QED-C:
Enabling & growing the quantum industry

Jonathan Felbinger, PhD
QED-C Deputy Director

QED-C membership snapshot

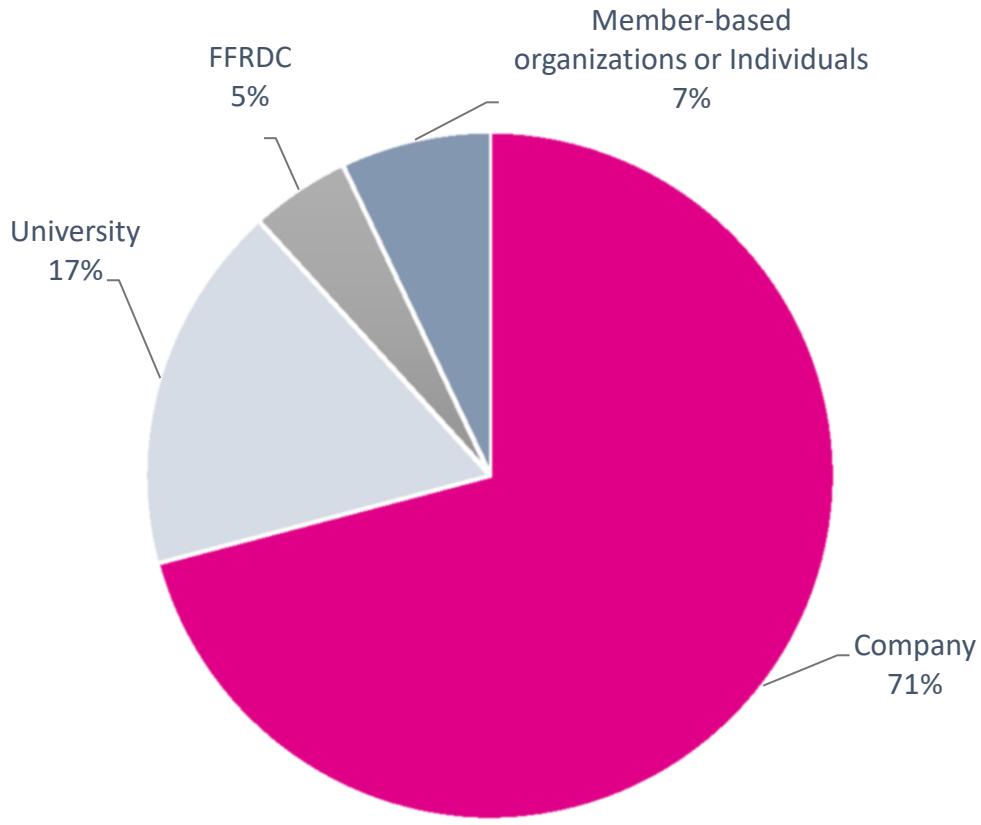
All sectors*

- ✓ Corporations
- ✓ Academic institutions
- ✓ National laboratories
- ✓ Professional societies and nonprofit orgs

All parts of the innovation ecosystem/supply chain:

- ✓ Hardware developers
- ✓ Software developers
- ✓ Suppliers
- ✓ Service providers
- ✓ End users
- ✓ Researchers
- ✓ Educators

*Also engage with 40+ government agencies



~240 members and growing

see quantumconsortium.org/members

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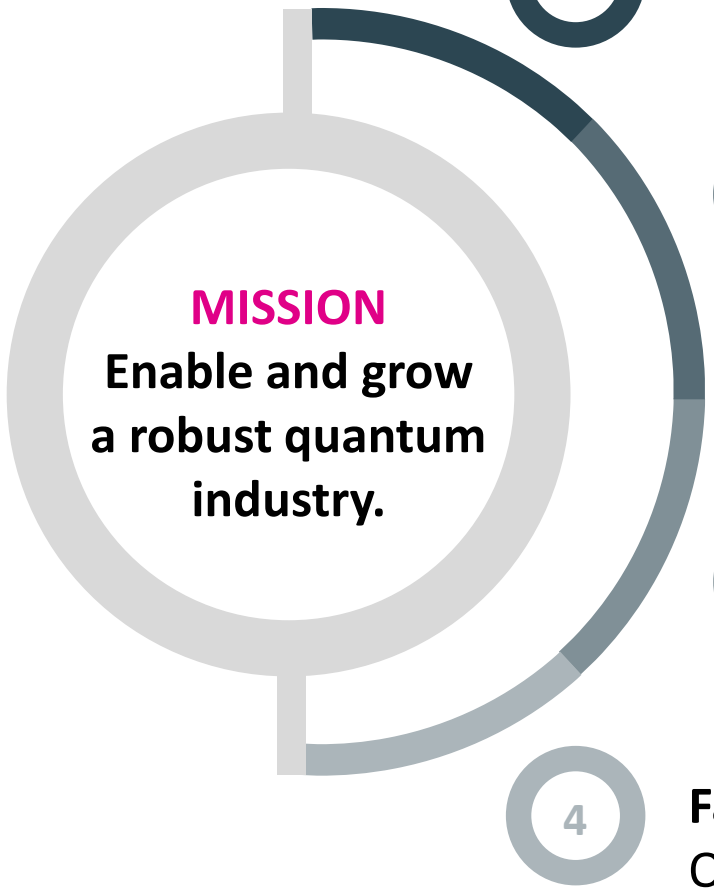
QED-C mission and objectives



