

The Cyber Breakfast Club®

Mr. Mike Charobee
Founder of SaaS Security Outfitter CYBER BUYER®
President and Founder of The Cyber Breakfast Club
6 Regional Chapters and over 200 Members
Nationwide
<https://www.linkedin.com/in/mikecharobee/>



Building a Quantum Foundry

Presented to Cyber Breakfast Club – Chicago Chapter

Wednesday, November 5, 2025

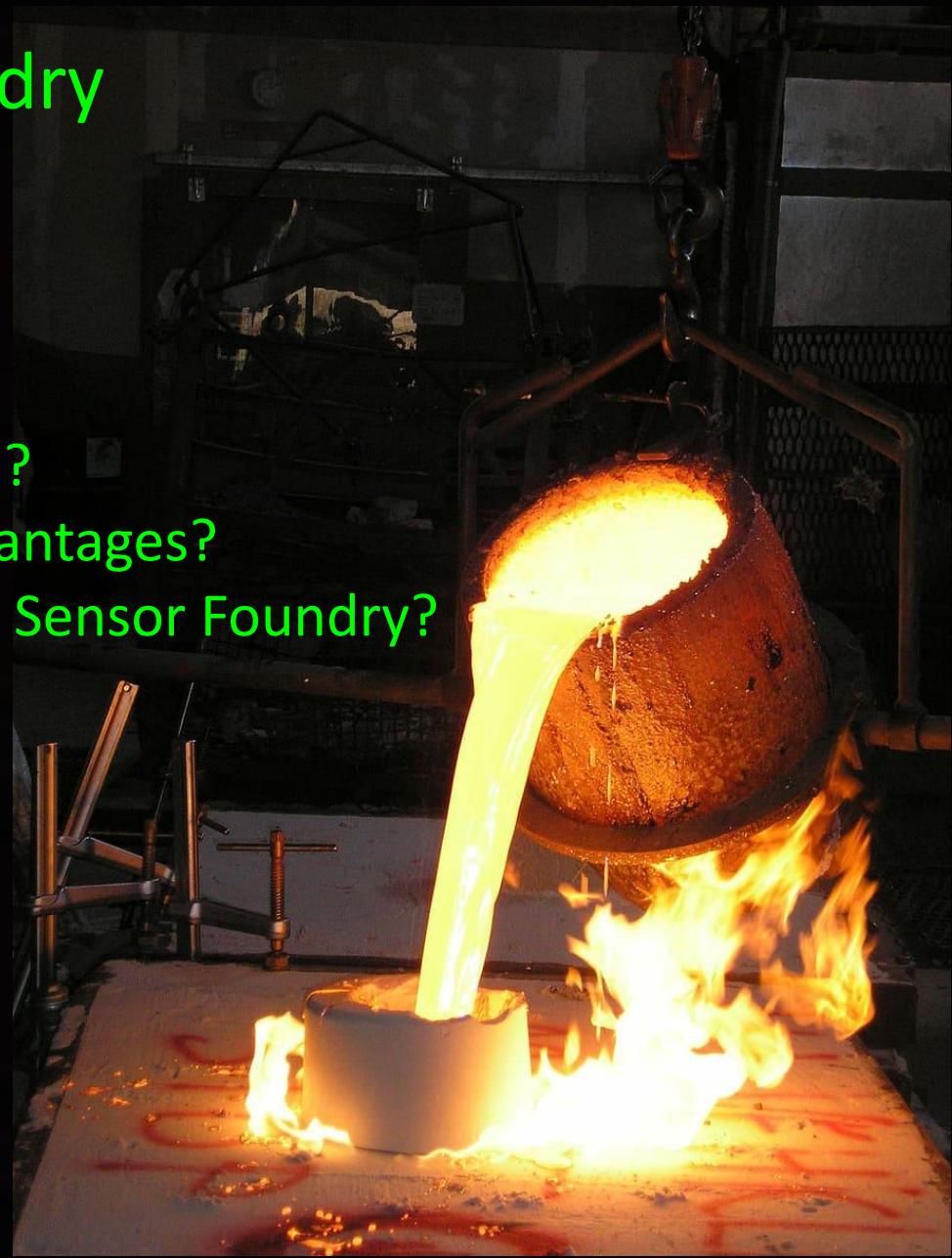
From Chicago, (Wicker Park), Illinois, USA

William Slater
President & CEO
Slater Technologies, Inc.

Building a Quantum Foundry

Agenda

- Introduction
- Announcements
- What is a " Quantum Foundry "?
- What Are the Benefits and Advantages?
- What Gets Made in a Quantum Sensor Foundry?
- How Do You Establish and Operate a Quantum Foundry?
- Examples
- A Cautionary Tale
- Conclusion
- Questions
- References
- About Me



Building a Quantum Foundry

Introduction

- Quantum Computing hardware, algorithms, and software are now evolving rapidly, giving birth to a new paradigm in computing.
- But it typically requires an understanding of mathematics and quantum physics concepts that are unfamiliar to many who are used to computing with more traditional computing platforms and software. To enable this new Quantum paradigm of computing, industry leaders like the IEEE, Google, Microsoft, IBM, Intel, NVIDIA, and DWave, are working diligently to usher in this new era of computing.
- The Standards being formed by these Quantum Industry leaders are helping to further accelerate the maturation, adoption, and use of quantum computing. But with this paradigm shift to Quantum Computing has come a realization that optimization maturity models and economics must be applied to ensure that investments are made wisely.
- ***This is an introduction on Building a Quantum Foundry will further refine and advance the use of Quantum Technologies using repeatable processes and best practices.***

Building a Quantum Foundry

Announcements



1. **Presentation:** You can each have a copy of this presentation:
<https://billslater.com/quantumfoundrychi.pdf>
2. **DARPA – Defense Advanced Research Projects Agency**
– We are finalist candidates for a multi-million Quantum Foundry DARPA Project
3. SPECIAL BONUS: Two Slides in this side deck contain information that will save you LOTS of MONEY. Look for this symbol:



Slater Technologies

Building a Quantum Foundry

What Is a “Quantum Foundry”?

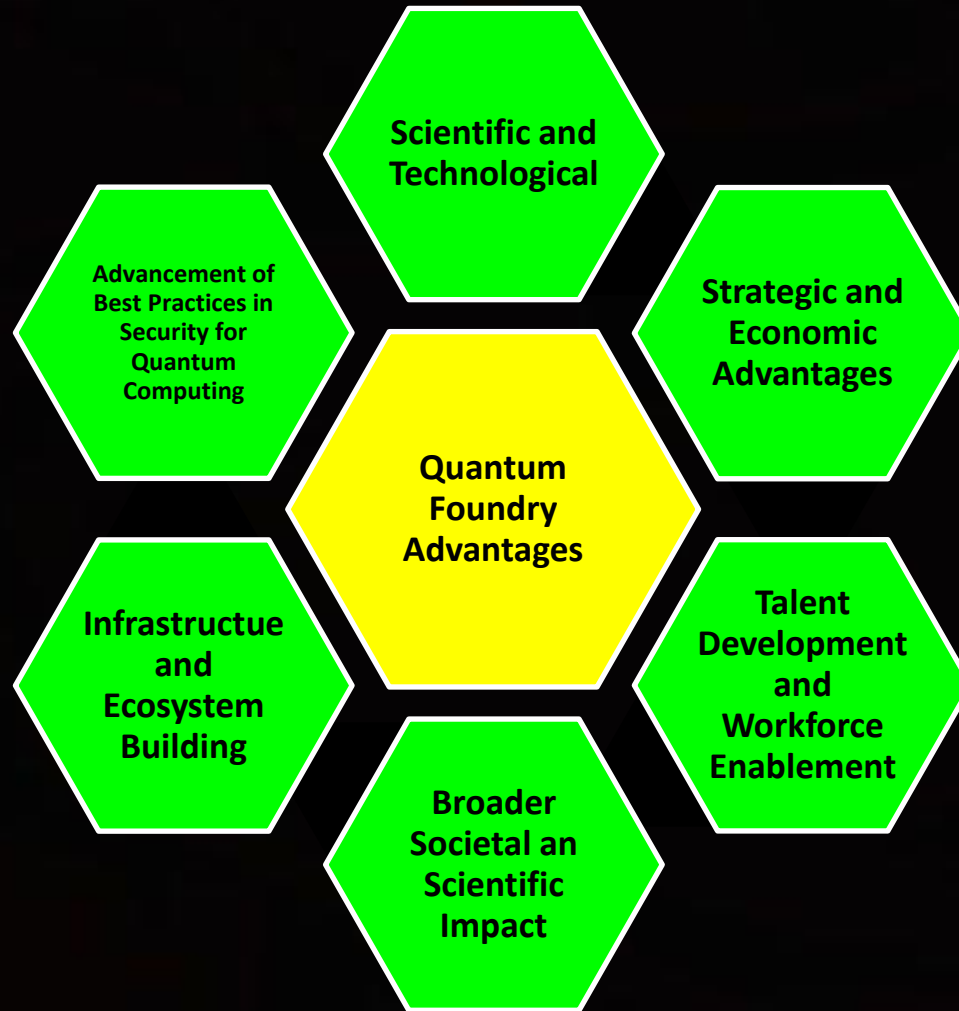
A **Quantum Foundry** — more specifically, a **Quantum Processing Unit (QPU) foundry** — is a specialized facility dedicated to the design, prototyping, and fabrication of custom quantum chips tailored to specific requirements. (Bing, 2025)

Quantum Foundry Copenhagen develops tools and processes for quantum chip manufacturing. Using advanced ultra high vacuum approaches, we will enable the future of high-performance quantum processors. (<https://qfcph.com/>, 2025)

Building a Quantum Foundry at UC Santa Barbara is a next generation materials foundry that develops materials and interfaces hosting the coherent quantum states needed to power the coming age of quantum-based electronics. The mission of the Foundry is to develop materials hosting unprecedented quantum coherence, train the next generation quantum workforce, and to partner with industry to accelerate the development of quantum technologies. (<https://quantumfoundry.ucsb.edu/>, 2025)

Building a Quantum Foundry

What Are the Benefits and Advantages?



Enter the Quantum Zone



Building a Quantum Foundry

What Are Quantum Sensors?

Within quantum technology, a quantum sensor utilizes properties of quantum mechanics, such as quantum entanglement, quantum interference, and quantum state squeezing, which have optimized precision and beat current limits in sensor technology. The field of quantum sensing deals with the design and engineering of quantum sources (e.g., entangled) and quantum measurements that are able to beat the performance of any classical strategy in a number of technological applications. This can be done with photonic systems or solid-state systems. (Wikipedia, 2025).

Building a Quantum Foundry

Why Quantum Sensors?

"Quantum sensors allow the estimation of parameters with precision higher than that obtained with classical strategies. Devices based on quantum physics have allowed the precise estimation of the gravitational field, the detailed imaging of the brain, the detection of gravitational-wave sources more than 400 million light years away, and an ever-increasing precision in the measurement of time. Quantum metrology, which is the conceptual framework that encompasses all these devices, is reviewed here, emphasizing recent results regarding noisy systems." Source: (Davidovich, 2024).

Building a Quantum Foundry

How Do Quantum Sensors Work?

1. Preparation of the Quantum System
2. Exposure to the Physical Quantity
3. Measurement of the Quantum State
4. Data Interpretation

(Boom, S., 2024)

Building a Quantum Foundry

What Gets Made in a Quantum Sensor Foundry?

Quantum Sensors and Quantum Sensor Components.

Here is a short list of present types of Quantum Sensors in use today:

1. Quantum Magnetometers
2. Atomic Clocks
3. Quantum Gravimeters
4. Quantum Accelerometers
5. Quantum Thermometers
6. Quantum LDAR (Light Detection and Ranging)
7. Atomic electric field sensors

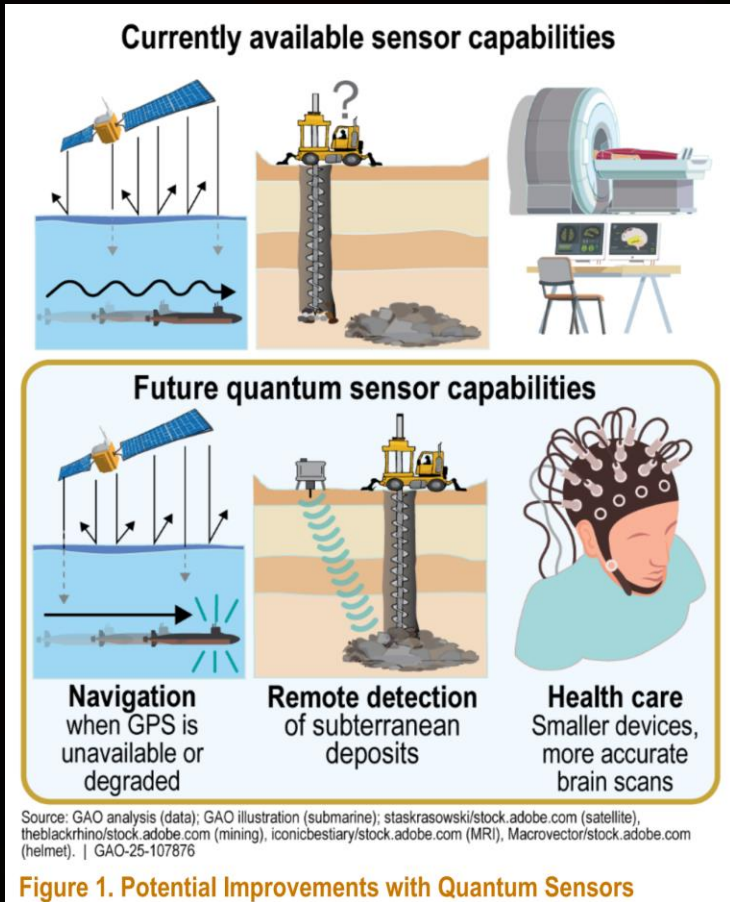
Source: (Boom, S., 2024)

(National Council for Science and Technology, 2022)

Building a Quantum Foundry

What Gets Made in a Quantum Sensor Foundry?

