

# Quantum Economic Development Consortium (QED-C)

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SRI International

QED-C DISTRIBUTION

# QED-C LOI Signatories

1. 1QB Information Technologies
2. Advanced Research Systems (ARS)
3. Amazon
4. AO Sense
5. APS
6. ARM
7. AT&T
8. Atom Computing
9. BAE Systems
10. Boeing
11. Boston Consulting Group
12. Bra-Ket
13. Caltech/INQNET
14. Citi
15. ColdQuanta
16. Colorado School of Mines
17. Corning
18. D-Wave
19. Entanglement Institute
20. EZ Form Cable Corp.
21. Fieldline
22. FLIR
23. GE Global Research
24. General Dynamics Mission Systems
25. George Mason University
26. Google
27. Harris
28. Honeywell
29. HPD
30. Hyperion Research
31. IBM
32. Inside Quantum Technology
33. Intel
34. IonQ
35. Janis Research
36. Keysight
37. KLA-Tencor
38. KMLabs
39. Lake Shore Cryotronics
40. Lockheed Martin
41. Microchip/Microsemi
42. Montana Instruments
43. NuCrypt
44. Photodigm
45. Photon Spot
46. Psi Quantum
47. QC Ware
48. QPRI
49. Qrypt
50. Quantum Circuits
51. Quantum Xchange
52. Qubitekk
53. Raytheon-BBN
54. Rigetti
55. Riverside Research
56. Rydberg Technologies
57. SEMI
58. SkyWater Technology Foundry
59. Stable Laser Systems
60. Strangeworks
61. SRI International
62. Toptica
63. Twinleaf
64. UMD
65. Vescent Photonics
66. Zapata Computing
67. Zyvex Labs