1. **Identify use cases** and associated economic benefits

2. Develop strategies to **address gaps** in:
   - Enabling technologies, including supply chain
   - Standards, metrics & benchmarks
   - Workforce
   - Policies

3. **Inform public & private investors** about enabling technology R&D, infrastructure and workforce development/education needs

4. **Facilitate collaboration** among members and with government to accelerate QIST development, commercialization, and value (economic benefit)

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QED-C structure

- Called for in the National Quantum Initiative Act
- Managed by SRI International
- Welcomes applicants from companies, and research institutes in 39 countries
- Activities generally initiated within 6 Technical Advisory Committees (TACs)
- Meet the staff and elected leaders at quantumconsortium.org/team

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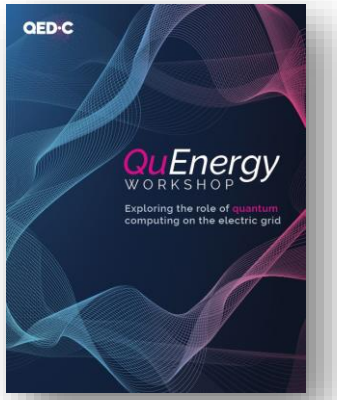
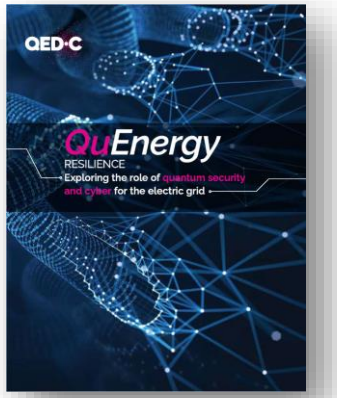
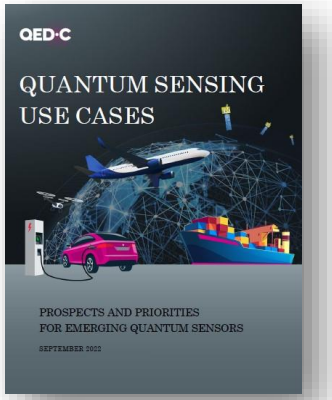
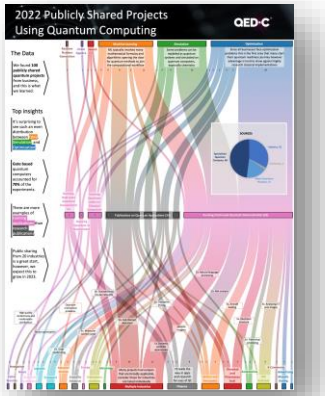
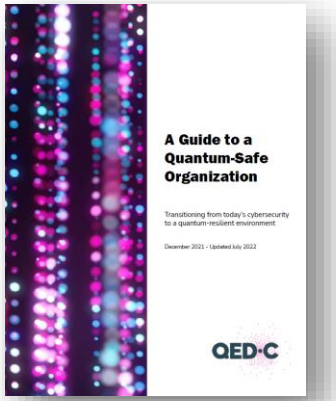
Sharing knowledge with members