Sensors and Quantum Sensors – Example Uses

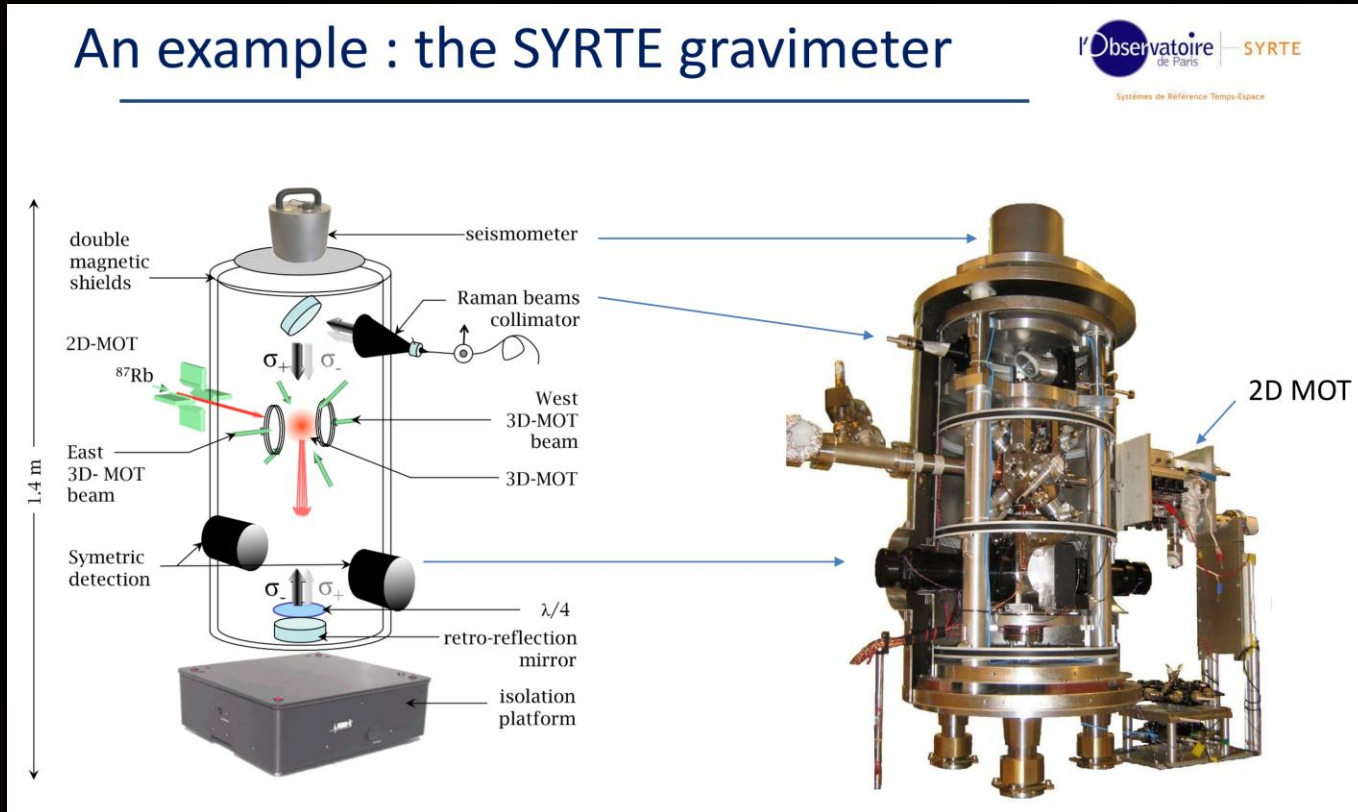


Source: (Government Accountability Office, 2025)

Building a Quantum Foundry

What Gets Made in a Quantum Sensor Foundry?

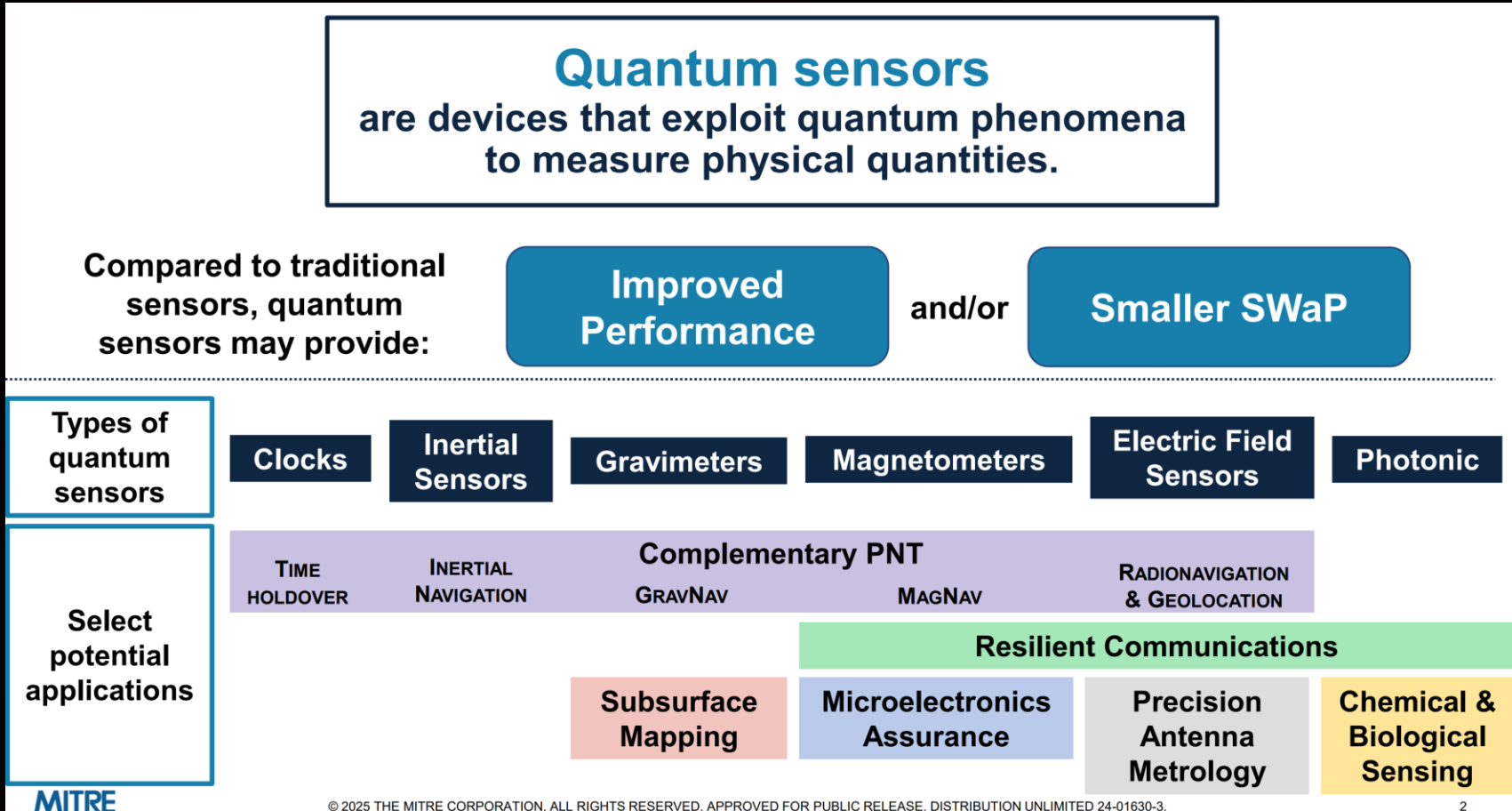
Quantum Sensors – Example Gravimeter



Source: (Santos, 2024)

Building a Quantum Foundry

Quantum Sensors - Types



© 2025 THE MITRE CORPORATION. ALL RIGHTS RESERVED. APPROVED FOR PUBLIC RELEASE. DISTRIBUTION UNLIMITED 24-01630-3.

2

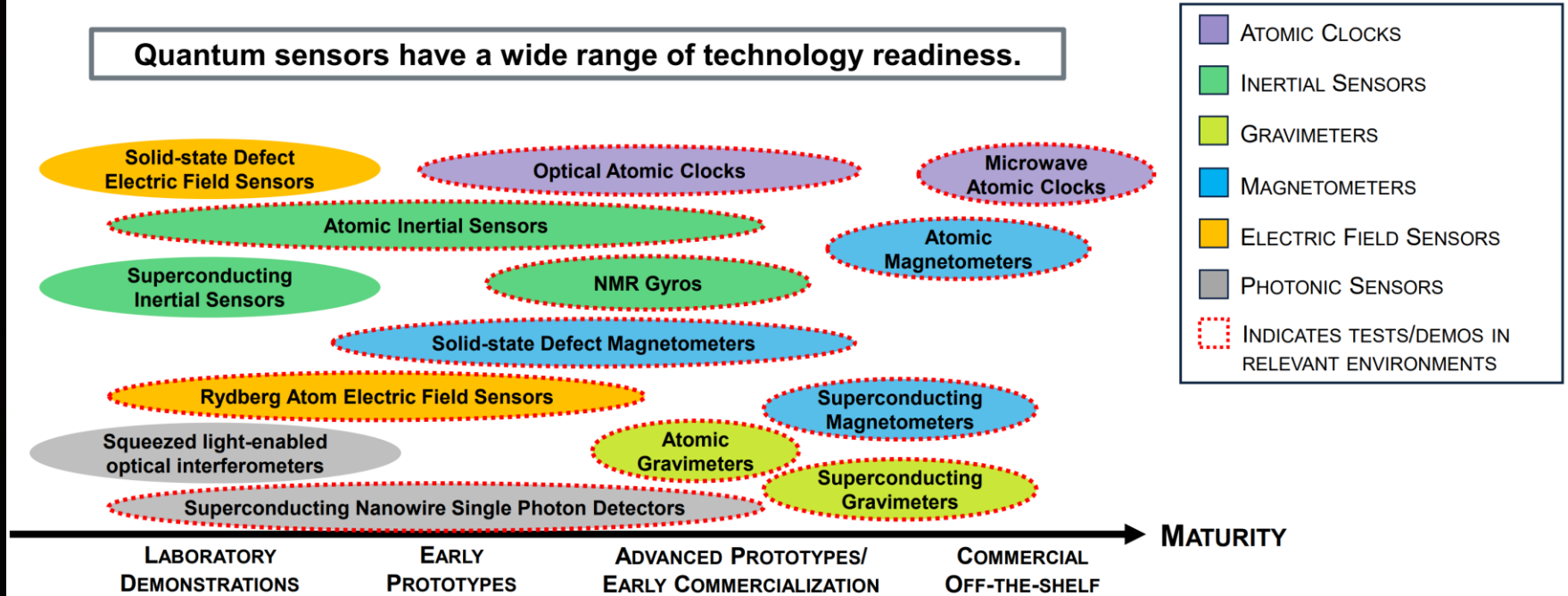
Source: (Backes, 2025)

Building a Quantum Foundry

Quantum Sensor Maturity

Maturity of Quantum Sensors

Quantum sensors have a wide range of technology readiness.



Source: (Backes, 2025)

Building a Quantum Foundry

Quantum Sensors – Facilitating the Development and Utilization

Box 7: Recommendations to Facilitate the Development and Utilization of Quantum Sensors

- 1. Agencies leading QIST R&D should accelerate the development of new quantum sensing approaches and prioritize appropriate partnerships with end users to elevate the technology readiness of new quantum sensors.**
- 2. Agencies that use sensors should conduct feasibility studies and jointly test quantum prototypes with QIST R&D leaders to identify promising technologies and to focus on quantum sensors that address their agency mission.**
- 3. Agencies that support engineering R&D should develop broadly applicable components and subsystems, such as compact reliable lasers and integrated optics, to facilitate the development of quantum technologies and promote economies of scale.**
- 4. Agencies should streamline technology transfer and acquisition practices to encourage the development and early adoption of quantum sensor technologies.**

Source: (National Council for Science and Technology, 2022)

Building a Quantum Foundry

Quantum Sensors - the Future and Development Challenges

Outlook

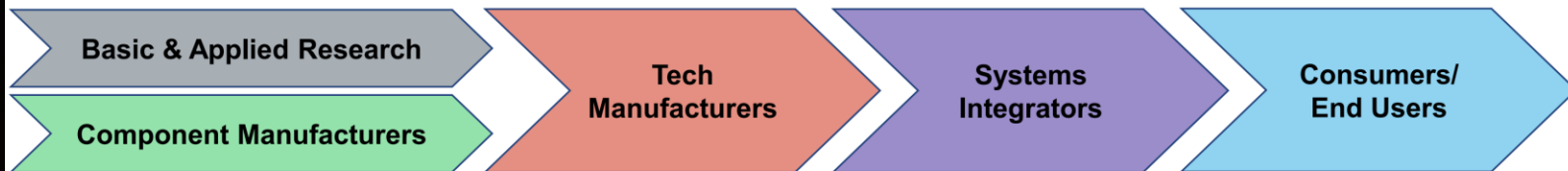
Challenges for Advancing Quantum Sensor R&D

Key Challenge I: Miniaturization and Ruggedization

- Photonic integration
- Laser miniaturization
- Atomic integration (e.g., waveguides for atoms)
- Fabrication (e.g., nitrogen-vacancy defects in diamond)
- Improved portability of ultra-high vacuum systems and cryogenic/liquid nitrogen cooling systems

Key Challenge II: Connecting End Users with Researchers and Developers to Accelerate the R&D Pipeline

- Facilitating increased communication between end users/other stakeholders and sensor researchers & developers would enable early identification of potential systems integration challenges, ruggedization requirements, and impactful performance metrics



Source: (Backes, 2025)

Building a Quantum Foundry

Quantum Sensors – Timelines and Metrics to Track Development Progress – Years 1 - 3

1-3 Years. In the next 1-3 years, community actions should include:

- Briefings and seminars on quantum sensors provided by QIST R&D leaders to various agencies. Surveys of available sensors and analysis of their impact on agency missions/needs should support these briefings. Ideally, these briefings will result in follow-up efforts to jointly test and demonstrate quantum sensors, as well as produce curated lists of existing and feasible performance metrics.
- Potential end users should engage with QIST-focused professional society meetings, workshops, and roundtables about their needs. End users could participate in proposers' day events to inform the R&D community about their interest in quantum technologies and desired performance metrics.
- Facilitate appropriate partnerships for new quantum sensor R&D on a rolling basis, to engage joint field tests and the evaluation of preliminary results. Acquisitions, demonstrations, and co-design of quantum sensors should help to pioneer and validate new applications. For tracking and assessment, it will be valuable to catalog existing and new joint R&D efforts on quantum sensors and their contributions toward maturing quantum sensing technologies.
- Identify specific, high-value applications for quantum sensors that can justify dedicated engineering and manufacturing efforts. One output would be prioritized lists of key components with specifications and plans for the associated engineering R&D.
- Identify and prioritize lists of engineering infrastructure and R&D activities that are needed to address gaps in enabling technologies and applications enabled by each activity. Estimate the time and investment required for each activity and its potential impact. Activities or infrastructure that will facilitate a broad set of quantum applications should be encouraged.
- Identify or establish bodies within agencies that can assist with the resolution of legal and policy issues in such a manner that facilitates quantum sensor technology development.
- Track engineering and scientific breakthroughs, as well as bibliometrics, participants, patents, licensing for quantum sensing technologies, and sales or revenue for quantum sensors, and track the key components or supporting technologies, both domestically and internationally.
- Project realistic resources required, including the supporting workforce, to implement the recommendations in this document.