# The Birth and Development of an Industry



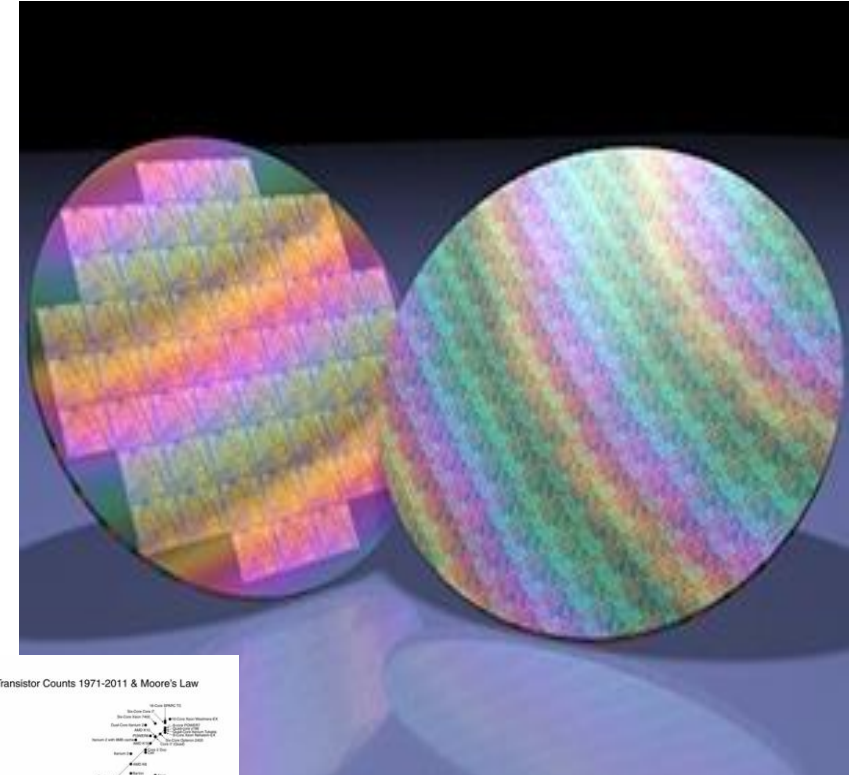
**First Transistor, 1947**

**William Shockley, John Bardeen, and Walter Brattain**

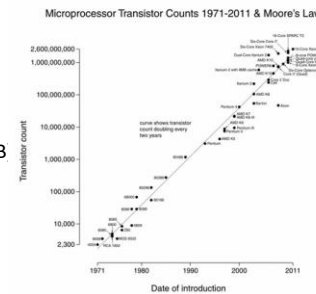
## INDUSTRY & INFRASTRUCTURE

### Supply Chain of Enabling Technologies

- Wafer processing
  - Wet cleans
    - Cleaning by solvents
    - Piranha solution
    - RCA clean
  - Photolithography
  - Ion implantation
  - Dry etching
  - Wet etching
  - Plasma ashing
  - Thermal treatments
    - Rapid thermal anneal
    - Furnace anneals
  - Thermal oxidation
  - 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
    - Wire bonding
    - Thermosonic bonding
    - Flip chip
    - Wafer bonding
    - Tape Automated Bonding (TAB)
- IC encapsulation
  - Baking
  - Plating
  - Lasermarking
  - Trim and form
- IC testing



**2018, IC (12", < 10 nm)**



# Quantum Economic Development Consortium (QED-C)

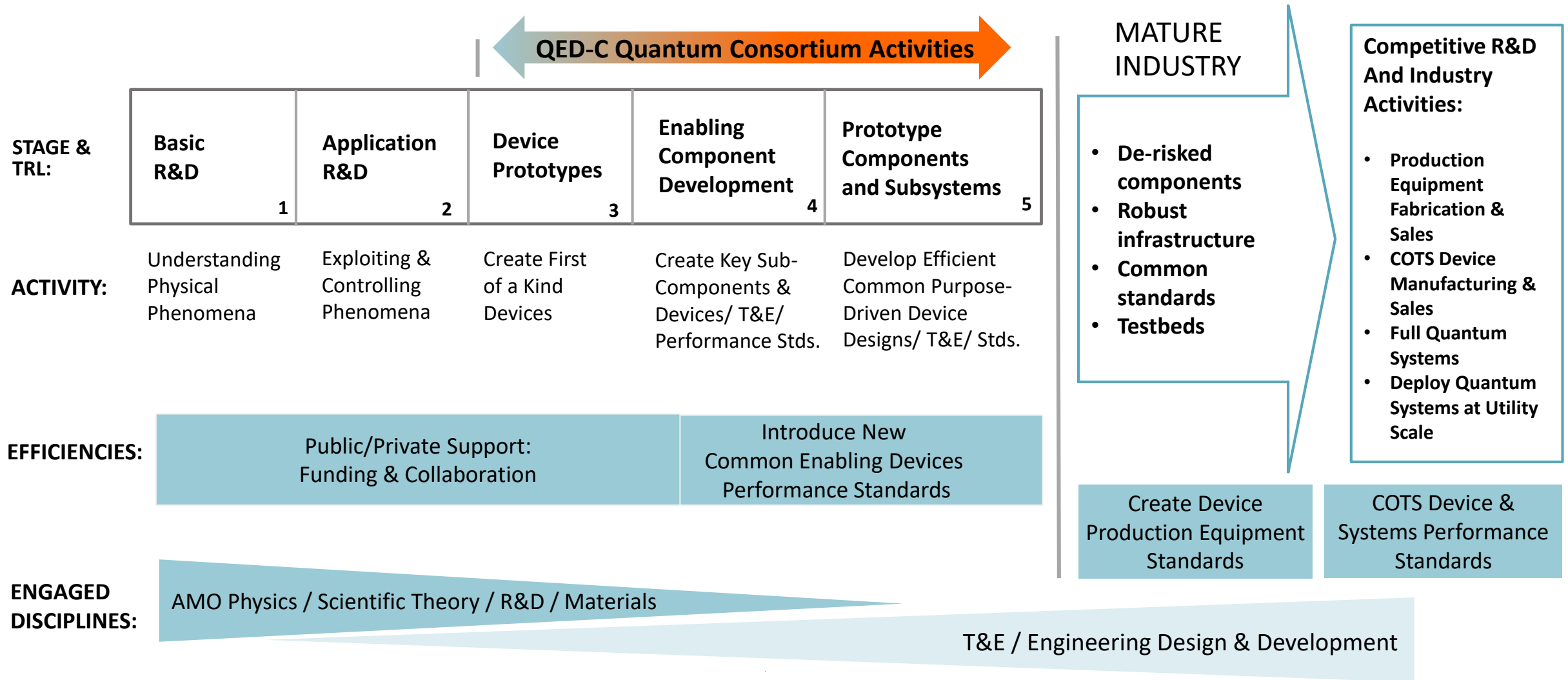
.... Will accelerate the Quantum Industry by fostering a robust Supply Chain and Infrastructure (including workforce and standards).