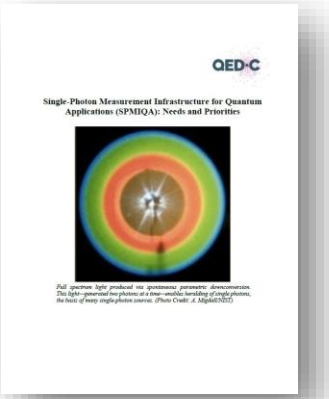


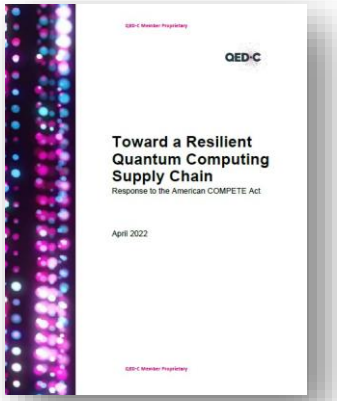


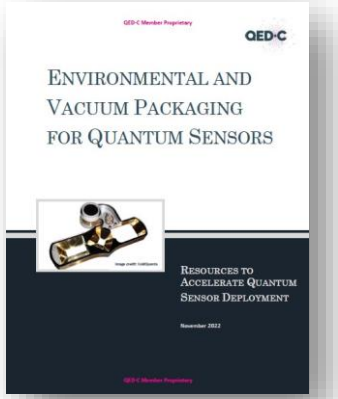


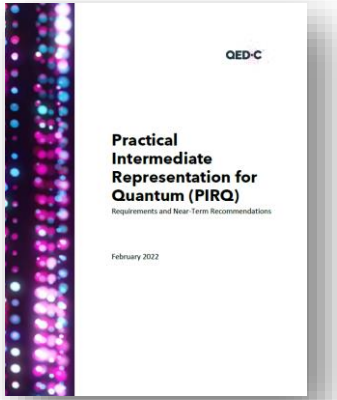












See the complete list at quantumconsortium.org/publications

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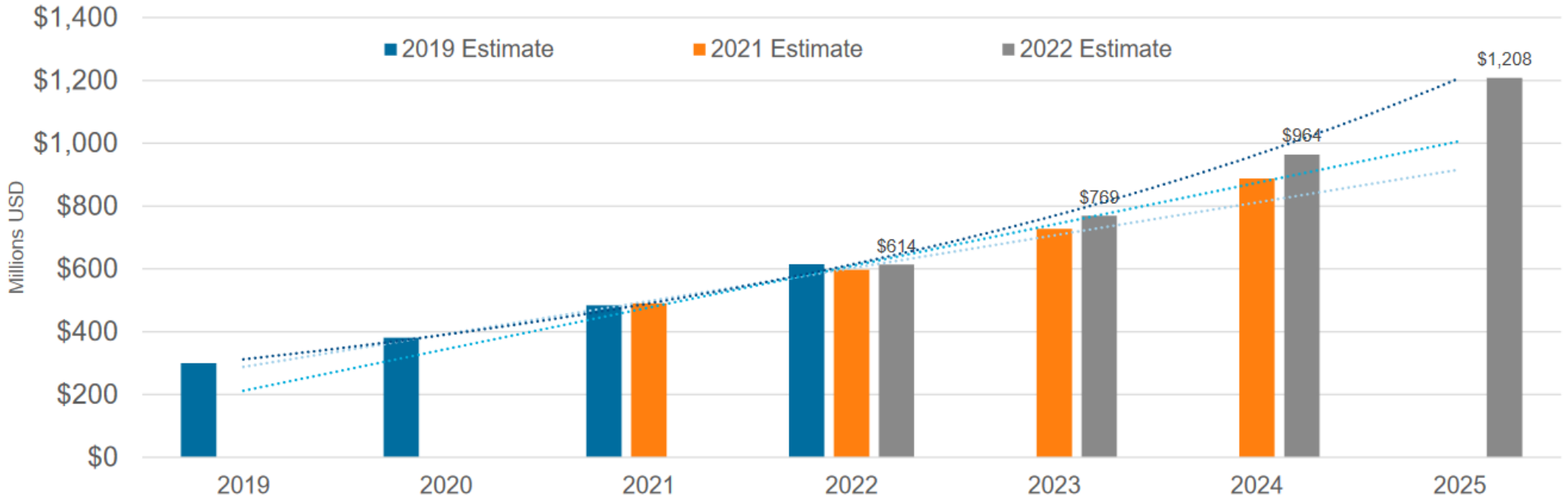
Annual quantum computing market forecast

- Survey of quantum computing (QC) suppliers worldwide
- QC suppliers anticipate accelerating revenue: no QC suppliers see a decline in 2023 revenue, few see no growth; smaller firms are more optimistic
- Expected areas of application: finance, R&D in QIST and QC, cybersecurity, chemical & pharma



Performed by Hyperion Research; co-sponsored with Q-STAR and QC-Ware Q2B quantumconsortium.org/theglobalqcmarket2022

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SRI's approach to quantum roadmapping

- In 2022, NIST's Office of Advanced Manufacturing solicited proposals and awarded grants for 14 roadmap projects for different industries
- Goal: "address high-priority research challenges to grow advanced manufacturing in the United States."
- SRI International was awarded a grant to develop a quantum technology manufacturing roadmap (QTMR)
- Unlike prior examples, QTMR is not focused on scientific discovery or a particular quantum application area
- Engaged quantum system integrators to identify and prioritize common manufacturing needs and challenges related to scaling on a 5-year horizon