Source: (National Council for Science and Technology, 2022)

Building a Quantum Foundry

Quantum Sensors – Timelines and Metrics to Track Development Progress – Years 3 - 8

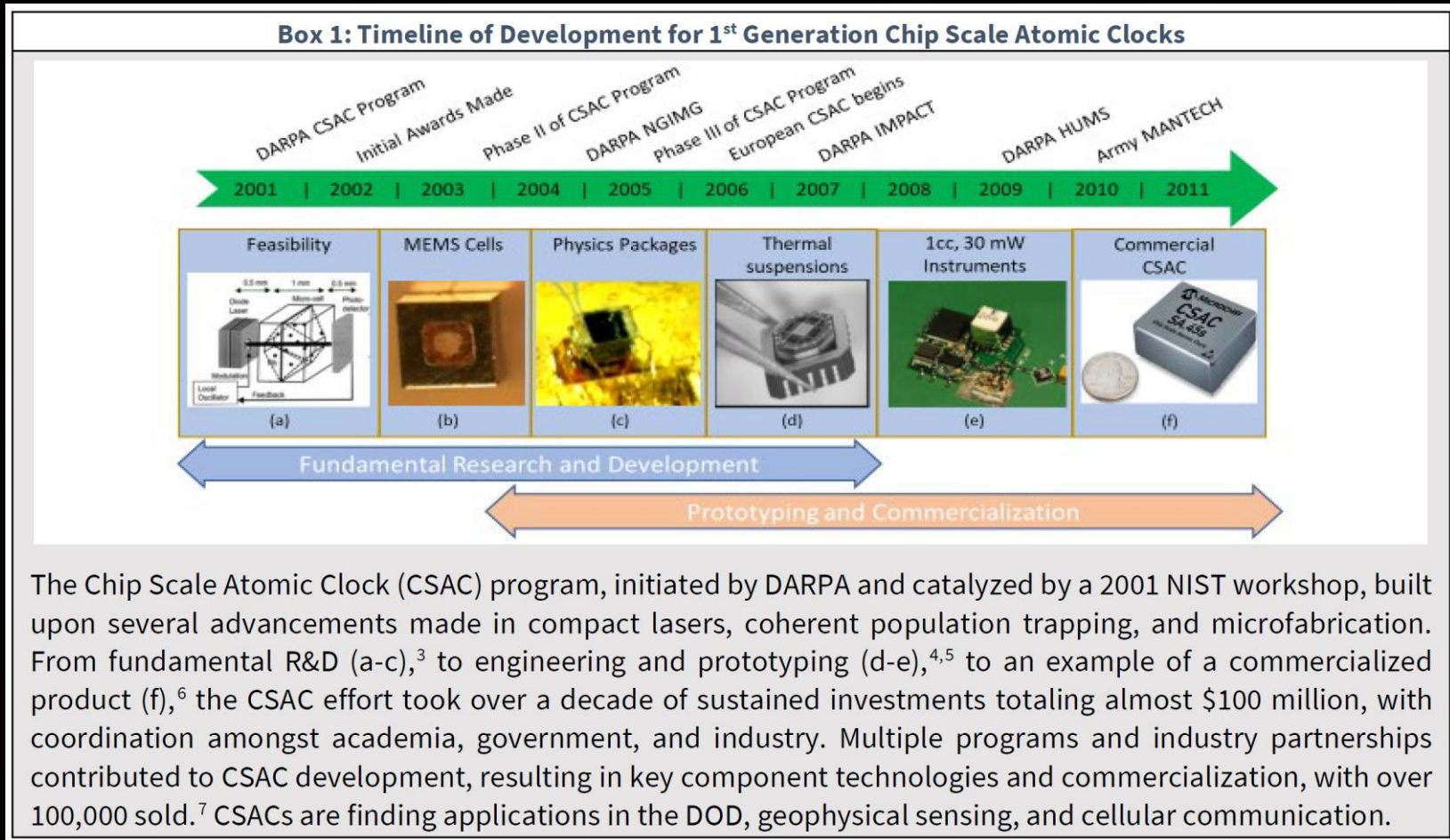
3-8 Years. Once suitable technologies have been identified by coordinated activities, over the next 3-8 years, the R&D community and the agencies in the SCQIS should work to:

- Collaborate with end users to perform field tests and demonstrations that expedite early adoptions and transitions.
- Prioritize component miniaturization and subsystem integration.
- Develop and build R&D infrastructure through consortia and foundries.
- Develop standards for the identified quantum sensors and component technologies.

Source: (National Council for Science and Technology, 2022)

Building a Quantum Foundry

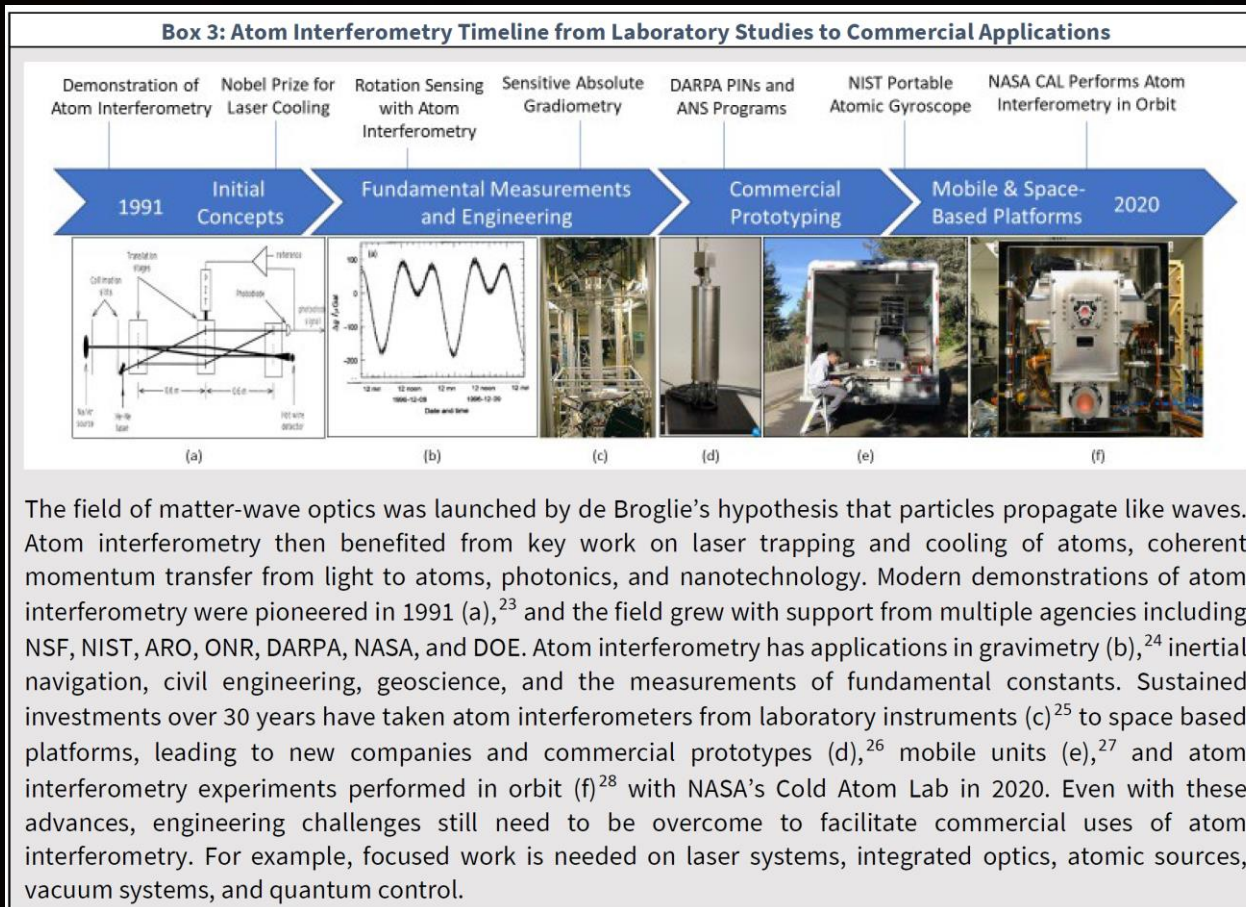
Quantum Sensors – 1st Generation Chip Scale Atomic Clocks



Source: (National Council for Science and Technology, 2022)

Building a Quantum Foundry

Quantum Sensors – Atom Interferometry Timeline, Lab Studies to Commercial Applications

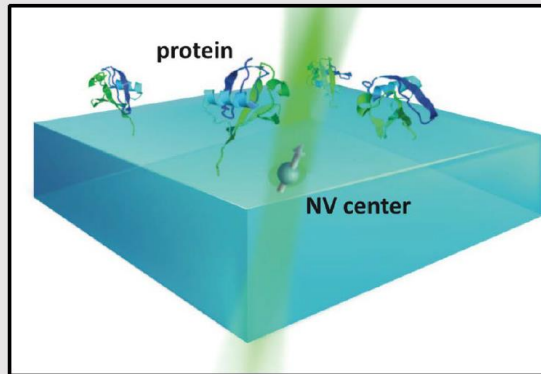


Source: (National Council for Science and Technology, 2022)

Building a Quantum Foundry

Quantum Sensors – Nitrogen Vacancy Center Magnetometry

Box 5: Nitrogen Vacancy Center Magnetometry Highlight



(a)



(b)

Nitrogen Vacancy (NV) centers in diamond allow for magnetometry and nuclear magnetic resonance (NMR) spectroscopy and imaging with spatial resolution approaching the nanometer scale. R&D on NV centers has spanned over two decades, with participation from NSF, NIST, DOE, DOD, and NIH. Notable achievements include the detection of multiple nuclear species within ubiquitin proteins, such as in (a),³⁵ NMR spectral resolution using NV centers, such as in (b),³⁶ the demonstration of scanning confocal microscopy with single NV centers, nanoscale magnetic field sensing, single cell imaging using quantum diamond microscope, and detection of single neuron excitations in live specimens. A possible near-term application for an NV diamond magnetic imager may be to detect changes in the conduction velocity of action potentials caused by diseases such as multiple sclerosis.

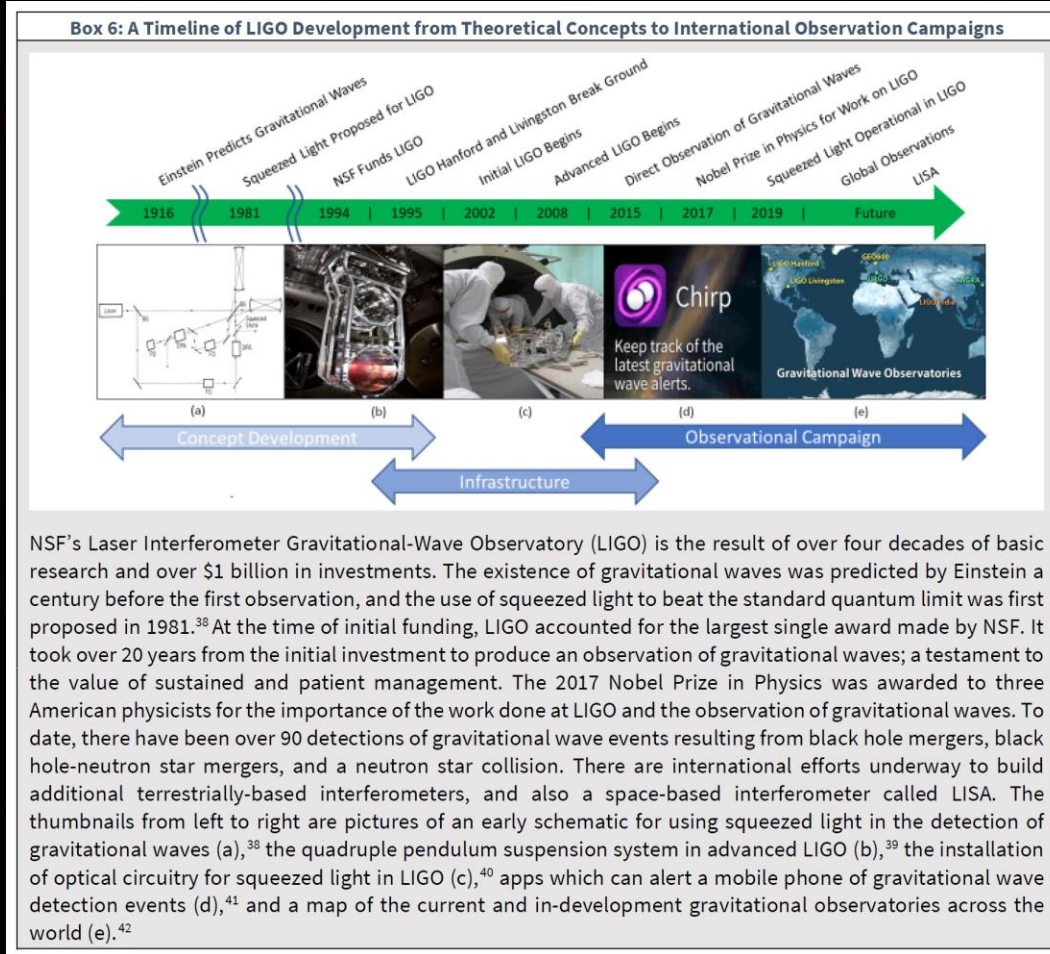
Source: (National Council for Science and Technology, 2022)