- Definition of a Consortium: an agreement, combination, or group of companies formed to undertake an enterprise beyond the resources of any one member
- SRI has been contracted to establish a Quantum Economic Development Consortium for the emerging Quantum Industry

The “QED-C”



# Quantum Enabling Device Development Continuum



# The Purpose of the QED-C is:

- To identify gaps and support enabling technology R&D to enhance the quantum “ecosystem”: e.g., quantum device components, instrumentation, performance and manufacturing standards, and workforce
- To facilitate industry coordination and interaction with Government agencies
- To provide the Government with a collective industry voice in guiding R&D investment priorities, use cases, and quantum workforce issues

# The Objectives of the QED-C

- Identify Gaps and the technology solutions for filling gaps in enabling technology and infrastructure;
- Determine workforce needs essential to the development of quantum technologies;
- Highlight use cases and grand challenges to accelerate development efforts;
- Foster sharing of intellectual property, efficient supply chains, technology forecasting and quantum literacy;
- Provide efficient public-private sector coordination; and
- Support standards development of the emerging quantum industry

# The Value Proposition of the QED-C: *Output / Input >> 1*

- Competitive Benefits: The U.S. Quantum Industry is nascent and fragmented (along transition, technical, organizational, sector and funding dimensions), and is  $\leq$ , or  $\ll$ , Near-Peer: EU, UK, China... *The QED-C will foster strong industry collaboration and coordination.*
- Close Enabling Technology Gaps: *The QED-C will help build a strong supply chain for research and industrial productivity.*
- The QED-C offers efficiency over “standard” RFP processes:
  - Coordinated public/private funding, and coordinated funding among multiple Federal agencies
  - Encourages non-traditional industry partners
- It's not about spending more... *The QED-C will spend smarter!*
- The U.S. Quantum Industry will benefit from performance and evaluation standards... *The QED-C will facilitate SDO participation.*



# QED-C Membership

The QED-C is primarily “Tier 1 Members of U.S. Industry” (voting members at all sizes and stages) to support U.S. economic growth:

- Includes Members that would self-identify as “members of the quantum industry community”, or “participating in the emerging quantum industry”
- Also includes equipment suppliers, instrumentation OEM’s, materials companies, service providers, end-users, etc.

QED-C will also engage “Tier 2 Members” (non-voting members):

- International Companies and Partnerships (non-US majority-owned)
- Academic Community (Non-voting for U.S. as Tier 1 Academic, and non-U.S.- Tier 2 Academic)
- Standards Development Organizations
- Professional Societies
- Investment Community

# QED-C Deliverables

## Years 1 & 2:

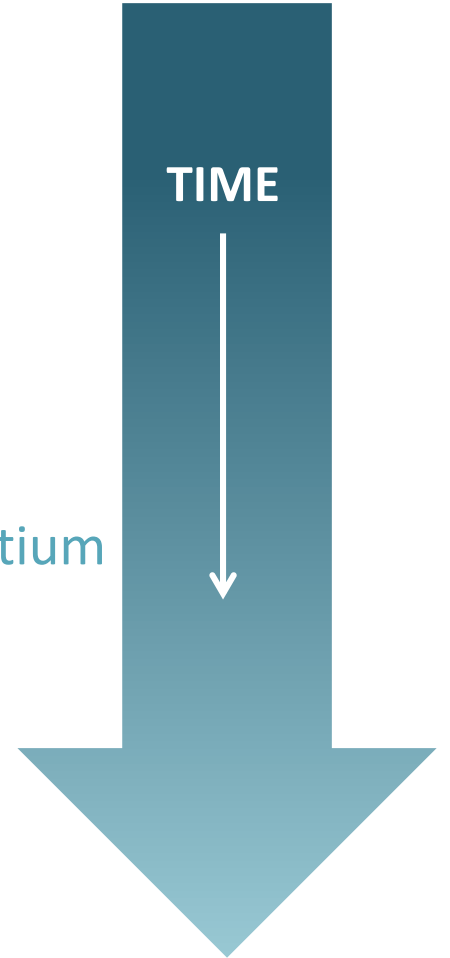
- Gap Identification and Needed Enabling Technology and Infrastructure
- Needs Assessments for Instruments and Tools
- Workforce Requirements Analysis and Actions
- Input to USG for R&D Programs

