Quantum Computing BLUprint

MARCH 2025

Akhilesh Agarwal

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Acknowledgement

Quantum computing technology has garnered attention globally since it has proven to offer exponential advantage over classical computers across several applications. Recently, the US government passed a bill to mandate all agencies to shift to quantum cryptography ensuring unbreakable security. The Indian government has also set up a National Quantum Mission to drive research and development in quantum computing.

India's nascent quantum ecosystem presents a rare opportunity to strategically align research, infrastructure, and capital, enabling the country to build a self-reliant quantum stack. With global advancements still in flux, India can leverage its strong talent pool, government initiatives, and emerging deep-tech investments to carve a competitive position in quantum computing.

We want to acknowledge the invaluable contribution of **Atharv Apshinge** on this thesis in distilling the technical intricacies into actionable insights. We've tried to cover all important aspects like competitive landscape, investment opportunities and risks, technological and scientific developments, applications, use-cases, and government policies to help founders, investors and other stakeholders in the ecosystem.

If you are a founder, researcher or stakeholder in quantum technology and would be interested to chat more about our work or discuss yours, feel free to reach out at akhilesh@blume.vc

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Methodology

261 funded startups

6 categories

28 subcategories

A clear understanding of how quantum computing differentiates itself from the classical tech is important for any stakeholder involved. We studied the underlying fundamental principles, inherent properties and the resulting advantages and limitations. Quantum systems will not be replacing the computers on our desks and used for everyday tasks like listening to music, watching videos, making presentations or sending emails. Quantum computers offer exponential speed-up in particular type of applications and use cases. We have identified those by reading through tens of scientific papers, news publications and articles by relevant people in the industry as well as through conversations with relevant experts in the field.

We analysed all publicly available funded startups in the quantum computing sector, carefully categorizing them into clear categories and subcategories along the value chain. We've compared the key metrics in quantum systems, when considered, along with the observed applications, a better set of quantum system can be built that would go hand in hand with market needs while also offering technological dominance.

We collected and analyzed funding data, market size projections, and performance metrics of quantum systems. Through research, we've tried to figure out a timeline of when the tech will be relevant enough to reach a point where large scale businesses can be built.

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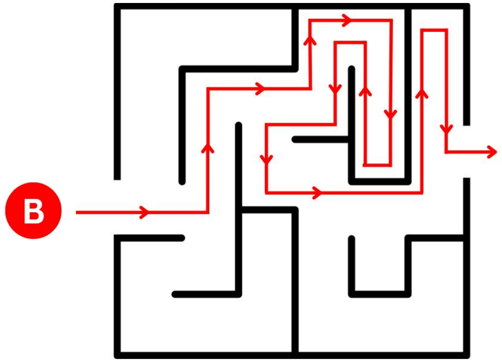
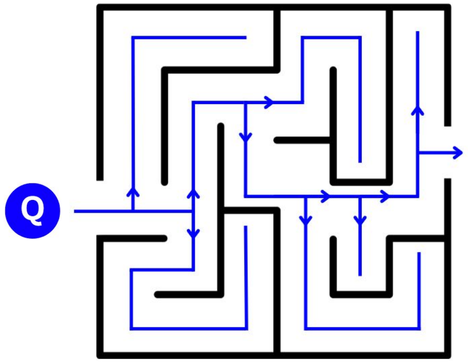
Quantum mechanics unlocks a new computing paradigm

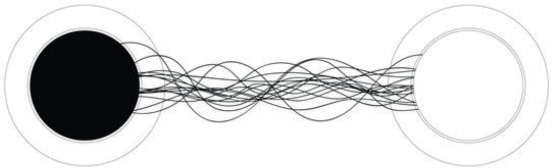
Qubits, a quantum analog of the classical bits, are reshaping how we process information and solving complex problems, offering exponentially more opportunities than classical bits

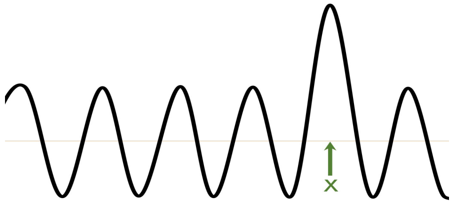
Classical **Bits** use one path, corner to corner to solve a maze, following a slow approach towards final point