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Roadmap participants—*thank you!*

Accenture
Aegiq
AFRL
Amazon Web Services
Anametric, Inc.
Atom Computing
Bleximo Corp.
Booz Allen
Brookhaven National Laboratory
ColdQuanta Inc
Cryomech, Inc.
Doppler Systems LLC
DRS Daylight Solutions
Duke University
Element Six
EuQlid
Fermilab
FormFactor Inc.
Freedom Photonics
General Dynamics Mission Systems
Great Lakes Crystal Technologies
Hamamatsu Corporation
Honeywell
HRL Labs
IBM
Iff Technologies
Infleqtion
IonQ
Keysight
L3Harris Technologies
Lake Shore Cryotronics
Lawrence Livermore National Laboratory
Lockheed Martin
Maybell Quantum
MemQ Inc.
Montana Instruments
NIST
NKT Photonics
Oak Ridge National Laboratory
Oxford Instruments
Pacific Northwest National Laboratory
PASQAL
Photodigm Inc.
PSI Quantum
QBlox
QCat
Q-CTRL
QuantCAD
Quantinuum
Quantum Machines
Qubitekk, Inc.
Qunnect
Raytheon BBN
Rigetti
Riverlane
Rydberg Technologies
Safe Quantum Inc.
SandboxAQ
Sandia National Laboratories
SCALINQ
SEEQC
Stony Brook University
StratConGlobal
Superchips llc
SV Microwave - an Amphenol Company
The MITRE Corporation
TOPTICA Photonics
UC Berkeley
University of Washington
Vector Atomic
Vescent Photonics
Wells Fargo Inc
XMA Corporation
Zettaflops, LLC