## Year 2+:

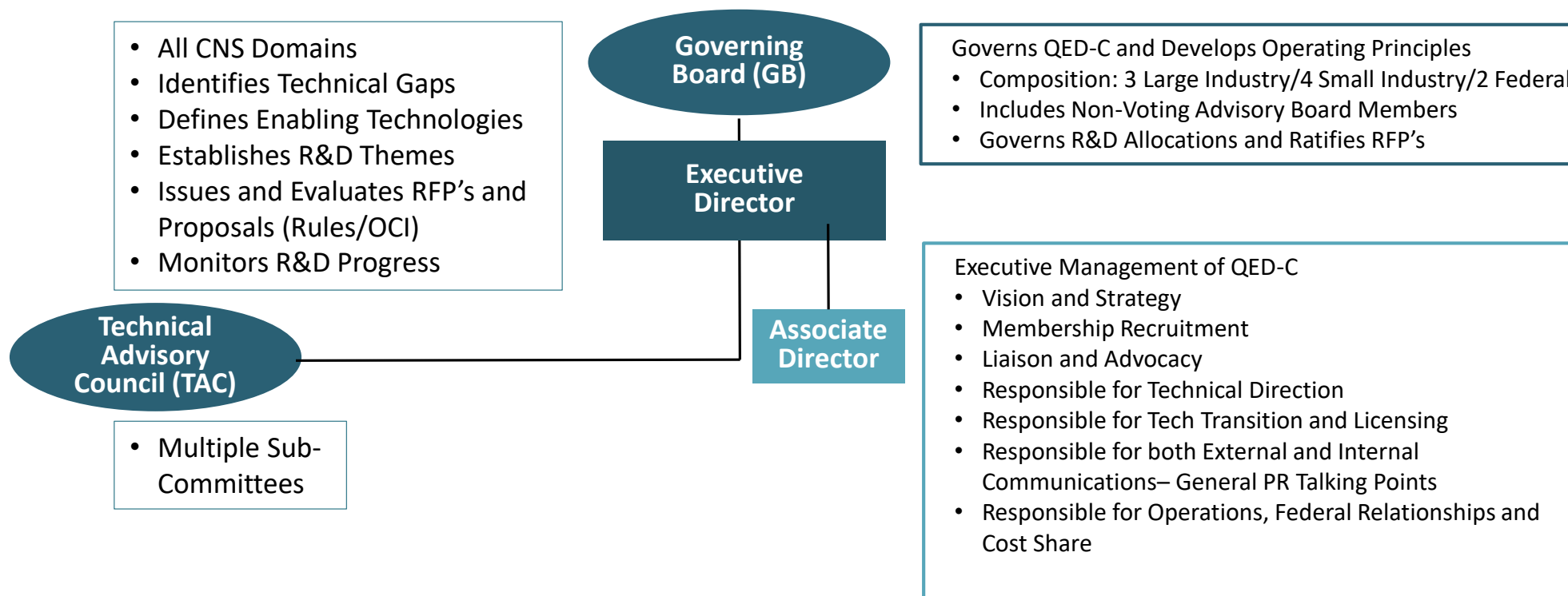
- Cost-Shared Funding of Enabling Technology R&D Programs in the Consortium