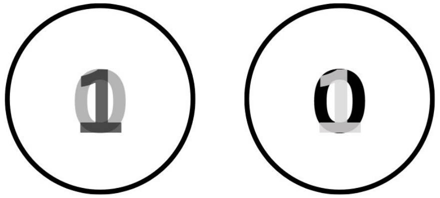




Qubits can explore multiple paths to solve a maze, reaching the desired point much faster







Entanglement allows paths to be analyzed in coordination, ensuring that once a dead-end is found, all related paths adjust simultaneously, reducing calculations

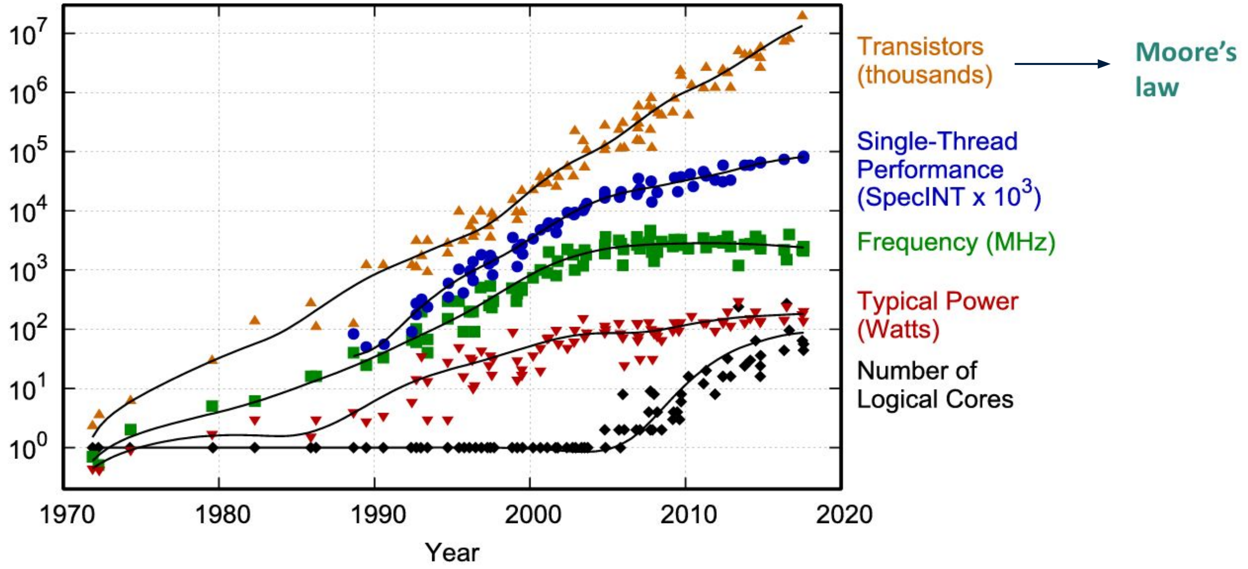
Interference helps remove incorrect paths dynamically, allowing the system to prioritize the most efficient route while filtering out bad choices

Superposition allows a qubit to exist in multiple states at once, meaning a quantum computer can explore many paths at the same time rather than sequentially

Source: Blume Research

Beyond Moore's law – leveraging quantum computing to surpass the limits of classical computers

Increasing transistor density will soon reach a cold phase soon as transistors have reached atomic scale and physical manufacturing limits. Qubits offer a better approach to build systems with extremely high computational power



The rate of increase in processing power has plateaued even though the transistor count is currently at par with Moore's law, because we are struggling to progress with other factors – single thread performance, chip clock rates, power per chip and their number of logical cores

Qubits offer exponential scale up, unlike the linearity observed in classical bits

1 qubit → 2^{50} times higher number of encoded states → **51** qubit

Source: Atom Computing, Olivier Ezratty

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From theory to trillion dollar tech – quantum's journey to 2040

By 2035, global quantum computing market will generate a potential economic value of $2 trillion across four industries: chemical, life sciences, finance and mobility[1]

Market Size

	2035	2040
Optimistic Estimate	**$72bn**	**$131bn**
Conservative Estimate	**$28bn**	**$45bn**

The revenue from hardware sales, QCaaS and professional services is estimated at a cumulative **$50bn** through to 2035

Source: McKinsey, Quantum Insider. Note: [1] Economic value is defined as the additional revenue and saved costs that the application of QC can unlock in all industries.