Building a Quantum Foundry

Quantum Sensors – LIGO Development Timeline

LIGO = Laser Interferometer Gravitational-Wave Observatory



Source: (National Council for Science and Technology, 2022)

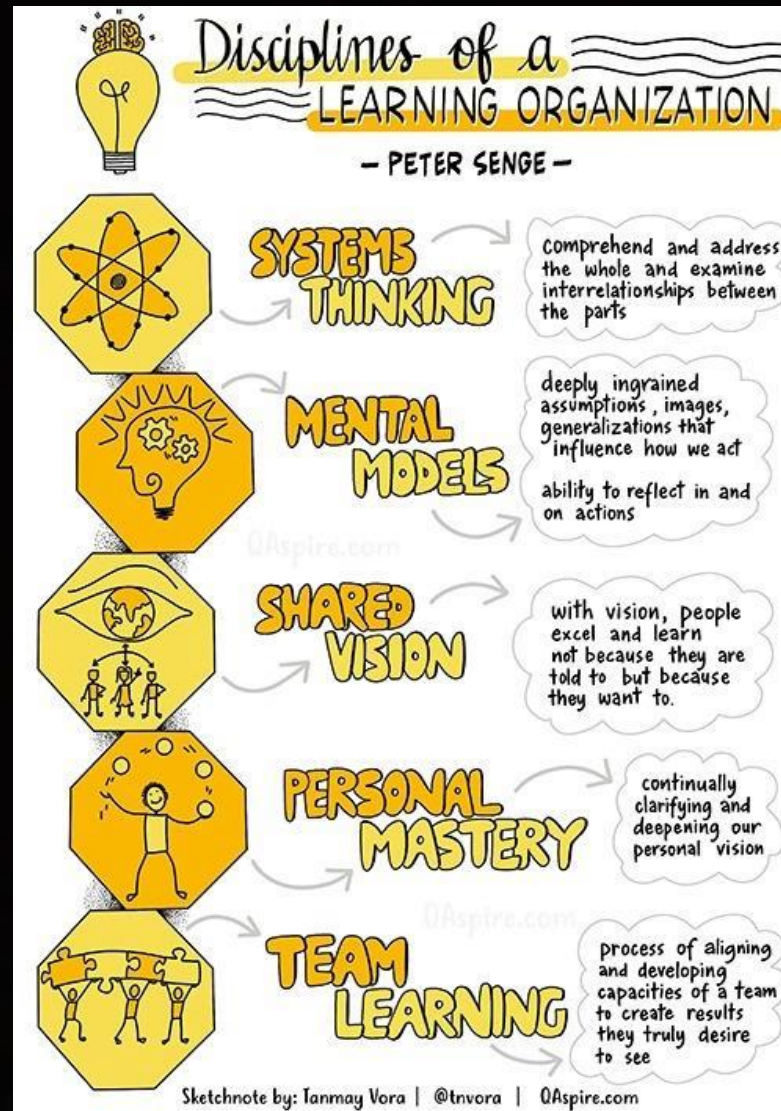
Building a Quantum Foundry

How Do You Establish and Operate a Quantum Foundry?

1. Build a Strong Quantum-Focused Team
2. Come up with great ideas
3. Appoint strong, Results-Focused Leaders with strong Leadership Skills, Quantum Skills, and People Skills, who can build strong Learning Teams (based on the *Peter Senge Learning Team Disciplines*)
4. Build a solid Project Plan and Budget
5. Get Sponsors and Funding
6. Kick off the Project and Execute on your Team's Shared Vision

Building a Quantum Foundry

How Do You
Establish and
Operate a
Quantum Foundry?
Peter Senge
Learning Team
Disciplines



Building a Quantum Foundry

How Do You Establish and Operate a Quantum Foundry?

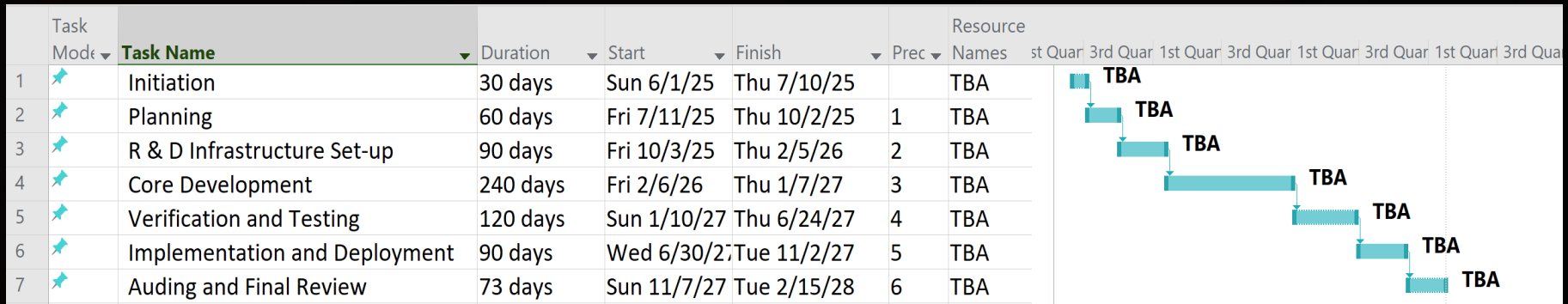
Project Phases with Key Deliverables

Phase	Timeline	Key Deliverables
Initiation	Month 1	Project Charter, Stakeholder Register, High-Level Requirements
Planning	Months 2–3	Work Breakdown Structure, Risk Plan, Schedule, Resource Plan
R&D Infrastructure Setup	Months 4–6	Lab Setup, Tools & Software Procurement, Team Onboarding
Core Development	Months 7–14	Quantum Sensor Design, Algorithms, Programming, PoCs
Verification & Testing	Months 15–18	Test Plans, Performance Benchmarks, Debug Reports
Implementation & Deployment	Months 19–21	Deployed Applications, Integration with Existing Systems
Auditing & Final Review	Months 22–24	Audit Reports, Lessons Learned, Final Presentations

Building a Quantum Foundry

How Do You Establish and Operate a Quantum Foundry?

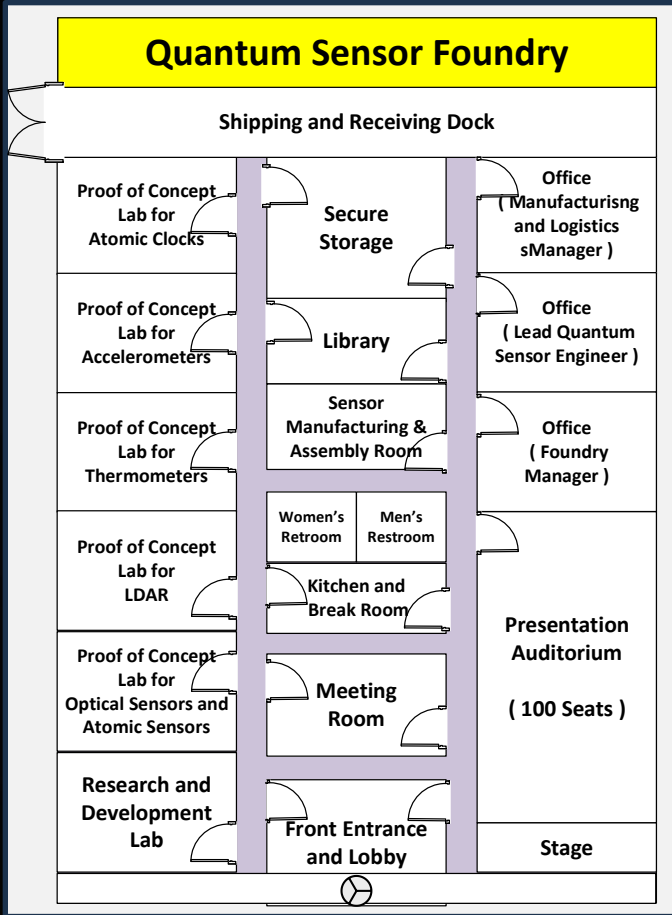
Project Phases High-Level Gantt Chart Timeline



Building a Quantum Foundry

What Does A Quantum Sensor Foundry Look Like?

Proposed Floor Plan, Resources, and Staff



Resources
Sensor Materials
Measurement and Calibration Tools
Computers
Access to the Internet & the Strategic Quantum Foundry Cloud Network
Artificial Intelligence and Component / Product Databases
CAD Tools
Library

Staff
Foundry Manager
Lead Quantum Sensor Engineer
Manufacturing and Logistics Manager

Building a Quantum Foundry

What Does A Quantum Sensor Foundry Look Like?

Future Expansion Plans:

Proposed Cloud Network with Strategic Quantum Sensor Foundry Locations

Designator	Location
SQSF01	Chicago, IL
SQSF02	Spokane, WA
SQSF03	Madison, WI
SQSF04	Tucson, AZ
SQSF05	Birmingham AL
SQSF06	Reno, NV
SQSF07	Pensacola, FL
SQSF08	Conroe, TX
SQSF09	Tulsa, OK
SQSF10	Albuquerque, NM
SQSF11	Memphis, TN
SQSF12	Burlington, VT
SQSF13	Merrimack, NH

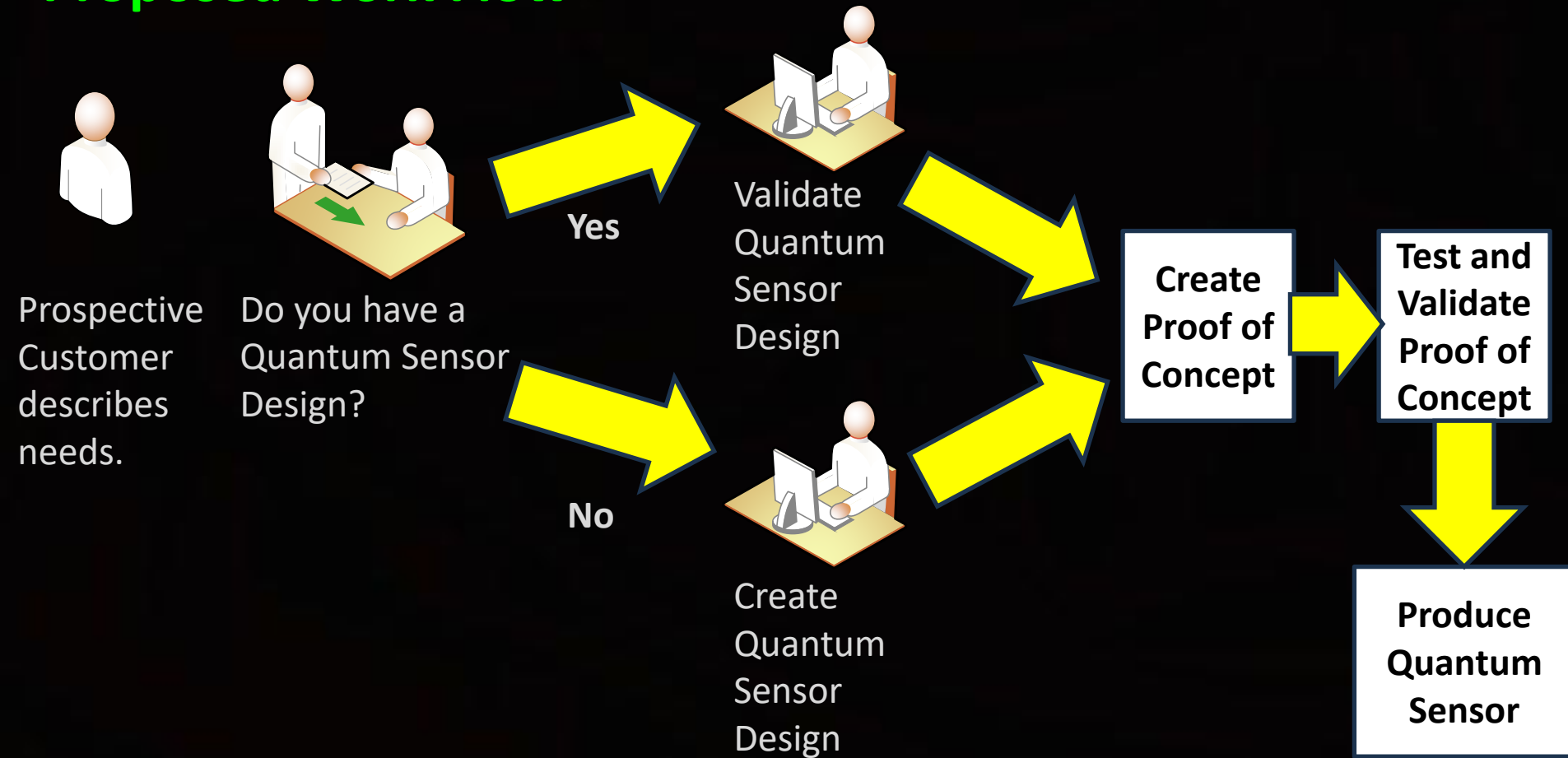


Strategic Quantum
Sensor Foundry
Network

Building a Quantum Foundry

What Does A Quantum Sensor Foundry Look Like?