## Potential Out-Year Activities:

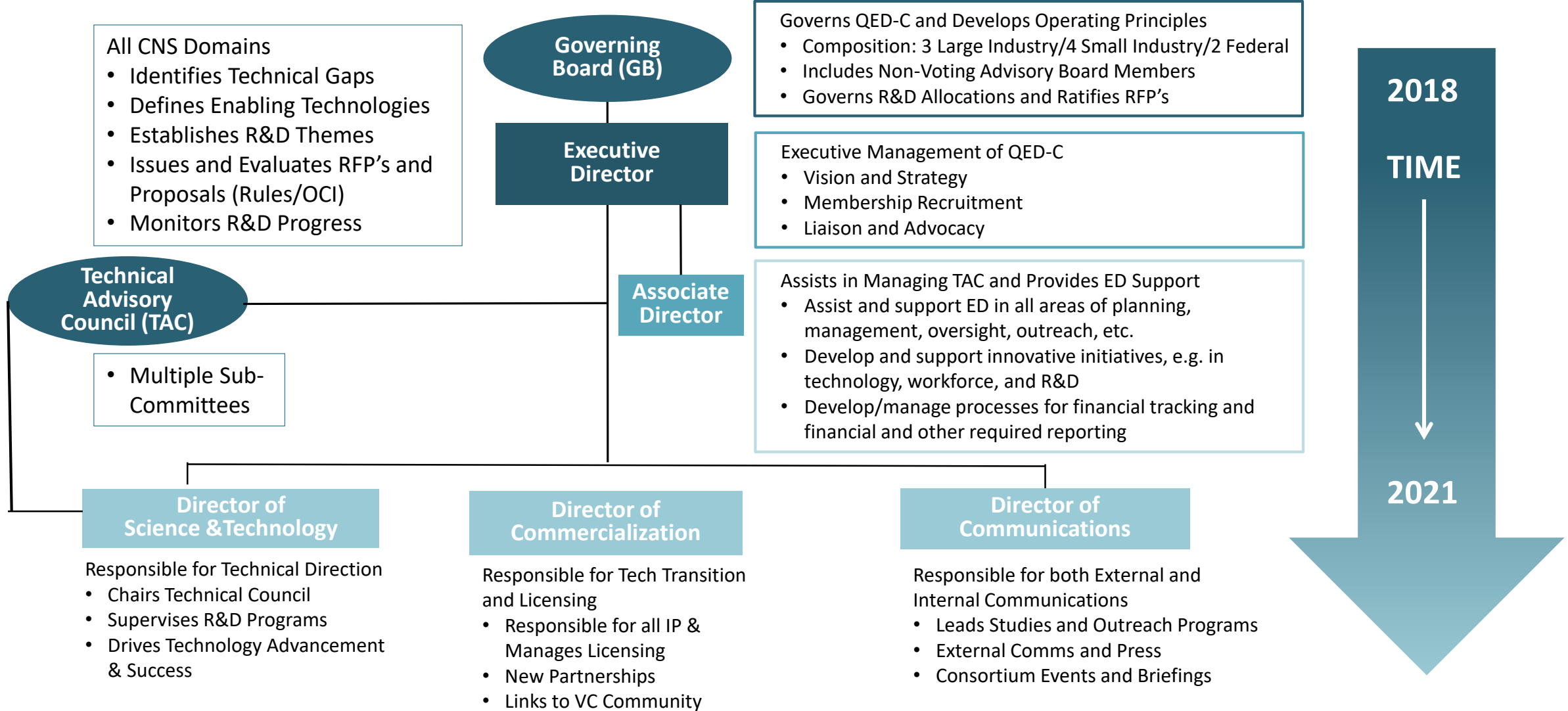
- Facilitate Quantum Standards and Metrics
- Use Cases and Studies of Q-Advantage
- Q-Community Representation
- Scientific and Market Forecasts



# Present QED-C Organizational Structure 2018



# Proposed Phased QED-C Organizational Structure





# Operational Structure and Leadership

Ratified

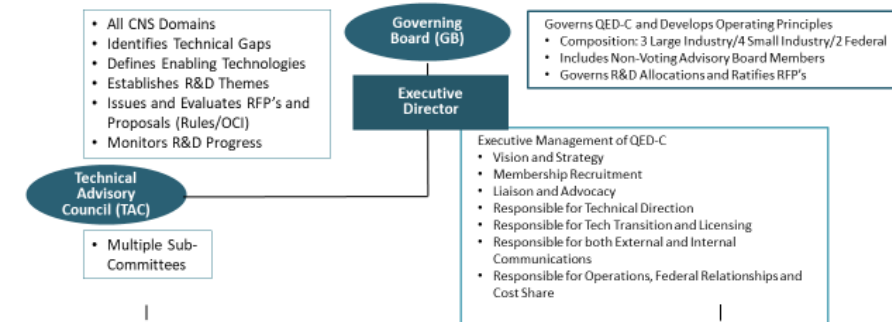
## Governing Board Composition (3-4-2)

- Large Industrial members (3)
- Representatives of medium and small-size companies (4)
- Federal Partners (2)
- (Possibly) non-voting state or regional economic development representatives
- Others as approved by GB