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Deriving the quantum computing value chain

Application layer software remains the most favourite part of the technology value chain for startups, followed by equipments and components required in building quantum systems

Equipments/ components — 36%
Providers of hardware components and equipments for quantum computers

Hardware — 20%
Manufacturers of processors and full stack quantum computers

Cloud Services — 27%
Offering QC capabilities via their own cloud solution or dedicated cloud player and distribution of QC software to users

System Software — 18%
Development of software that interacts with the quantum processing unit (e.g. low-level programming)

Application Software — 50%
Development of algorithms that run on quantum computers/ equipment and interact with the systems layer

Services — 18%
Consulting and education services about strategic and technological aspects of quantum technologies

Source: Tracxn, Blume analysis. Note: Numbers represent the percentage of total quantum computing startups offering solutions in the segments. It is common for startups to service multiple value chain segments.

Startup landscape across the value chain segments

Value chain segments: Equipments/ components → Hardware → Cloud Services → System Software → Application Software → Consulting, Educational Services

Equipments/ components

- LIGHTSYNQ
- chiral
- QUANTUM DICE
- Pixel Photonics
- QUANTUM MACHINES
- SILENT WAVES
- QPHOX
- LIGHTELLIGENCE
- Delft Circuits – Hardware for quantum engineers
- Q→NU

Hardware

- atom computing
- QOLAB
- IQM
- QπAI
- eleQtron
- IONQ
- SemiQon™
- QBoson 玻色量子
- Nord Quantique
- ephos

Cloud Services

- Aliro QUANTUM
- seeqc
- rigetti
- agnostiq
- QUANSCIENT
- Quantagonia
- QCWARE
- Qbitcloud
- QUANDELA
- Amazon Braket

System Software

- qruise
- QCDESIGN
- [,]
- STRANGE WORKS
- river lane
- HAIQU
- QBLOX
- planqc
- QS
- horizon quantum

Application Software

- SANDBOXAQ™
- MULTIVERSE COMPUTING
- BosonQ Psi
- QUANTUMXCHANGE™
- CLASSIQ
- BlueQubit
- algorithmiq
- KIPU QUANTUM
- Qubit PHARMACEUTICALS
- kvantify

Consulting, Educational Services

- evolution
- g2Q COMPUTING
- qutools
- QπAI
- CYBRANE
- Dime Chain

Source: Blume Analysis

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Equipments and components – building a quantum computer

A developing global supply chain is visible, but more than 75% providers of quantum computing equipments and components are populated in the American and European continents

Qubit Control and Generation

CAVERO QUANTUM

RYDBERG TECHNOLOGIES

rigetti

Cryogenic and Cooling

国盾量子 QuantumCTek

Infleqtion

BLUE FORS

Measurement and Readout

QBLOX

KEYSIGHT

QUANTUM MACHINES

Interconnects and Networking

Ki3 PHOTONICS Technologies

LIGHTELLIGENCE

Qunnect

LIGHTSYNQ

A map of funded startups providing equipments and components required for Quantum Computing

Source: Blume Analysis

Qubits as the building blocks of a revolutionary industry

Choosing the right qubit type is crucial as it impacts the R&D investments, development timelines, scalability and end-use applications

Superconducting Qubits: The most common type, made of superconducting materials cooled to cryogenic temperatures and based on the Josephson junction, which is a device that allows the flow of supercurrent without resistance.

Google, rigetti, IBM, ALICE & BOB, IQM, 本源量子 Origin Quantum, seeqc, D-Wave The Quantum Computing Company™, QOLAB, SPINQ

Photonic Qubits: Based on the quantum properties of light, such as polarization and phase. They are manipulated using optical components such as beam splitters, phase shifters, and detectors.