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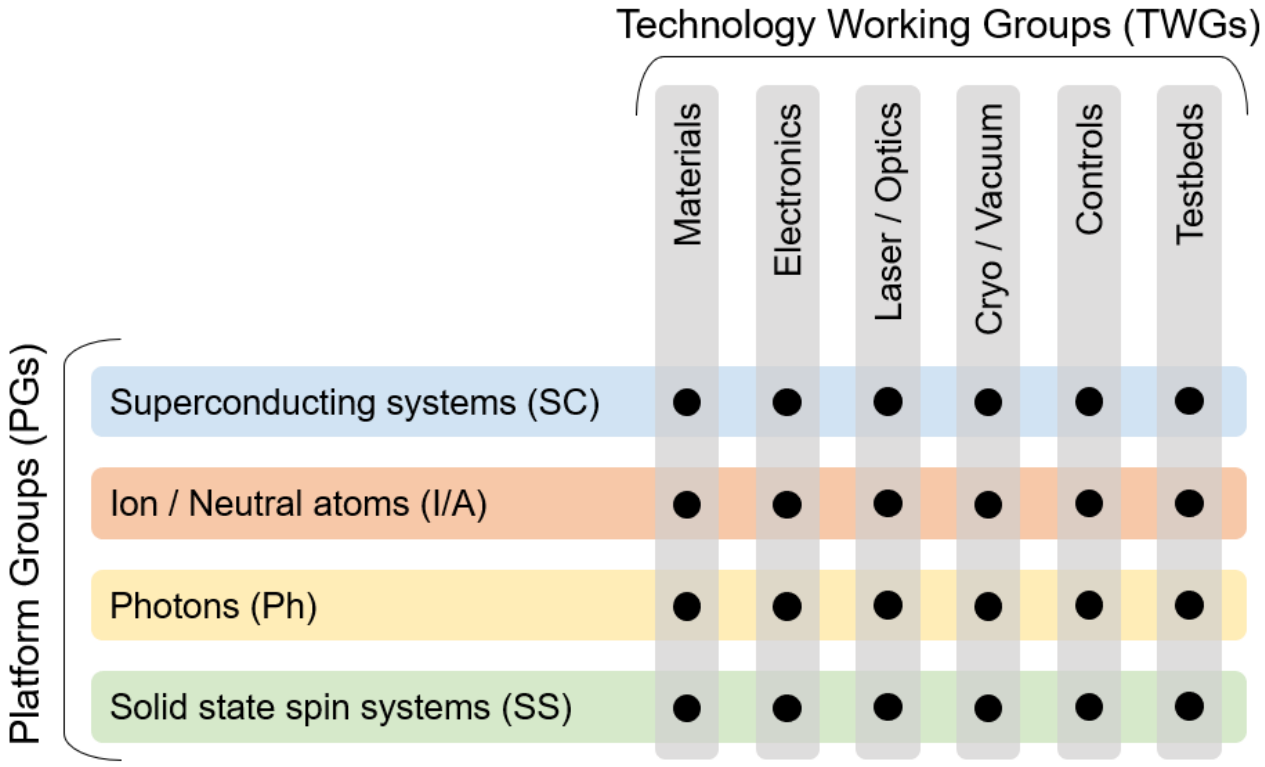
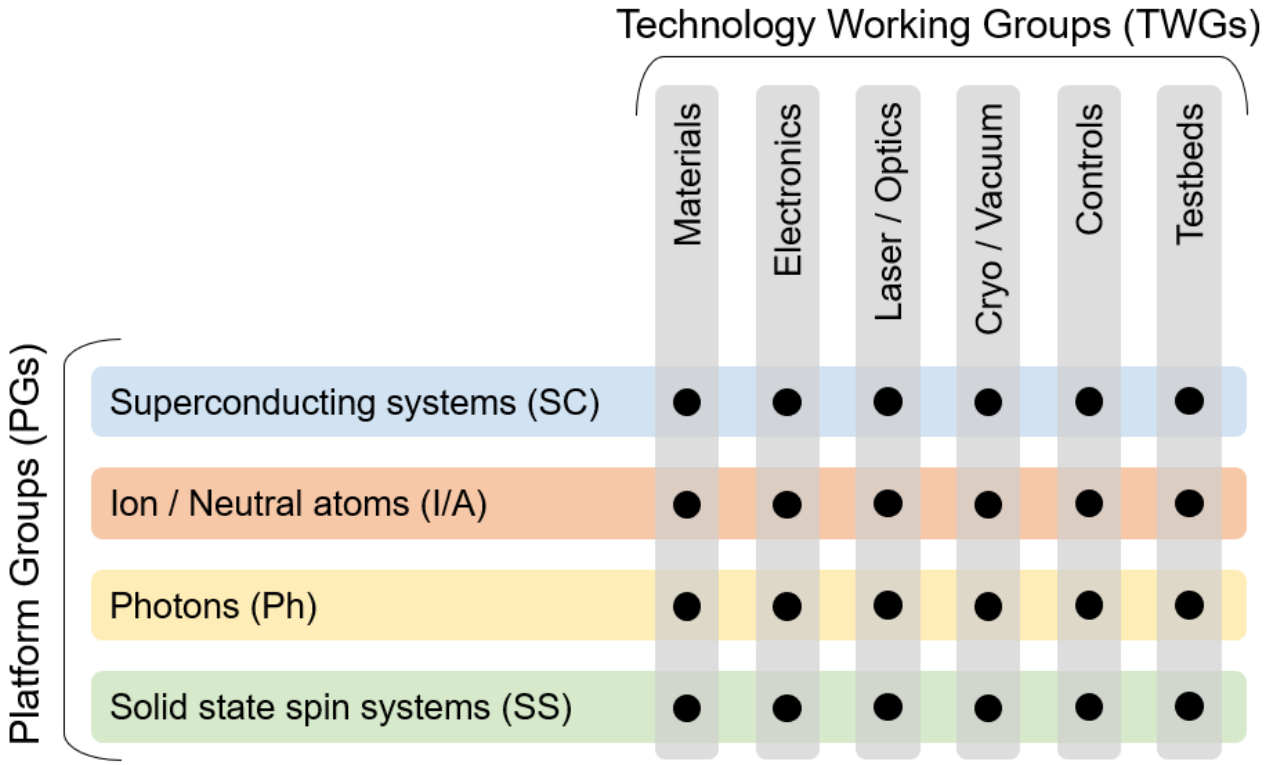
QTMR findings

- There is no one universal approach, material, configuration, or platform.
  - The roadmap process considered varying permutations of needs and challenges
- Different applications (e.g., sensing, computing, communications) have very different needs
  - Responses implied over 100 suitable lasers with different wavelengths and materials, and laser choice depending on the use case or application.
  - "Depends on the application or the tool": e.g., specs for linewidth needed for a laser varied if it was for a specific isotope, use in an optical clock, or for Rydberg sensing.
- Many non-quantum and qualitative needs arose (e.g., knowledge and data sharing, open-source software, structural/electrical engineering, supply of components, higher quality materials)



QTMR findings, cont'd

- There are often tradeoffs in manufacturing, which suppliers are more likely to recognize than integrators:
  - Efficiency vs. reliability
  - Size and power vs. cost
  - Temperature vs. timing jitter
  - Variety of options for materials, sources, wavelengths vs. cheap, off-the-shelf options
- Small production volume is one of the greatest challenges across all needs for system integrators
  - Custom-built unique tools at small volumes are really expensive
  - Platform, tools, and approaches standardization will allow manufacturers to produce useful off-the-shelf components at scale and bring the costs down
  - Commonality or formal standardization will also accelerate the usefulness of testing and modeling