Proposed Work Flow



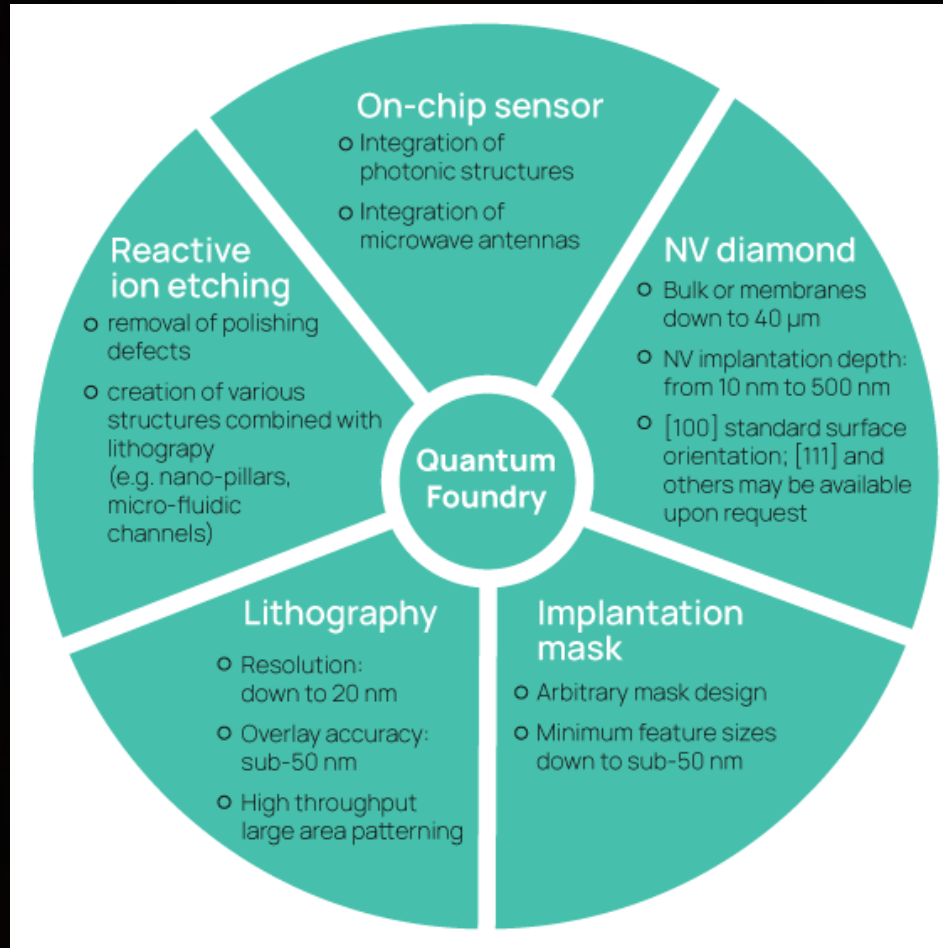
Building a Quantum Foundry

Examples

- 1. We chose a *Quantum Sensor Foundry* as our example.
- 2. Switzerland has a Quantum Sensor Foundry, *Qnami*.

Building a Quantum Foundry

Swiss Quantum Sensor Foundry Services



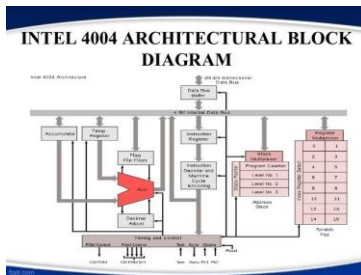
This diagram is from Qnami in Switzerland, which is operating as a functional Quantum Sensor Foundry. (Qnami, 2025).

Building a Quantum Foundry

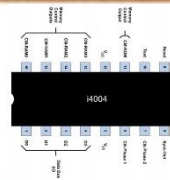
A Cautionary Tale

Ted Hoff, Co-Inventor of the Intel i4004 CPU, the World's First commercially available microprocessor:

"You can be smart and talented, and invent and produce great things, but if you can't demonstrate the Business Value, and Market it and monetize it, you are doomed to fail."



Ted Hoff, Inventor of the Microprocessor



- ◆ Introduced: November 15, 1971
- ◆ Clock speed: 108 kilohertz
- ◆ Transistor Count: 2,300
- ◆ Chip Performance: .06 MIPS (millions of instructions per second)
- ◆ Circuit Line Size: 6.5 (10 microns)
- ◆ Addressable memory: 640 bytes
- ◆ The 4004 microprocessor was originally built on 2-inch silicon wafer.
- ◆ The 4004 was Intel's first microprocessor. This breakthrough invention powered the *Business calculator* and paved the way for embedding intelligence in inanimate objects as well as the personal computer.



Source: <https://www.youtube.com/watch?v=7MgHsgoilQ4&t=80s>


Building a Quantum Foundry

Conclusion

- Rapid advances in Quantum Physics and Quantum Science have led to the creation of Quantum Computers and Quantum Sensors.
- Using tools like Quantum Computers and Quantum Sensors we are now able to compute things and measure phenomena in ways that are helping us discover more science and in shorter periods of time than ever imagined.
- One essential key to enable the acceleration of the development of Quantum Technologies will be Building a Quantum Foundry.
- As more organizations discover the efficiencies and successes that result from Quantum Foundries, they will become a preferred method of manufacturing Quantum Technologies.

Building a Quantum Foundry

Conclusion



"The future is
already here –
it's just not
evenly
distributed."
–William Gibson

Building a Quantum Foundry

Questions and Answers



Supplemental Slides


Quantum References

- Ahsan, M., Meter, R V., and Kim, J. (2015). Designing a Million-Qubit Quantum Computer Using a Resource Performance Simulator. A scholarly article published at the ACM in December 2015. Retrieved from: <https://tinyurl.com/ya2q92xa>.
- Aaronson, S. (2013). Quantum Computing Since Democritus. Published by Cambridge University Press, Cambridge, UK.
-  Backes, K. (2025). "Quantum Sensors for Complementary PNT and Resilient Communications. Published and Compyrighted by Mitre Corporation. Retrieved from https://www.westconference.org/WEST25/Custom/Handout/Speaker0_Session11709_1.pdf .
- Bricmont, J. (2017). Quantum Sense and Nonsense. Published by Springer. Louvein la Nouve, Belgium.
- Bloom, S. (2024). "What Is Quantum Sensing and How Does It Work?". Published on December 24, 2024. Retrieved from <https://scientificorigin.com/what-is-quantum-sensing-and-how-does-it-work>.
- Chancé, A., et al. (2024). "AI-driven Quantum Molecular Sensing For Cybersecurity". A presentation to QSECDEF on November 24, 2024. Retrieved from <https://bit.ly/4dyhOgd> .
- Chongo. (2021). Homeless Interpretation of Quantum Mechanics. (Self-Published). Yosemite National Park, CA.
- Davidovich, L. (2024). "Quantum Sensing: Beyond the Classical Limits of Precision", A research paper published at the Institute of Quantum Science and Engoneering, Texas A&M University, College Station, Texas. Retrieved from <https://arxiv.org/pdf/2401.136588> .
- Da Silva, W. (2015). Quantum computer coding in silicon now possible. Published at the University of New South Wales Newsroom on November 17, 2015. Retrieved from: <https://newsroom.unsw.edu.au/news/science-tech/quantum-computer-coding-silicon-now-possible> .
- DeAngelis, S. (2014). A Glossary of Quantum Computing Terms. Retrieved from <https://www.enterrasolutions.com/blog/glossary-quantum-computing-terms/> .
- Esat, T., et al. (2024). " A Quantum Sensor for Atomic-Scale Electric and Magnetic Fields ". Am article published at Nature Nanotechnology, July 25, 2024. Retrieved from <https://www.nature.com/articles/s41565-024-01724-z.pdf> .
-  Esterlis, I. (2024). Quantum Sensing (condensed matter perspective) - A presentation prepared for the Wisconsin Summer School for Science, University of Wisconsin Madison, Augus 28, 2024. Retrieved from https://www.physics.wisc.edu/quantum-summer-school/wp-content/uploads/sites/16/2024/09/quant_science_summer_school_2024.pdf .
- Fedorov, A. K. , Kiktenko, E. O., and Lvovsky, A. I. (2018). Quantum computers put blockchain security at risk. Published November 19, 2018 in Nature. Reteived from: <https://www.nature.com/articles/d41586-018-07449-z> .
- Gerschenfeld, N. and Chuang, I. L. (1998). Quantum Computing with Molecules. Published in the June 1998 edition of Scientific American magazine. Retrieved from: <http://cba.mit.edu/docs/papers/98.06.sciqc.pdf> .


Quantum References

- Gomes, L. (2018). Quantum Computers Strive to Break Out of the Lab. Published at IEEE Spectrum on March 22, 2018 Retrieved from <https://spectrum.ieee.org/computing/hardware/quantum-computers-strive-to-break-out-of-the-lab>.
- Government Accountability Office (CAO) (2025). Science & Tech Spotlight - Quantum Sensors. GAO-25-107876, January 2025. Retrieved from <https://www.gao.gov/assets/gao-25-107876.pdf> .
- Gururaja, W. (2016). "Advances in Quantum Sensors: Principles and Applications". Published in IJRAR, June 2018, Volume 3, Issue 2. Retrieved from <https://ijrar.org/download.php?file=IJRAR19D6172.pdf> .
- Herman, A. (2018). Winning the Race in Quantum Computing. Published in American Affairs Journal. Retrieved from: <https://americanaffairsjournal.org/2018/05/winning-the-race-in-quantum-computing/> .
- Hidary, J. D. (2019). Quantum Computing: An Applied Approach. Published by Springer Nature. Switzerland.
- Hoff, T. (2009). Lecture by Ted Hoff at U.C. Berkley. Located at: <https://www.youtube.com/watch?v=7MgHsgoilQ4&t=80s> .
- Hurley, W. (2018). Quantum Computing Standards. A webinar presented on April 24, 2018 and located at <https://www.youtube.com/watch?v=qKt7dOf4pXY&t=7s> .
- IBM. (2018). IBM Q. Located at <https://www.research.ibm.com/ibm-q/>.
- IEEE. (2018). IEEE P7130 - IEEE Nomenclature Standard. Quantum Computing Working Group. Located at: <https://standards.ieee.org/develop/project/7130.html> .
- IEEE. (2018). IEEE P7131 - IEEE Benchmarking Standard. Quantum Computing Working Group. Located at: <https://standards.ieee.org/develop/project/7131.html> .
- Johnston, E., et al. (2019). Programming Quantum Computers. Published by O'Reilly. Sebastapol, CA.

Quantum References

- Kaye, P., et al. (2010). An Introduction to Quantum Computing. Published by Oxford University Press. Oxford, UK.
- Kholodov, I. (2009). The von Neumann Computer Model. From the CIS-77 course at Bristol Community College. Retrieved from: <http://www.c-jump.com/CIS77/CPU/VonNeumann/lecture.html> .
- Klarreich, E. (2018). Graduate Student Solves Quantum Verification Problem. Published in Quanta Magazine, October 8, 2018. Retrieved from <https://www.quantamagazine.org/graduate-student-solves-quantum-verification-problem-20181008/> .
- Loredó, R. (2020). Learn Quantum Computing with Python and IBM Quantum Experience. Published by Packt Publishing. Birmingham, UK.
- McMahon, D. (2008). Quantum Computing Explained. Published by Wiley Interscience. Hoboken, NJ.
- Miller, S. (2018). DARPA digs into the details of practical quantum computing. Retrieved from: <https://gcn.com/articles/2018/07/12/darpa-quantum-architecture.aspx> .
- New York Times. (2018). The next tech talent shortage: Quantum computing researchers. Retrieved from <https://indianexpress.com/article/technology/science/the-next-tech-talent-shortage-quantum-computing-researchers-5412552/> .
- Nielsen, M., and Chuang, I. (2016).. Quantum Computation and Quantum Information, 10th edition. Published by Cambridge University Press. Cambridge, UK.
-  National Science and Technology Council (NSTC) (2022). "Bringing Quantum Sensors to Fruition", Retrieved from <https://www.quantum.gov/wp-content/uploads/2022/03/BringingQuantumSensortoFruition.pdf>
- Nomura, Y., et al. (2018). Quantum Physics, Mini Black Holes, and the Multiverse. Published by Springer. Switzerland.
- Panetta, K. (2017). The CIO's Guide to Quantum Computing. Published November 29, 2017. Retrieved from <https://www.gartner.com/smarterwithgartner/the-cios-guide-to-quantum-computing/> .
- Perry, R. T. (2012). Quantum Computing from the Ground Up. Published by World Scientific. Singapore.

Quantum References

- Polkinghorne, J. (2002). Quantum Theory: A Very Short Introduction. Published by Oxford University Press. Oxford, UK.
- Quantum Foundry Copenhagen (2025). Quantum Foundry Copenhagen, Retrieved from <https://qfcp.com/> .
- QED-C (2025). State of the Global Quantum Industry 2025. Retrieved from <https://quantumconsortium.org/publications/stateofthequantumindustry2025/>,
- Qnami. (2025). Retrieved from <https://qnami.ch/portfolio/quantum-foundry/>.
- Quantum Computing Playground. (2014). Located at <http://www.quantumplayground.net/#/home> .
- Rieffel, E. and Polak, W. (2011). Quantum Computing: A Gentle Introduction. Published by MIT Press. Cambridge MA.
- Sattel, S. (2016). The Future of Computing - Quantum & Qubits. Retrieved from: <https://www.autodesk.com/products/eagle/blog/future-computing-quantum-qubits/> .
-  Santos, F. P. D. (2024). "Quantum Sensors: Principles and Ground Applications". A presentation presented to LNE-Syrte, Paris Observatory. Published in NKG Science Week Online, March 12, 2024. Retrieved from <https://www.nordicgeodeticcommission.com/wp-content/uploads/2024/05/Talk-NKG.pdf>
- Seskir, Z. (2022) Quantum Sensors: Principles, Types, and Applications (according to ChatGPT). Retrieved from https://www.researchgate.net/profile/Zeki-Seskir/publication/366168027_Quantum_Sensors_Principles_Types_and_Applications_according_to_ChatGPT/links/639470a811e9f00cda32f91d/Quantum-Sensors-Principles-Types-and-Applications-according-to-ChatGPT.pdf
- Silva, V. (2018). Practical Quantum Computing for Developers. Published by Apress. New York, NY.
- Sutor, R, S, (2019). Dancing with the Qubits. Published by Packt Publishing. Birmingham, UK.
- Wikipedia. (2011). Quantum Machine. Retrieved from: https://en.wikipedia.org/wiki/Quantum_machine .
- Wikipedia. (2018). Article on Quantum Superposition. Retrieved from https://en.wikipedia.org/wiki/Quantum_superposition.
- Wikipedia. (2025). What is Quantum Sensing?. Retrieved from https://en.wikipedia.org/wiki/Quantum_sensor .
- Woody, L.S. (2022). Essential Mathematics for Quantum Computing. Published by Pakt. Birmingham, UK.