PsiQuantum, ORCA COMPUTING, QUANTUM SOURCE, QUANDELA, ephos, Quantum Transistors, QUIX QUANTUM, 图灵量子 TURING, XANADU, QC82

Neutral Atom Qubits: Formed by trapping individual neutral atoms using optical tweezers and manipulating their quantum states with lasers. These qubits leverage the atom's electronic energy levels to encode information.

QuEra Computing Inc., atom computing, PASQAL, planqc

Trapped Ion Qubits: Utilizes electronic and nuclear spin states of ions as they are trapped and manipulated using electromagnetic fields.

QUANTINUUM, IONQ, eleQtron, AQT, oxford ionics, Quantum Art

Source: Blume Research

Comparison metrics – quantifying qubit performance

A single universal metric is challenging due to diverse architecture, multi-faceted performance and application specific needs. Let's take a dive into several comprehensive metrics used to evaluate and compare quantum computing platforms.

Factor	What does it mean?	Favourable Value
Coherence time	Duration a qubit retains quantum information before disrupting its state. Increased time enables solving complex problems and reduce error correction overhead	**Long**
Gate Fidelity	Quantum gates are operations that manipulate qubits similar to classical logic gates (AND, OR); This measures accuracy of gate executions while running algorithms	**High**
Scalability	Ability to increase qubit counts while maintaining control, coherence and error rates at optimal levels. Millions of qubits are required to build reliable systems with the potential of industry-wide adoption	**High**
Error rates	Likelihood of a quantum operation deviating from expected result. Errors occur due to environmental noise or hardware imprecision and control inaccuracies.	**Low**
Fabrication Complexity must be **low** to ensure ease and low cost of manufacturing		
Operating Conditions of hardware preferably **room temperature** and **pressure,** eliminating the need of huge cryogenic and pressure control systems		

Source: Blume Research

Performance benchmarking: Which qubit technology is better?

Each qubit type has its strengths and weaknesses, companies are developing their qubit technology depending on the type of problem to be solved and their business goals

Factor	Superconducting	Trapped Ion	Neutral atom	Photonic	Quantum Dot	Topological
Coherence time						
Gate Fidelity						
Scalability						
Error rates						
Fabrication complexity						
Operating conditions	Cryogenic	Ultra high vacuum	Laser cooling	Room temperature	Cryogenic	Cryogenic
Key application	General purpose	Simulations	Scalable QC	Communication	General purpose	Fault-tolerant systems

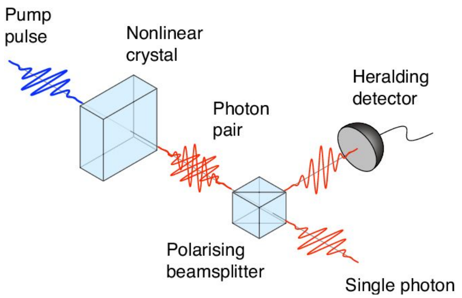
Source: Blume Analysis. Note: This is a rapidly evolving landscape and we expect quick and consistent disruption in this benchmarking.

Photonic qubits to innovate with lower R&D costs and near-term industry adoption (1/2)

*Photonic qubits are favourable tech for a startup as they can be manufactures by integrating into the existing semiconductor manufacturing fabs, eliminating need for high capital investments. There are **16** known and funded startups building photonic QPUs or full stack systems*

1 — 2 — 3 — 4

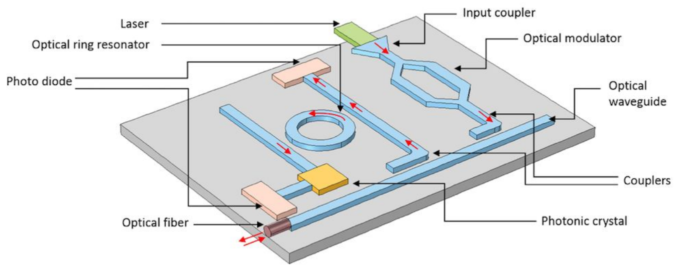
Fundamental Information Unit



- Innovation in photon sources needed for producing identical photons (same wavelength, amplitude, etc) on demand, rather than probabilistically