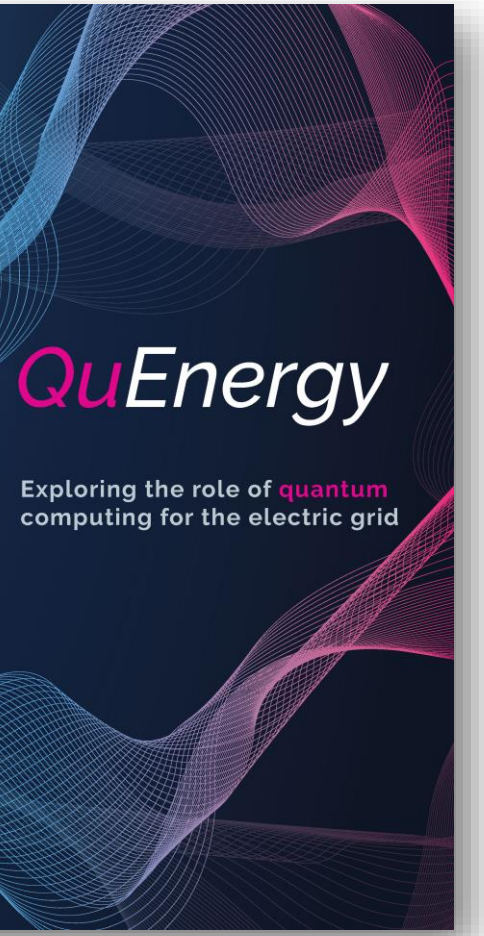
Watch for the roadmap v1.0 at sri.com/quantum

SRI International®

Thank you

QED-C®

QED-C use case workshop on quantum computing for electricity transmission and distribution



National Labs

BERKELEY LAB
Argonne NATIONAL LABORATORY
Los Alamos NATIONAL LABORATORY
Sandia National Laboratories
Lawrence Livermore National Laboratory
SLAC NATIONAL ACCELERATOR LABORATORY
Brookhaven National Laboratory
OAK RIDGE National Laboratory
NREL
Pacific Northwest NATIONAL LABORATORY
Fermilab

Utilities

EPRI ELECTRIC POWER RESEARCH INSTITUTE
Bonneville POWER ADMINISTRATION
comed AN EXELON COMPANY
epb
GREEN MOUNTAIN POWER
exelon
TVA TENNESSEE VALLEY AUTHORITY

Quantum Industry

Microsoft
IBM
NVIDIA
IQuEra COMPUTING INC.
aws
qci Quantum Circuits, Inc
IONQ
QCWARE
ZAPATA
D-Wave The Quantum Computing Company

Hosts & Collaborators

QED-C
accenture
U.S. DEPARTMENT OF ENERGY Office of TECHNOLOGY TRANSITIONS
Office of ELECTRICITY

90+ Participants/Observers from QED-C, Use Case TAC, Quantum Industry, National Labs, Federal Agencies, & Academia

quantumconsortium.org/QuEnergy22

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Quantum Marketplace

A first of its kind

The Quantum Marketplace™ aims to help those with quantum-related technology needs find suppliers, customers and partners. Monthly webinars highlight QED-C® member companies that offer a range of quantum technology and services. Technology providers and users present and then engage in panel discussions, sharing expert views on the state of the art and emerging applications and markets.

LATEST WEBINAR

Quantum Computing Systems II

June 28, 2022

View all recorded webinars

NEXT WEBINAR

Quantum Marketplace Webinar: Cryo for Quantum

August 30, 2022

The next Quantum Marketplace webinar features QED-C members who are providers and experts on cryogenic technologies as they apply to quantum. Presenters include Maybell, FormFactor, Photon Spot, Cryomech, Oxford Instruments, and Bluefors. 1:00-2:15pm EDT | Public event (QED-C hosted) Read more...

Register

View all scheduled webinars

What are you in the "market" for?

ALL | OTHER | APPLICATIONS / SYSTEMS | SERVICES | SOFTWARE | HARDWARE COMPONENTS | END USERS

2022 highlight
Updated *Guide*

- Aimed at CIOs and CISOs
- Outlines various technologies
- Describes threats and risks
- Provides actionable recommendations

quantumconsortium.org/quantum-safe-guide

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2022 highlight
Updated benchmarking tools

Application-Oriented Performance Benchmarks for Quantum Computing

Thomas Lubinski,[1,2] Sonika Johri,[3] Paul Varosy,[4] Jeremiah Coleman,[5] Luning Zhao,[3] Jason Necaise,[6] Charles H. Baldwin,[7] Karl Mayer,[7] and Timothy Proctor[8]

