership in the quantum technology industry

GOALS

• Facilitate industry coordination and interaction with Government agencies

• Provide a collective industry voice in guiding R&D investment priorities, standards needs, and quantum workforce issues

• Identify use cases and address gaps in enabling technology (mid-TRL) and infrastructure, performance metrics and standards, and workforce
Integrated QED-C focus areas

Workforce:
- The “Needle” that “Threads” through all

Standards & Performance Metrics
- Describe quantum standards landscape
- Prioritize standards needs and gaps
- Engage with SDOs to address gaps

Enabling Technologies
- Identify & prioritize:
  - Technology gaps
  - Needed R&D
  - Supply Chain strength

Quantum Use Cases

Define:
- Killer quantum apps
- Markets
- Timelines
- Roadblocks
QED-C Membership

Voting Members:
• U.S. companies that are part of the quantum industry ecosystem
• U.S. Government agencies

Non-voting Members:
• Foreign companies and partnerships (non-U.S. majority-owned)
• Universities
• National laboratories and other FFRDC’s
• Standards development organizations
• Professional societies
QED-C LOI Signatories

- Amazon
- AO Sense
- APS
- ARM
- AT&T
- Atom Computing
- BAE Systems
- Boeing
- Boston Consulting Group
- Bra-Ket
- Caltech/ INQNET
- Citi
- Cold Quanta
- Corning
- Colorado School of Mines
- Entanglement Institute
- Fieldline, Inc.
- GE Global Research
- General Dynamics Mission Systems
- GMU
- Google
- Harris
- Honeywell
- HPD
- IBM
- Intel
- IonQ
- Janis Research
- Keysight
- KLA-Tencor
- Lake Shore Cryotronics
- Microchip/ Microsemi
- Montana Instruments
- NuCrypt
- Photodigm
- Photon Spot
- Psi Quantum
- QC Ware
- QPRI
- Quantum Circuits, Inc.
- Quantum Xchange
- Qubitekk, Inc.
- Raytheon / Raytheon-BBN
- Rigetti
- Rydberg Technologies
- SEMI
- SkyWater Technology Foundry, Inc.
- Stable Laser Systems (SLS)
- SRI
- Toptica
- Vescent Photonics
- Zapata Computing
- Zyvex Labs

US Government Representatives
- NIST
- DOE
Summary

- **QED-C is off to a fast start with 53 non-govt + 2 government members**, including most U.S. quantum industry companies and their suppliers (equipment, components, etc.); membership categories defined for foreign, academic, and other entities

- **QED-C is tackling the barriers** to realizing the widespread benefits of quantum science and technology

- **QED-C is a public-private partnership** that will be guided by industry needs and will enhance government efforts to help the quantum industry of today and tomorrow to flourish in the United States.

For more information about the QED-C or to become a member contact:

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