- Currently pursued tech includes Laser pumped nonlinear crystal, excited **Semiconductor nanostructures**, Defects in diamonds as a coherent photon source **compatible with semiconductor fab**

Routing and manipulating qubits



CMOS compatible chip fabrication using PICs for qubits

- SiN and Glass recently found to offer improved performance

- **Lithography and Etching** to make on-chip waveguides for directing photons through circuit

- **35% of component providers** offer products for integration of active components like phase shifters, beam splitters, to manipulate photonic qubits

Qubit detection and read-out systems

System integration and scaling

Source: Blume Research

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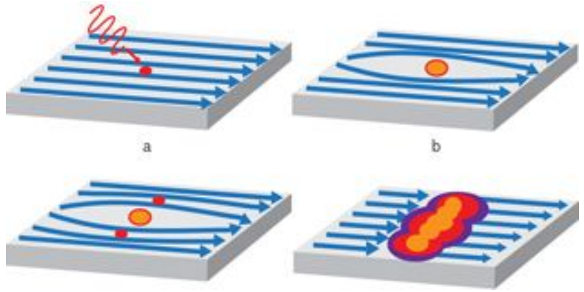
Photonic qubits to innovate with lower R&D costs and near-term industry adoption (2/2)

Optical and photonic systems are more scalable than others, along with room temperature operations enabling commercial applications in secure networking and communication; and being increasingly adopted by top firms and government agencies

1 Fundamental Information Unit

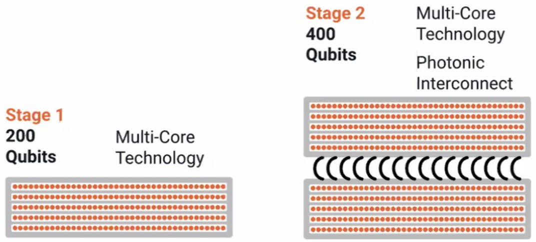
2 Routing and manipulating qubits

3 **Qubit detection and read-out systems**



- Superconducting Nanowire Single Photon Detectors are fabricated using materials like **NbN** onto chips
- Resolving photon numbers is crucial (using **PNRD**s), but existing tech lacks in finding balance between accuracy and resolution
- Innovations in custom circuitry using cryogenic compatible components to interface detectors with photonic elements like lasers and modulators is necessary for efficient readout systems.

4 **System Integration and Scaling**



- Photonic systems offer **modular assembly** by combining multiple chips and interconnecting optical fibers or on-chip waveguides for easier scalability
- Existing **Telecom and Fiber Optic Infrastructure** can be leveraged for distributed quantum computing
- Efficient and long term **quantum memory** in photonic systems is necessary for complex applications, which is still under development

Source: Blume Research

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Near-term adoption will be through software applications

Quantum computing software adoption has started – from integrating computing power in classical systems to application based solutions, the broad range of use cases will offer returns on lower investment size than in hardware

System Software →

Application Software →

Hardware Control
- QBLOX
- Infleqtion
- Q-CTRL
- QuantrolOx

Compilers and Runtime environment
- 1QBit
- HORIZON QUANTUM COMPUTING
- Aliro QUANTUM

Cloud Services
- seeqc
- QUANDELA
- ARQIT
- qBraid

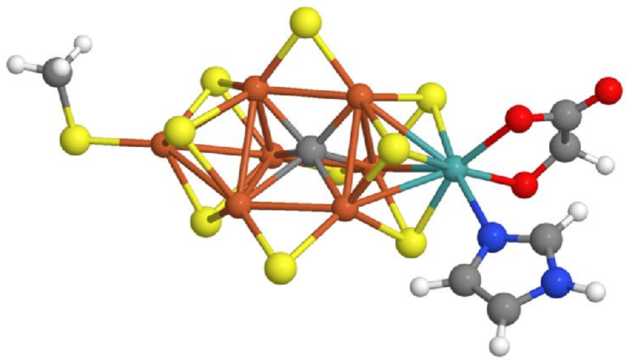
Algorithms and Middleware
- KIPU Quantum
- PHASECRAFT
- bloq

Application and industry use cases
- Terra Quantum
- quantropi
- QCWARE
- CLASSIQ
- algorithmiq