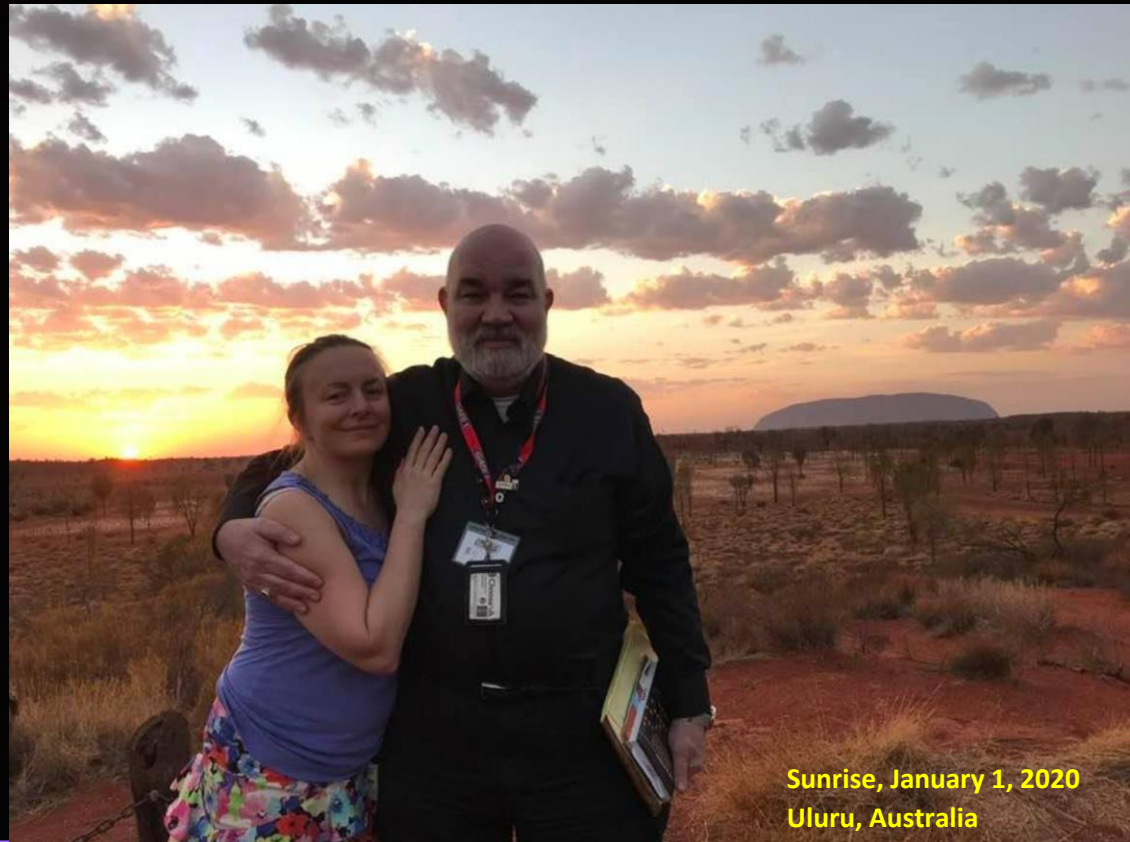
Quantum References

- Wilburn R. and Harris, K. Theory of Quantum Mechanics and Its Implications. Retrieved from <https://80000hours.org/podcast/episodes/david-wallace-many-worlds-theory-of-quantum-mechanics/> .
- Williams, C. P., and Clearwater, S. R. (1998). Explorations in Quantum Computing. Published by Springer-Verlag. New York, NY.
- Williams, C. P., and Clearwater, S. R. (2000). Ultimate Zero and One: Computing on the Quantum Frontier. Published by Springer-Verlag. New York, NY.
- Wilson, L. (2015). The Rise of Quantum Computers - The Current State of Cryptographic Affairs. Retrieved from <http://www.activecyber.net/rise-quantum-computers-current-state-cryptographic-affairs/> .
- Wikipedia. (2011). Quantum Machine. Retrieved from: https://en.wikipedia.org/wiki/Quantum_machine .
- Wikipedia. (2018). Article on Quantum Superposition. Retrieved from https://en.wikipedia.org/wiki/Quantum_superposition .
- Wikipedia. (2025). What is Quantum Sensing?. Retrieved from https://en.wikipedia.org/wiki/Quantum_sensor .
- Wilburn R. and Harris, K. Theory of Quantum Mechanics and Its Implications. Retrieved from <https://80000hours.org/podcast/episodes/david-wallace-many-worlds-theory-of-quantum-mechanics/> .

Building a Quantum Foundry

About Me

1. E-Mail [williamslater @ gmail.com](mailto:williamslater@gmail.com)
2. Phone 1-312-342-2626
3. CEO and owner of Slater Technologies, Inc. (since 1989)
4. In Quantum since 2011
5. Started in Cybersecurity in the U.S. Air Force: 1977.
6. Former U.S. Air Force Computer System Staff Officer who served at Strategic Air Command HQ.
7. Programming Languages: 43
8. 3 Graduate Degrees
 - MS Computer Information Systems
 - MBA
 - MS Cybersecurity
9. 88 Certifications including CISSP, SSCP, CISA, PMP.
10. Certified Project Manager with over 25 years experience.
11. Born and Raised in Memphis, Tennessee
12. Lives and works in Chicago, Illinois, USA
13. Published Author: <https://billslater.com/writing>
14. Working with QSECDEF since September 2024.
15. Happily married to Joanna Roguska since December 2000.
16. Working with Joe Reddix and The Reddix Group since 2024.
17. Avid fan of Andreas Vollenweider Music (since 1985), Chess (since 1964), and Judo (since 1968).
18. Voracious Reader with 18,000 physical books and 8000 digital books.
19. Meyers-Briggs: INFP.
20. Non-Denominational Christian (since 1973).



Sunrise, January 1, 2020
Uluru, Australia

William Slater


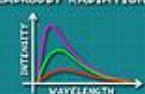



Slater Technologies, Inc
November 5, 2025

Building a Quantum Foundry






43

THE MAP OF QUANTUM PHYSICS

PRE-QUANTUM MYSTERIES

ATOMIC SPECTRA

BLACKBODY RADIATION

THE STABLE ATOM

RADIOACTIVITY

PHOTOELECTRIC EFFECT


QUANTUM FOUNDATIONS





THE WAVE FUNCTION

PARTICLE-WAVE DUALITY

THE BORN RULE

INTERFERENCE PATTERN

DOUBLE SLIT EXPERIMENT

THE SCHRÖDINGER EQUATION

$$i\hbar \frac{\partial}{\partial t} \Psi = -\frac{\hbar^2}{2m} \nabla^2 \Psi + V(\mathbf{r}) \Psi$$




THE DIRAC EQUATION

$$i\hbar \gamma^\mu \partial_\mu \psi - mc\psi = 0$$

INTERPRETATIONS OF QUANTUM MECHANICS

COPENHAGEN

MANY WORLDS THEORY

CONSISTENT HISTORIES

QBISM

AND MANY OTHERS...
 STOCHASTIC INTERPRETATION
 COSMOLOGICAL INTERPRETATION
 QUANTUM BAHYSEISM
 ALTERNATIVE COLLAPSE
 TRANSACTIONAL INTERPRETATION

QUANTUM GRAVITY

M-THEORY

STRING THEORY

LOOP QUANTUM GRAVITY


QUANTUM PHENOMENA

PARTICLE PROPERTIES
 POSITION, MASS, ELECTRIC CHARGE, WEAK HYPERCHARGE, LEFT/RIGHT FAMILY NUMBER, SPIN, ANGULAR MOMENTUM, COLOR CHARGE, FLAVOR, BARYON NUMBER, LEPTON NUMBER

QUANTUM SPIN

SUPERPOSITION

SCHRODINGER'S CAT

ENTANGLEMENT

QUANTUM TUNNELING

SUPERCONDUCTIVITY
 COOPER PAIRS

SUPERFLUIDITY




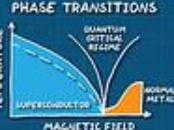

DECOHERENCE

CASIMIR EFFECT

QUANTUM HALL EFFECT

TOPOLOGICAL PHASE TRANSITIONS
 LOWER TEMPERATURE, HIGHER TEMPERATURE



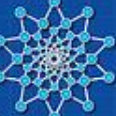

MAGNETIC RESONANCE IMAGING


THE HEISENBERG UNCERTAINTY PRINCIPLE
 DEFINITE POSITION, DEFINITE MOMENTUM

BELL'S THEOREM
 CORRELATION

ENERGY QUANTIZATION
 HIGHER ENERGY

PHASE TRANSITIONS
 QUANTUM CRITICAL REGION, SUPERCONDUCTOR, NORMAL METAL

ZERO-POINT ENERGY




QUANTUM THEORY

POSTULATES (PARAPHRASED)







1. WAVE FUNCTION DETERMINES EVERYTHING.
2. ALL OBSERVABLES HAVE OPERATORS
3. OBSERVABLES ARE HERMITIAN
4. EIGENFUNCTIONS OF OPERATORS ARE INDEPENDENT
5. EXPECTATION VALUE INTEGRAL
6. TIME DEPENDENT SCHRÖDINGER EQUATION

PATH INTEGRALS

QUANTUM FIELD THEORY

SYMMETRIES

HILBERT SPACE


PARTICLE PHYSICS

QUANTUM CHROMODYNAMICS
 STRONG FORCE

ELECTROWEAK INTERACTIONS
 ELECTROMAGNETISM + WEAK FORCE
 γ, W^-, W^+, Z^0
QUANTUM ELECTRODYNAMICS


QUANTUM INFORMATION

QUANTUM CRYPTOGRAPHY

QUANTUM COMMUNICATION

QUANTUM TELEPORTATION
 BELL-STATE ANALYSER, CLASSICAL SIGNAL, ENTANGLED PHOTONS

QUANTUM COMPUTING
 QUBITS, QUANTUM SIMULATION

QUANTUM INTERNET

QUANTUM COMPLEXITY
 COMPUTATIONAL COMPLEXITY
 P SPACE, NP PROBLEMS, BQP, P PROBLEMS


THE STANDARD MODEL OF PARTICLE PHYSICS

QUARKS
 c, t, d, s, u, b
LEPTONS
 e, μ , τ , ν_e , ν_μ , ν_τ
GAUGE BOSONS
 γ, W^+, W^-, Z^0
ANTI-MATTER
 PROTON, ANTI-PROTON, P, P-bar

FEYNMAN DIAGRAMS

PARTICLE ACCELERATORS


SOLID STATE DEVICES

BAND THEORY OF SOLIDS

TRANSISTORS
 SOURCE, GATE, DRAIN, N-TYPE, P-TYPE

SOLAR PANELS

LIGHT EMITTING DIODES
 POSITIVE TERMINAL, NEGATIVE TERMINAL

CHARGE-COUPLED DEVICES
 CCD SENSOR

SUPERCONDUCTING MAGNETS

LASERS

ATOMIC CLOCKS

SQUIDS
 JOSEPHSON FUNCTION

ELECTRON MICROSCOPES

SCANNING TUNNELING MICROSCOPES

ATOMIC FORCE MICROSCOPES


CONDENSED MATTER PHYSICS

PHOTOSYNTHESIS

BIRD NAVIGATION

SENSE OF SMELL

ENZYMES





QUANTUM BIOLOGY

GOLD ATOM PHYSICS




DEGENERATE ULTRACOLD GASES
 DEGENERATE FERMI GAS, BOSE-EINSTEIN CONDENSATE

RYDBERG MATTER


NUCLEAR PHYSICS

NUCLEAR FISSION

NUCLEAR FUSION

RADIOACTIVE DECAY
 ALPHA DECAY, BETA DECAY, GAMMA DECAY


QUANTUM CHEMISTRY

ELECTRONIC STRUCTURE

MOLECULAR DYNAMICS

QUANTUM MONTE CARLO METHODS


Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ Scientific and Technological Advantages

1. Accelerated Innovation

- Provides a centralized environment for R&D, prototyping, and testing.
- Speeds up the development cycle for new quantum sensing technologies.

2. Standardization and Repeatability

- Enables consistent fabrication of quantum sensor devices using standardized processes.
- Improves reliability and reproducibility — critical for scaling technologies to real-world use.

3. Cross-Disciplinary Collaboration

- Facilitates integration of quantum physics, materials science, nanofabrication, and software engineering.
- Promotes innovation through synergy between diverse research domains.

4. Scalable Fabrication

- Supports volume manufacturing of quantum sensors, moving from lab-scale prototypes to commercial products.

Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ Strategic and Economic Advantages

5. *National and Technological Sovereignty*

- Reduces reliance on foreign quantum technologies.
- Helps build sovereign capabilities in quantum hardware and systems integration.

6. *Market Leadership*

- Positions organizations or nations as pioneers in the rapidly growing quantum sensor market, with applications in:
 - ✓ Navigation (GPS-denied environments)
 - ✓ Medical imaging
 - ✓ Environmental monitoring
 - ✓ Defense and security
 - ✓ Geological and archaeological exploration

7. *IP Creation and Commercialization*

- Generates high-value intellectual property.
- Opens avenues for startups, spin-offs, and licensing deals.

Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ Talent Development and Workforce Enablement

8. *Hands-On Training and Upskilling*

- Acts as a live environment for training scientists and engineers in real-world quantum device development.
- Supports workforce development and retention in high-tech sectors.

9. *Pipeline for Next-Gen Experts*

- Encourages collaboration with universities and research institutions.
- Builds a pipeline of skilled quantum engineers, physicists, and system integrators.

Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ Broader Societal and Scientific Impact

10. Enablement of Breakthrough Applications

- Quantum sensors can detect minute changes in gravity, magnetic fields, or time — enabling breakthroughs in:
 - ✓ Earth science
 - ✓ Climate change monitoring
 - ✓ Healthcare diagnostics
 - ✓ Quantum-enhanced imaging

11. Collaboration Hub

- Attracts partnerships from academia, industry, and government.
- Acts as a national or international innovation hub.

Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ Infrastructure and Ecosystem Building

12. Reusable Design & Process IP

- Develops and maintains libraries of quantum device architectures and process flows.
- Supports modular design for flexible development of new sensor types.

13. Supply Chain Development

- Stimulates local and regional supply chains in quantum materials, cryogenics, microfabrication, and control systems.

Building a Quantum Foundry

What Are the Benefits and Advantages?

➤ *Advancement of Best Practices in Security for Quantum Computing*

14. Identification of Possible Security Issues

- Security issues with hardware
- Security issues with manufacturing
- Security issues with integration (network, devices, software, etc.)

16. Team Communication and Stakeholder Communication of Security Issues

- Security issues with hardware
- Security issues with manufacturing
- Security issues with integration (network, devices, software, etc.)

16. Management of Security Issues

- Security issues with hardware
- Security issues with manufacturing
- Security issues with integration (network, devices, software, etc.)

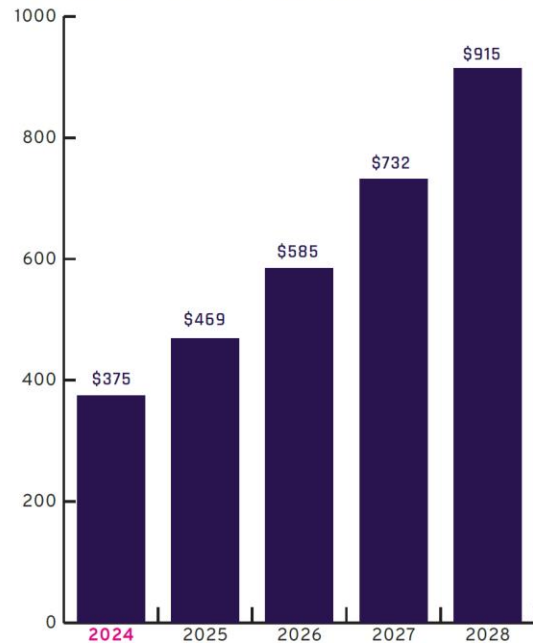
Building a Quantum Foundry

International Quantum Sensor Market

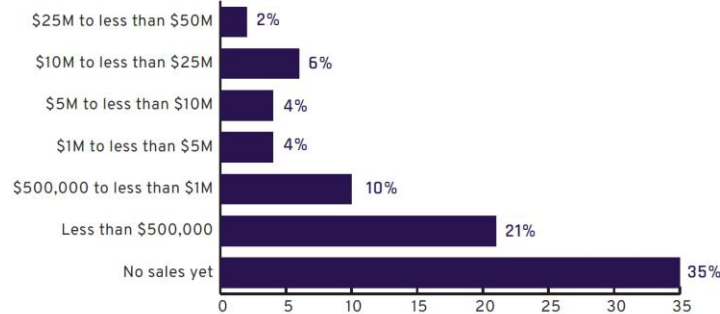
QUANTUM SENSING MARKET ESTIMATE: \$375M IN 2024

25% ANNUAL GROWTH RATE ESTIMATED TO DRIVE GLOBAL QUANTUM SENSING MARKET TO \$915M IN 2028

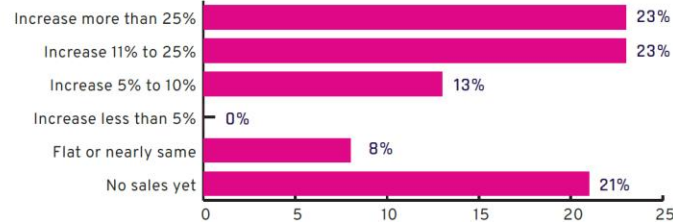
GLOBAL QUANTUM SENSING MARKET (\$M)



2024 QUANTUM SENSING-RELATED COMPANY REVENUE



PROJECTED QUANTUM SENSING-RELATED COMPANY REVENUE CHANGE FROM 2024 TO 2025



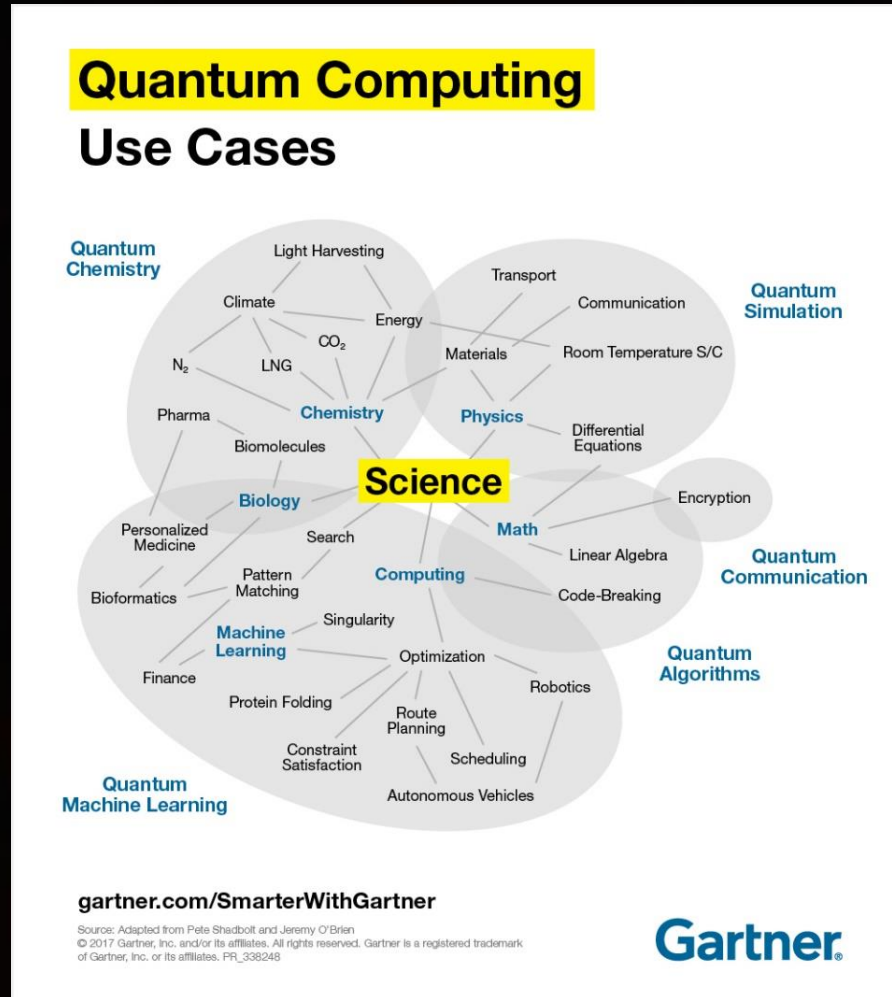
- Global market for quantum sensors is expected to grow over next decade, driven by applications in health care, defense, and advanced manufacturing
- Atomic clocks are currently among most in-demand quantum sensors, with applications related to geospatial navigation, telecommunications, and financial services

Note: For graphs conveying percentages of companies estimating revenue, companies with unshareable proprietary information or uncertainty in their estimates were excluded, hence percentages may sum to less than 100%.

Source: QED-C, 2025.

Building a Quantum Foundry

Quantum Computing Use Cases



Building a Quantum Foundry

Quantum Industry, as of January 1, 2025

COMPOSITION

6,502 

QUANTUM-ENGAGED ORGANIZATIONS

 **513**

PURE-PLAY QUANTUM COMPANIES

MARKET

\$1.45B+
2024
MARKET SIZE 

 **\$1.07B**

REVENUE FROM QUANTUM COMPUTING

 **\$375M**

REVENUE FROM QUANTUM SENSING

WORKFORCE



14,500+ PURE-PLAY WORKERS ADVANCING QUANTUM



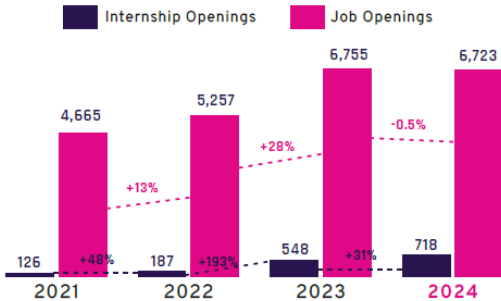
7,400+ QUANTUM-RELATED POSITION OPENINGS IN 2024

Source:
QED-C, 2025.

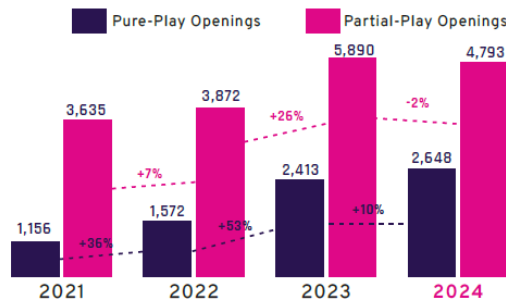
Building a Quantum Foundry

Quantum Industry Workforce, as of January 1, 2025

QUANTUM-RELATED OPENINGS BY POSITION TYPE

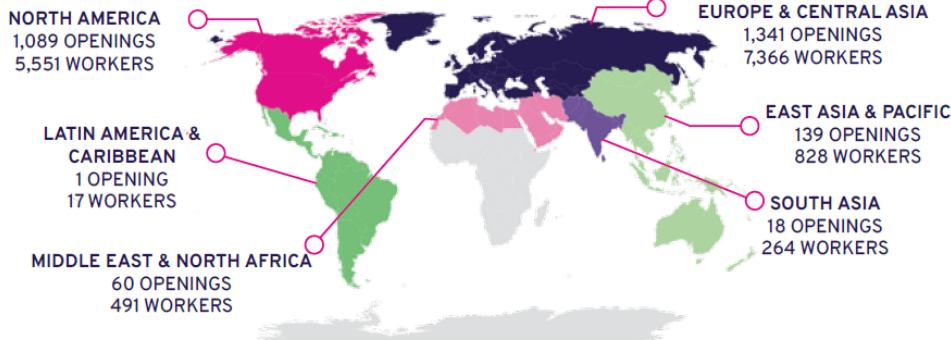


QUANTUM-RELATED OPENINGS BY ORGANIZATION TYPE



- Over past three years, annual growth rates of quantum-related internship openings outpaced those of quantum-related job openings, and annual growth rates of job & internship openings among pure-play companies outpaced those among partial-play organizations
- 2024 saw substantial increase in number of recruiters engaged in candidate searches for quantum technology workers

PURE-PLAY JOB & INTERNSHIP OPENINGS AND WORKERS BY REGION IN 2024



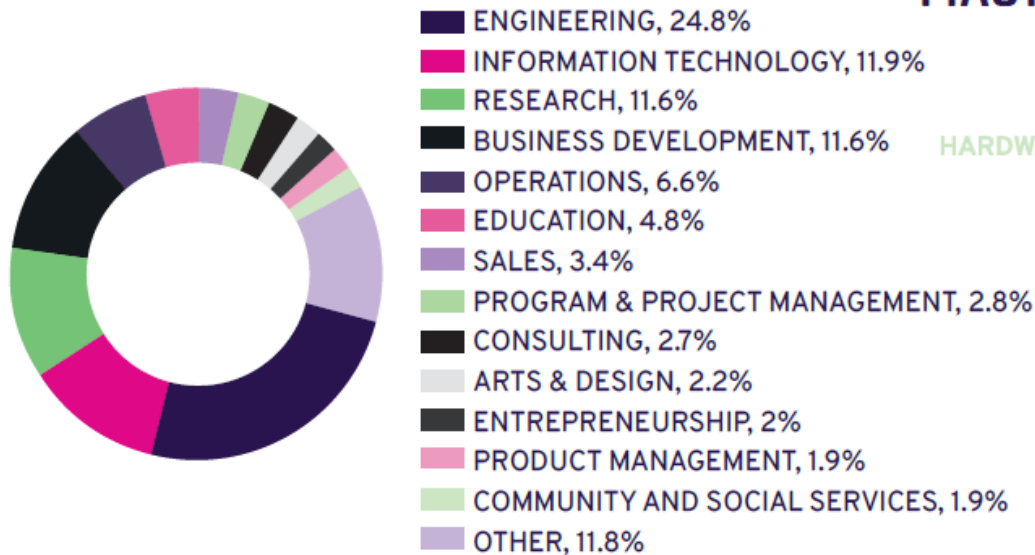
Note: Remote job & internship openings are not represented on the map.

Source:
QED-C, 2025.