(Quantum Economic Development Consortium (QED-C) collaboration)*

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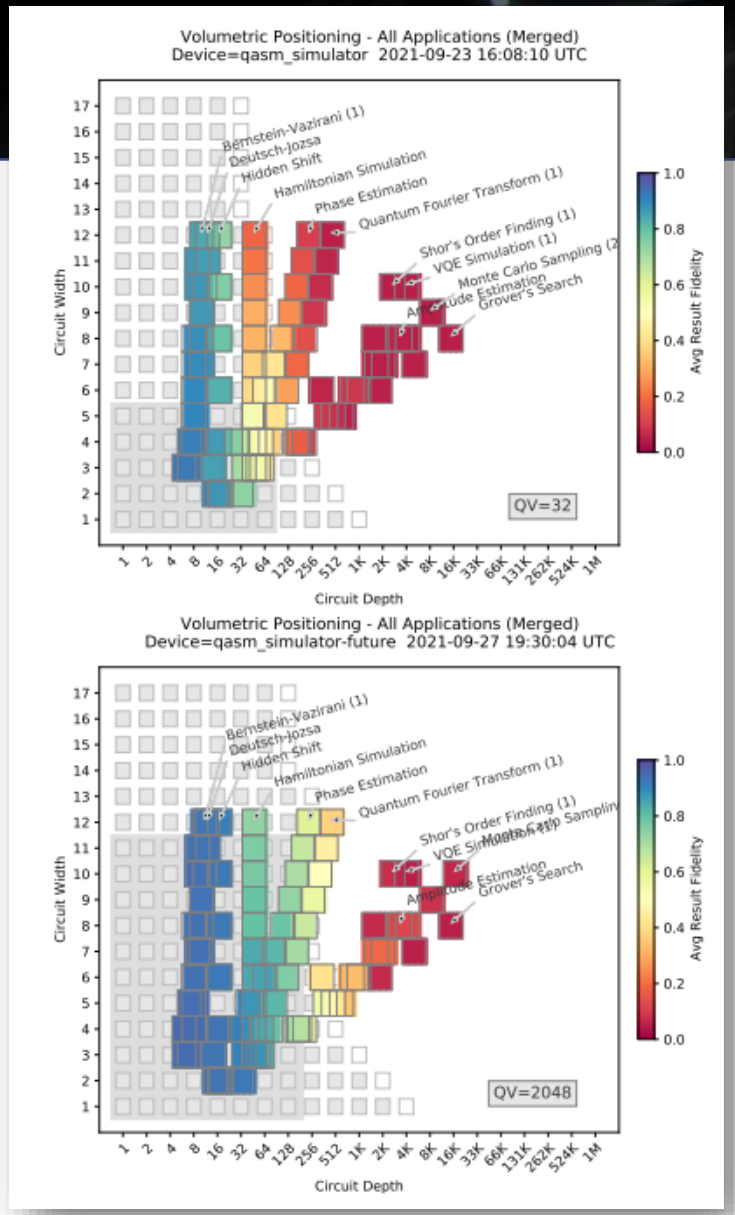
[4]*Department of Physics, Colorado School of Mines, Golden, CO 80401, USA*
[5]*Department of Electrical and Computer Engineering, Princeton University, Princeton, NJ, 08544, USA*
[6]*D-Wave Systems, Burnaby, British Columbia, Canada, V5G 4M9, Canada*
[7]*Quantinuum, 303 S. Technology Ct, Broomfield, CO 80021, USA*
[8]*Quantum Performance Laboratory, Sandia National Laboratories, Livermore, CA 94550, USA*

(Dated: January 11, 2023)



https://arxiv.org/pdf/2110.03137.pdf

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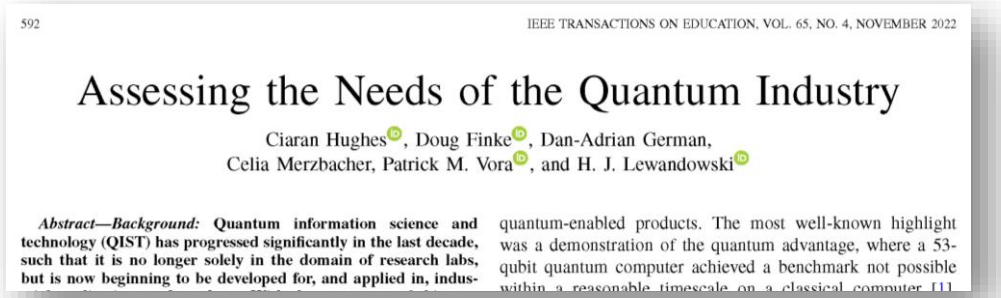
2022 highlight
Published QED-C study of industry workforce needs