Source: Blume Analysis

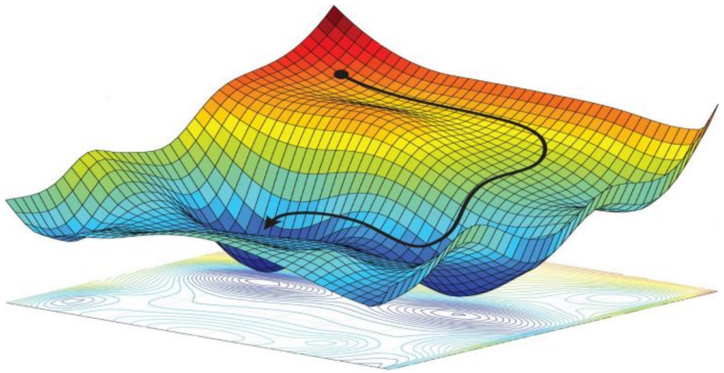
Algorithms and software solutions are being widely used for material discovery, data security, and optimization

Quantum computing software will be adopted at scale in the next 10 years – application based solutions will offer returns on lower investment size than in hardware



~45% of quantum application based software startups provide simulation services for material discovery, engineering and design

- Classical computers approximations for quantum mechanics simulations.
- Quantum algorithms can predict exact electron behaviours for simulating molecular behaviours



~40% of quantum application based software startups provide optimization solutions for finance, supply chain, telecom and media industries

- Optimization problems involve finding solution among millions of possibilities, requiring classical brute-force
- Quantum algorithms explore solutions simultaneously, faster optimization.

~25% of quantum application based software startups provide data and network security solutions being widely adopted in defense, finance and telecom

- Classical methods use complex mathematical problems that future computers may be able to solve
- Inherent properties like randomness and entanglement for hack proof systems

Source: Blume Analysis

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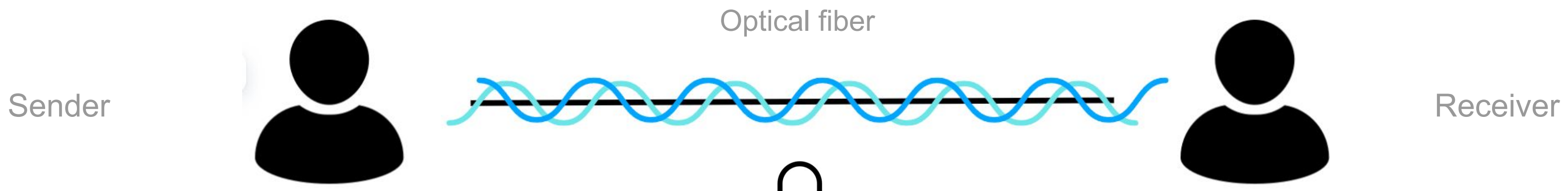
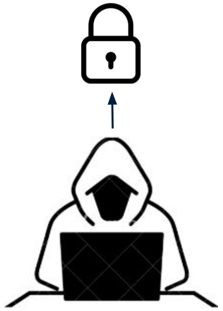
The convergence of quantum key distribution and post-quantum cryptography is reshaping global cybersecurity

The Global Risk Institute estimates a 17-34% chance of a cryptographically relevant quantum computer existing by 2034, capable of breaking RSA 2048 in 24 hours – as classical encryption methods face existential threats, these twin technologies offer a coordinated defense strategy

Users share pairs of entangled photons – measurement of these photons by both parties conveys the information
No information is actually transmitted down the fiber!





PQC offers algorithmic resistance to attacks even from quantum computers, while being deployable on classical hardware. It relies on mathematical problems that can't be solved by quantum computers – like lattice based cryptography

QKD generates encryption keys for secure information exchange, shared through photons and encoded in random bases - information where bases match is kept, discarding rest. If someone intercepts, errors are introduced, detectable by the sender and receiver

This creates an unhackable communication network

Quantum networks and security – building the ecosystem

Organisations are moving from the discovery phase to deploying PQC at scale in 2025 – The U.S. government will be spending approximately $7.1bn between 2025 and 2035 for transitioning sensitive information within the government agencies to post-quantum encryption

Satellite Networks: Global coverage through space

Terrestrial QKD faces inherent distance limitations due to ~0.2 dB/km photon loss in fiber. China's Micius satellite demonstrated intercontinental QKD in 2020, achieving 1,200 km ground-to-satellite links. Their 2025 expansion plans include 12 MEO satellites for transcontinental links, 72 LEO satellites for regional coverage, and ground stations through 40+ facilities.