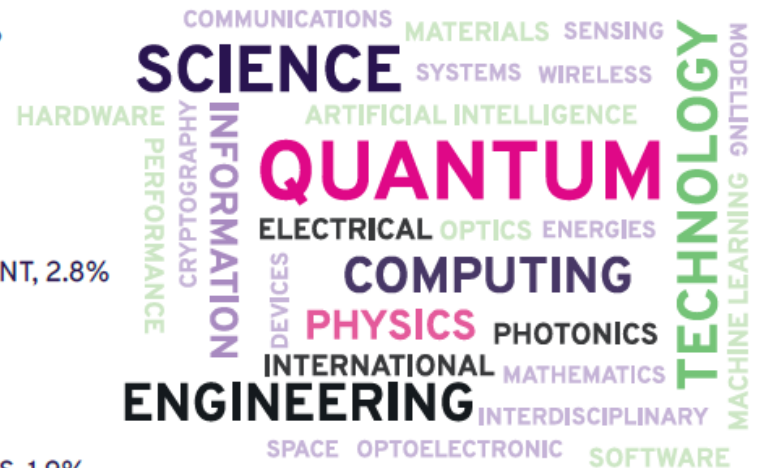
Building a Quantum Foundry

Quantum Industry Workforce, as of January 1, 2025

QUANTUM WORKFORCE BY ROLE



KEY TERMS AMONG QUANTUM MASTER'S DEGREE PROGRAM TITLES



- Top three roles in quantum workforce—engineering, information technology, and research—account for almost half (48.3%), reflecting industry's reliance on STEM skills; however, non-STEM expertise is also common, reflecting multidisciplinary collaboration among technical, business, and end-use roles in quantum technology development
- Universities are increasingly offering quantum-specialized graduate programs in engineering, computing, physics, and related fields, creating more focused pathways to quantum careers

Source: QED-C, 2025.

Enter the Quantum Zone

Join Our QSECDEF Group Meeting Every Tuesday

3 PM Paris Time, 2 PM UK, 9 AM New York, 8 AM Chicago, 2 AM Wed. Australia

Event Link on Zoom, CLICK HERE:

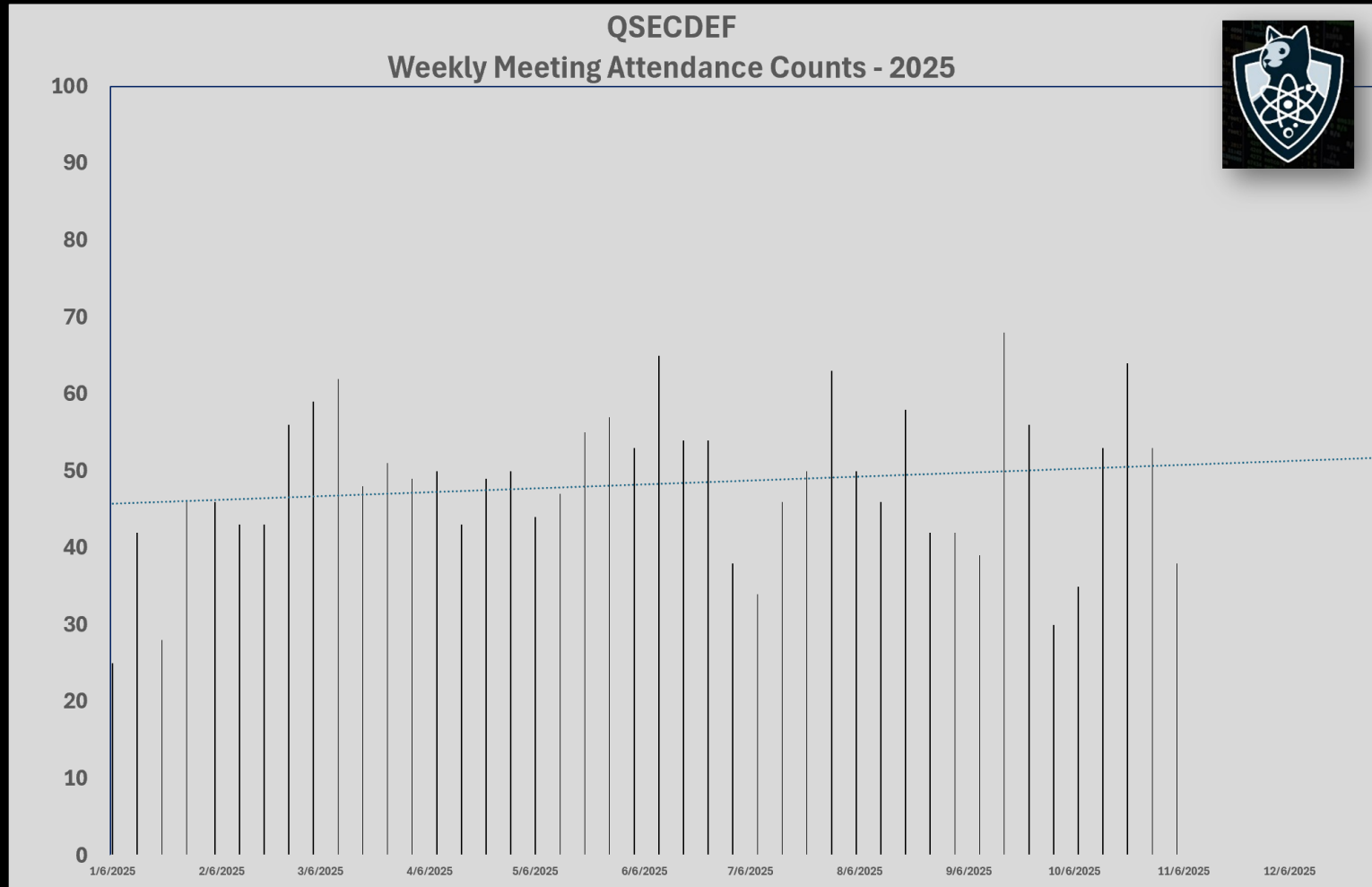
<https://zoom.us/j/91685969165>



Join Our FREE QSECDEF Group Meeting Every Tuesday

3 PM Paris Time, 2 PM UK, 9 AM New York, 8 AM Chicago, 2 AM Wed. Australia

<https://zoom.us/j/91685969165>

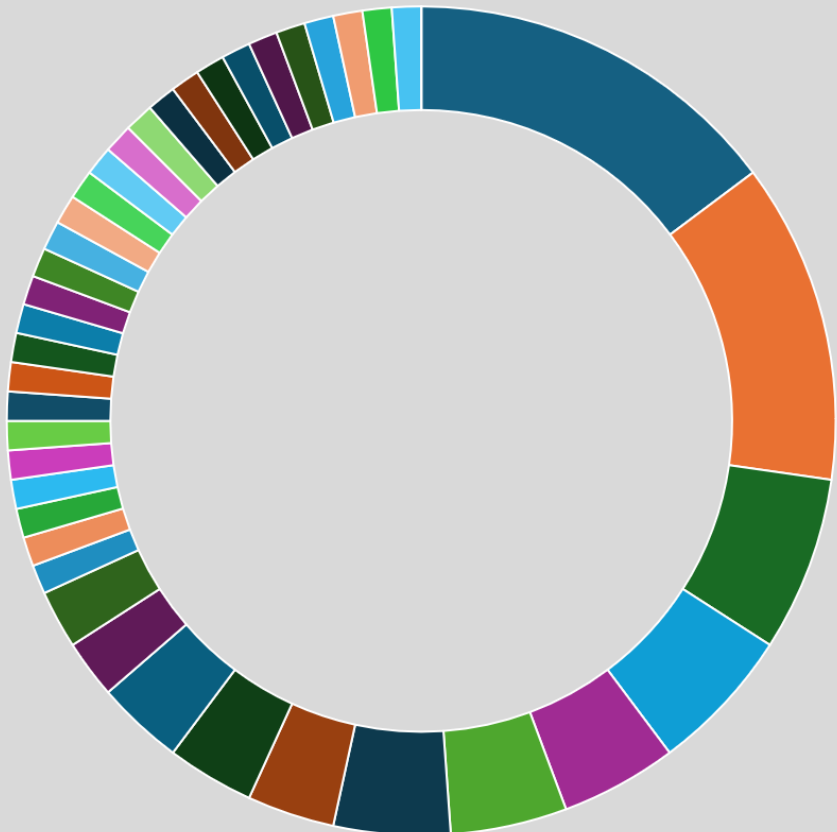


Join Our FREE QSECDEF Group Meeting Every Tuesday

3 PM Paris Time, 2 PM UK, 9 AM New York, 8 AM Chicago, 2 AM Wed. Australia

<https://zoom.us/j/91685969165>

QSECDEF Topics Covered
September 2024 - September 2025



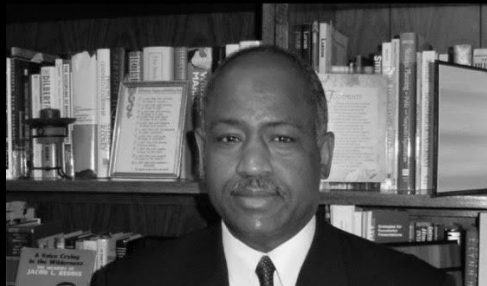
- Post Quantum Cryptography (PQC)
- Quantum Networking
- Quantum and AI
- Quantum Random Number Generators (QRNG)
- Quantum Foundry
- Quantum and IT Security
- Hybrid Infrastructures with Quantum & HPC
- Quantum Algorithms
- Quantum and Enterprise Integration
- Quantum Careers & Recruiting
- Quantum Computers
- Quantum Cryptanalysis
- Quantum Edge Computing
- Quantum IP and the Law, Export Policies, Etc.
- Quantum Programming
- Quantum Safe Networks
- Quantum Sensors - Space
- Quantum Space Networks
- Quantum Startup Analysis and Valuation
- Quantum Time Applications
- Quantum Memory Management
- Quantum Key Distribution (QKD)
- Quantum Satellite Communications
- Quantum Computing, Banking & Finance
- Quantum Cryptography
- Quantum Organization Planning
- Quantum App Development Tools
- Quantum & Other Emerging Technologies
- Quantum and Cryptographic Agility
- Quantum and the Cosmos
- Quantum Communications
- Quantum Computing and Encoding
- Quantum Data Centers
- Quantum Financial Threats: Cryptocurrency & Enabling Money Laundering
- Quantum Photonic Systems
- Quantum Safe Cryptocurrency
- Quantum Security
- Quantum Software Verification on Chain
- Quantum Standardization & Start-Ups
- Quantum Technology and the Law
- Secure Quantum App Development
- Quantum Sensors

Free Audio Book

Building a Quantum Foundry

Presented to the QSECDEF Group

Tuesday, June 3, 2025



THE REDDIX GROUP

Building The Quantum Foundry

Joe Reddix
William Slater

Visit to Listen

<https://www.youtube.com/watch?v=kuiVO2EkZYM&t=20s>

Free Presentation

Building a Quantum Foundry

Presented to the QSECDEF Group

Tuesday, June 3, 2025

From Chicago, Illinois, USA

William Slater

CEO

Slater Technologies, Inc.

William Slater

Slater Technologies, Inc

June 3, 2025     

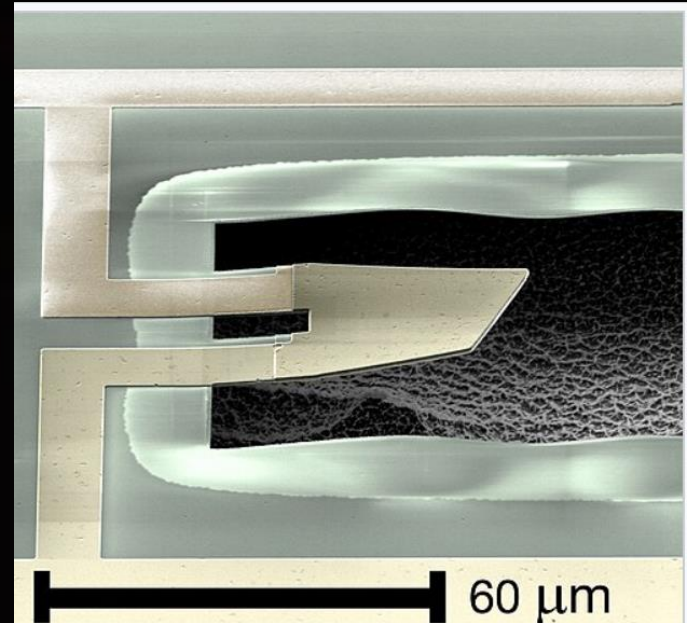
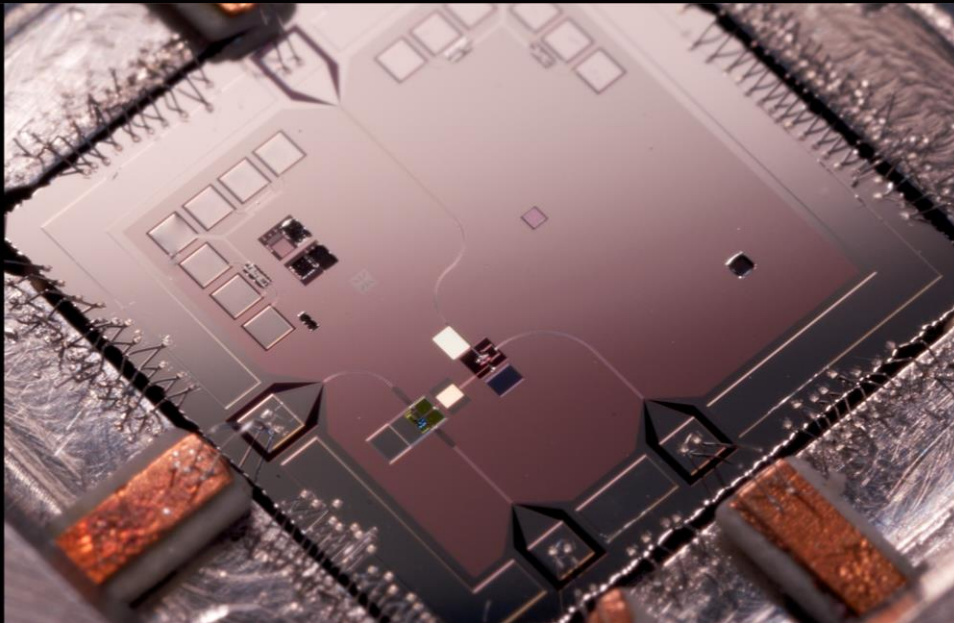
Visit to View and Download William Slater's Slides

<https://billslater.com.com/quantumfoundrydc.pdf>

Building a Quantum Foundry

World's First Quantum Machine, 2010

Wikipedia, 2011 - https://en.wikipedia.org/wiki/Quantum_machine



End of Presentation