## Technical Advisory Council

- Multiple Sub-Committees with Leadership
  - Workforce
  - Enabling Technologies
  - Standards and Performance Metrics
  - Use Cases
- TAC SC's make recommendations to GB

## Present QED-C Organizational Structure 2018



# QED-C Governing Board

Ratified

(Elected October 29, 2018 to a 2-Year term)

- Jay Lowell, Boeing
- Dana Anderson, Cold Quanta
- Steve Binkley, DOE
- Eric Ostby, Google
- Mark Ritter, IBM
- Carl Williams, NIST
- Matt Johnson, QCWare
- Open Seat (formerly Rigetti)
- Christopher Savoie, Zapata Computing

Joe Broz, SRI Acting QED-C Chairman and Executive Director (Non-voting)

Celia Merzbacher, Associate Director (non-voting)

## Initial Board Composition (3-4-2)

- Large Industrial members at highest dues levels (3)
- Representatives of medium and small-size companies (4)
- Federal Partners (2) + USG Observers
- (Possibly) non-voting state or regional economic development representatives
- Others as approved by GB

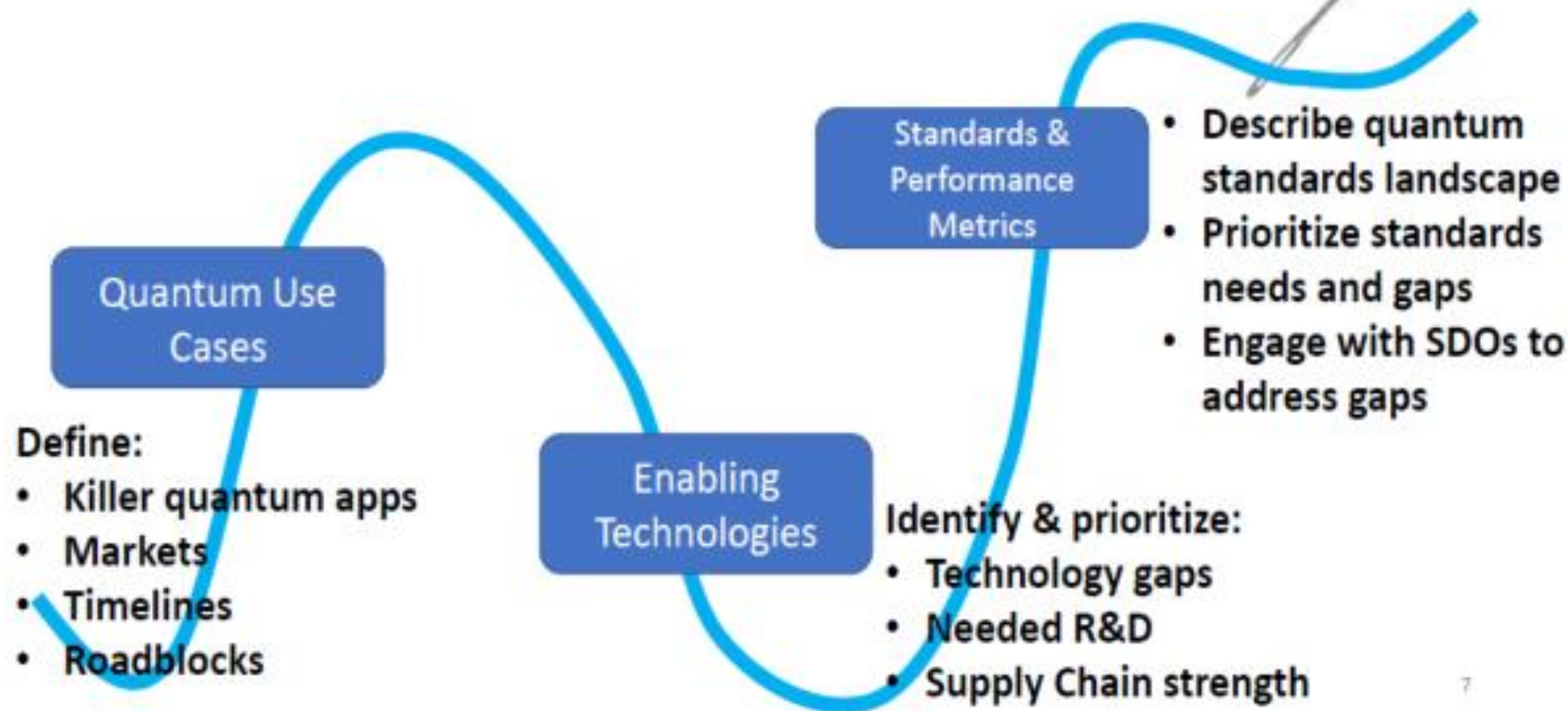
# QED-C Technical Advisory Council Sub-Committees