The Pentagon's 2025 roadmap allocates $2.1bn for 12 quantum satellites for global key distribution and QKD terminals with 8-hour battery life.

Photonic Integration: From Lab to Chip

Toshiba's PICs miniaturized QKD components onto 3x5 mm silicon chips. Field tests showed a 400x size reduction from previous setups. Mass production via 300 mm wafer CMOS processes could lower unit costs, enabling QKD integration into 5G base stations and IoT hubs.

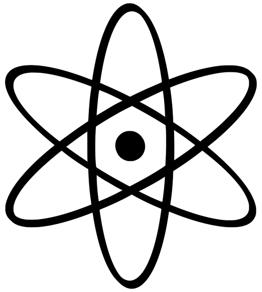
Metric	2024 state	2030 projection
QKD distance	1,200km	Global mesh networks
PQC Performance	5x RSA overhead	1.2x RSA overhead

Source: Blume Research

Google Willow completes a task in 5 minutes, would take 10^{25} years to perform it using the most powerful classical supercomputer!

Industry leaders like Google, IBM, Microsoft, AWS are exploring technologies and pursuing full-stack quantum computing with an aim to achieve quantum supremacy and invest heavily for in-house research and development – this approach may not be the best one for startups

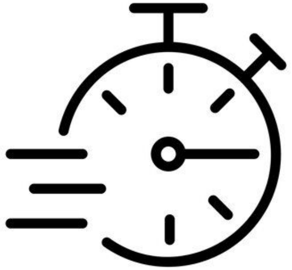
Tailoring a Quantum Strategy for Startups



Instead of standalone quantum supremacy, startups should aim for scalable technologies that can integrate quantum computing with classical high-performance computing (*HPC*), ensuring incremental and adoption in real world applications.

Being a highly capital demanding sector, specifically the hardware segments, startups should form alliances with universities, government programs, and R&D hubs for access to top-notch fabrication and testing facilities.

Startups should prioritize niche applications in drug discovery, materials science, finance and logistics for clear pathways to market viability. Innovation in error mitigation and system software is crucial for building large scale fault-tolerant systems.



To survive and scale beyond the deep tech valley of death, define clear technical and business milestones, such as error rate reduction, circuit depth optimization or early commercial use cases. Transparent progress tracking will also build investor confidence.

Source: Google Blog, Blume Analysis

Spotlight

Global startups making their mark in the quantum world

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rigetti

Developer of an AI-powered full-stack quantum computing solution based on superconducting qubits

Funding and Financials

Founded: 2013
Location: Berkeley, United States
Funding: $198m
Stage: Public
Investors: Bessemer Venture Partners, DCVC, Northgate Capital, Seabed VC, a16z, Vy Capital, Y Combinator, Morado Ventures, Susa Ventures

Technology and Innovation

First **quantum integrated circuit foundry**—enables in-house chip fabrication resulting in faster R&D cycles. Barrier to entry for competitors, providing a strategic moat.

3D signal delivery enables high density, modular processor I/O

Product Market

On premise quantum computing sold to governments, labs and enterprises with **cloud services** offered via AWS, Azure, Strangeworks. Quantum Processing Units available for direct purchase (*Novera QPU*).
Consulting and partnerships with NASA, HSBC, Moody's Analytics

Challenges and Opportunity

Multi-chip modularity by leveraging existing semiconductor manufacturing infrastructure. Well-positioned to monetize quantum computing via cloud services and QPU sales while benefiting from early adoption by government.
Revenue needs to be enterprise dominant for sustainable growth.