592 IEEE TRANSACTIONS ON EDUCATION, VOL. 65, NO. 4, NOVEMBER 2022

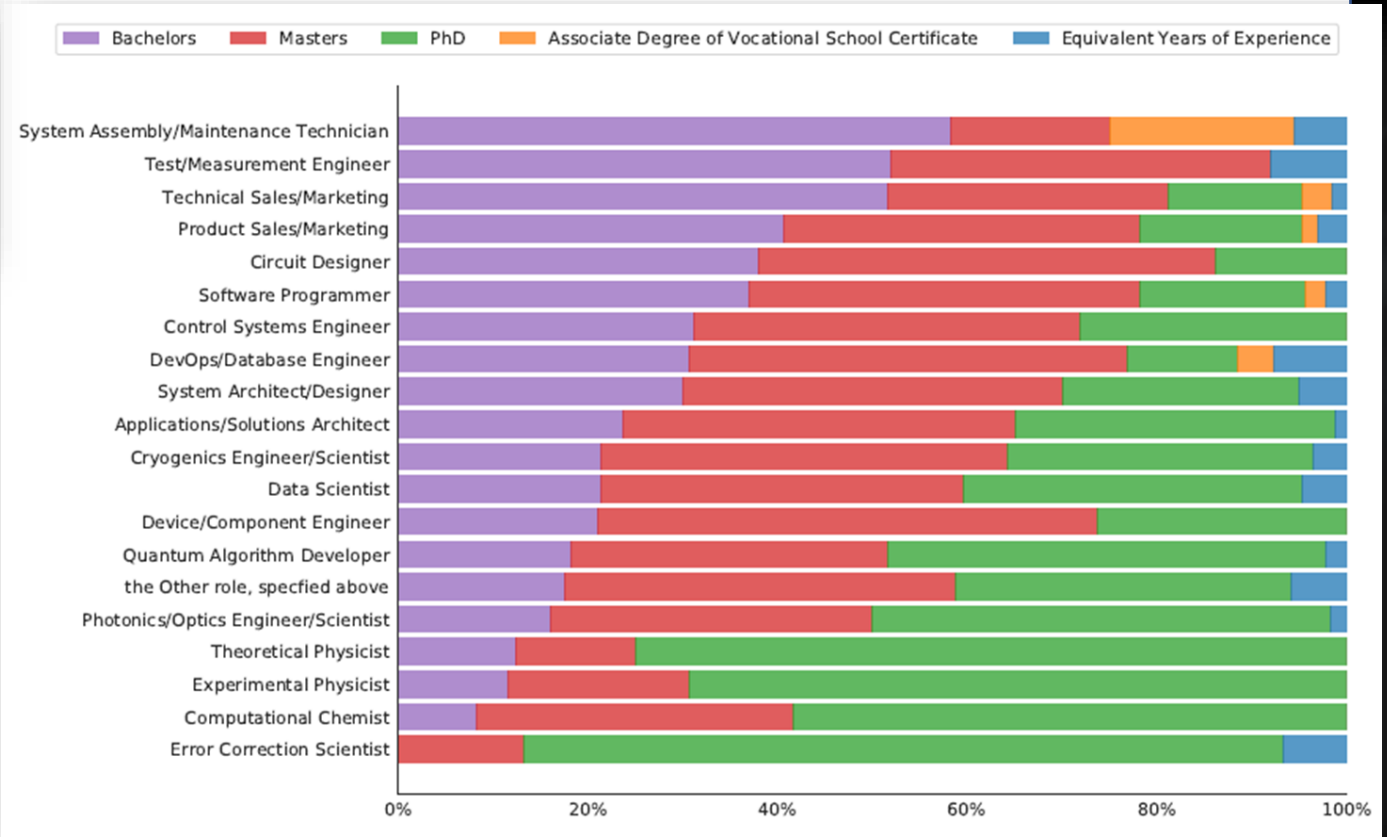
Assessing the Needs of the Quantum Industry

Ciaran Hughes, Doug Finke, Dan-Adrian German, Celia Merzbacher, Patrick M. Vora, and H. J. Lewandowski

Abstract*—*Background: **Quantum information science and technology (QIST) has progressed significantly in the last decade, such that it is no longer solely in the domain of research labs, but is now beginning to be developed for, and applied in, indus-**

quantum-enabled products. The most well-known highlight was a demonstration of the quantum advantage, where a 53-qubit quantum computer achieved a benchmark not possible within a reasonable timescale on a classical computer [1]

- ✓ Survey of QED-C member companies
- ✓ Hiring plans show steady growth
- ✓ Diverse jobs will need to be filled (including sales, marketing and other business roles)
- ✓ Diverse skills will be required—many are NOT quantum-specific
- ✓ Most jobs do not require a PhD



doi:10.1109/TE.2022.3153841

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