- **Workforce** – Leader: Jason Turner, Entanglement Institute. Quantum workforce shortfall, data, solutions, USG R&D impact, Assess Resources Required
- **Enabling Technologies** – Leader: Thomas Ohki, Raytheon BBN. Identify gaps, Categorize, Prioritize, Identify needed R&D, Supply Chain, Assess Required Resources
- **Quantum Use Cases** – Leader: Jim Gable, Bra-Ket Sciences. Define the “Killer Quantum Apps”, Markets, Timeline, Roadblocks, CONOPS, CSWaP, R&D Required
- **Standards and Performance Metrics** – Leader: Tom Lubinski, Quantum Circuits, Inc. Types of Stds. and KPI’s, Organization(s) and Structures

# Cross-TAC Integration

## Workforce:

- The “Needle” that “Threads” through all TAC’s





# Consortium and IP Owner Rights

- USG License: Grant to the USG a non-exclusive, nontransferable, paid-up, worldwide perpetual license to use the Consortium IP for any Government purpose
- Evaluation License: Grant to each QED-C Member a non-exclusive, royalty-free, non-transferable license for the duration of Member's membership to use the Consortium IP (without the right to sublicense) for the limited purposes of further evaluation and R&D
- Commercial License: On request, grant to any QED-C Member a non-exclusive, transferable worldwide license (with the right to sublicense) on commercially reasonable, nondiscriminatory ("RAND") terms
- Third-Party Licenses: On terms negotiated by the Development Partner

# Consortium Development 3-Year Timeline (DRAFT)

## 2019:

- Complete formation documents (IP, Membership, Dues, etc.); All LOI's converted to formal Participation Agreements; Grow Membership to 50+ entities
- Initial TAC Deliverables on Workforce and Infrastructure Gaps, Identify Major Enabling Technology Gaps, Primary Use Cases, and Survey the Quantum Standards Landscape

## 2020:

- Establish Consortium R&D Strategy (by USG and Industry) for closing identified Gaps
- Complete initial Enabling Technologies, Workforce, Use Case, and Standards Landscape
- Set-up system for Enabling Technology R&D Funding and Evaluation; Prepare and Issue initial R&D RFP's

## 2021:

- First Proposal Award(s) and First Technology Transition and Consortium License(s) Issued
- SDO Implementation of Initial Quantum Performance and Quantum Manufacturing Equipment (QME) Industry Standards
- Expand Enabling Technology Funding and TAC Subcommittee Scope; Add TAC SC's

# Why Industry Should Support Standards?

- Standards Allow transparent Intra-Device Comparison:
  - Q2Q: Defines Development Pathways
  - Q2C: Quantifies Quantum Advantage and ROI
  - Enables credible measures of Progress and Advancement/Manages the “hype” surrounding quantum technologies
- Supports Supply Chain Development by Reducing Investment Risk in Emerging Enabling Technologies
- Creates a level playing field for Solution Vendors, and Establishes a Global Market among Standards Participants
- Well-crafted Standards accelerate Transition, Growth, and Industry Development; Allows companies to efficiently Innovate and take Products to Market

# Conclusions

- The QED-C is off to a fast-start, with 63 members (large and small)
- Membership includes majority of the U.S. Quantum Industry and significant Manufacturing Supply Chain companies; Membership Tiers defined for foreign company and academic engagement
- Industry Technical Advisory Councils in key areas of: Workforce, Quantum Manufacturing Equipment and Enabling Technologies, Primary Quantum Use Cases, and Standards
- QED-C focused on identifying and resolving major enabling technology barriers and gaps, technical standards, use cases, and workforce issues
- The QED-C has established a formal structure for Standards Development, Consortium IP Development and Licensing