Rigetti's 9 Qubit QPU

Source: Rigetti Computing Website and Investor Deck, Tracxn riverlane

Providing computing elements in the stack like CPU, FPGAs and qubits with focus on quantum error correction

Funding and Financials

Founded: 2017
Location: Cambridge, United Kingdom
Funding: $122m
Stage: Series C
Investors: Planet First Partners, ETF Partners, Cambridge Innovation Capital, Molten Ventures, Amadeus Capital, European Commission

Technology and Innovation

Dedicated **Quantum Decoder Chip** addressing the challenge of scaling quantum operations from a few hundred to millions without failure

QEC stack – proprietary QEC chips, hardware, and software technologies working in unison to correct billions of errors per second, essential to achieve FTQC

Competitor examples

Q-CTRL

QEDMA

Product Market

All hardware manufacturers have long term goals to scale **scale quantum processors to 1000+ qubits with reduced errors.**

This hardware market will drive reliable solutions for complex and high value use cases across industries

Challenges and Opportunity

Universal error correction that works across multiple quantum technologies is a rare and valuable gem. If it becomes an **industry-standard** error correction stack, quantum hardware manufacturers will create a perpetual revenue stream

Product

Deltaflow 2 performs real-time error correction on up to 250 physical qubits

Source: Riverlane website, Tracxn

QNU

QNu labs is a pioneer in quantum cryptography, quantum encryption and quantum communication products and solutions

Funding and Financials

Founded: 2016
Location: Bengaluru, India
Funding: $15.2m
Stage: Seed
Investors: Speciale Invest, Tenacity Ventures, Uthishtaa Solutions, Karnataka Trustee, Waao Partners, Venture Catalysts + Angel investors

Technology and Innovation

Developing hardware - QKD, QRNG and Security Modules along with platform and service layer software.
Enabling end-to-end infrastructure and information security from classical and quantum computers by providing NIST compliant PQC solutions.

Competitor examples

bit labs
ISARA
CRYPTO QUANTIQUE
SECURE MACHINES

Product Market

Scales quantum-safe security for integration into existing infrastructures, superior data protection for banking, healthcare, data centres, etc
Bagged a contract with the **Indian Navy** for procurement and deployment of large scale **quantum encryption** systems.

Challenges and Opportunity

India's National Quantum Mission prioritizes network and communications security, which will unlock more contracts from the defense sector.
Immediate applications includes entering $170bn market of **anti-counterfeit** packaging and developing **secure voting** machines.

Source: QNu Labs website, Tracxn, The Economic Times

Pioneering company that vertically integrates Quantum Computing and AI to develop advanced solutions across various industries

Funding and Financials

Founded: 2019
Location: Bengaluru, India
Funding: $11.3m
Stage: Seed
Investors: YourNest, SIDBI Venture Capital, We Founder Circle + Angel investors

Technology and Innovation

Scalable spin-qubit-based Quantum Processing Units and cryogenic control chips.
AI-enabled system for controlling various types of qubits. This platform offers ultra-low latency feedback (<100ns) and capabilities for quantum error correction and mitigation

Products

QpiAI's flagship 25 qubit quantum computer

Scalable and modular control electronics

Product Market

Diverse industry specific applications – predictive analytics for operational efficiency in manufacturing, risk assessment and portfolio optimization, AI driven drug discovery and simulation tools

Challenges and Opportunity

The integration of quantum computing and AI is still in its nascent stages. Convincing industries to adopt quantum-AI solutions involves overcoming skepticism and demonstrating clear value propositions.

Source: Qpi AI website, Tracxn

Essential ingredients for a thriving quantum startup: Market maturity, viable business model and commercial-ready tech

What about startups that disappeared? You would guess that there are many given the technological immaturity of the sector. Well, less than 10% of all the companies in the sector have shut down

SeQureNet *(2008 – 2017, France)*

It was a spin-off of Telecom ParisTech specialized in the distribution of **long distance CV-QKDs**. Funded within the framework of the European research project SECOQC (secure communication based on quantum cryptography)

*It had been launched a little **too early compared to the QKD market maturity***

Zapata AI *(2017 – 2024, USA)*

Developed quantum-classical hybrid computing platform, to solve real-world problems in finance, logistics, chemistry and more

*Over time, as quantum computing adoption was slower than expected, it died after a **failed pivot towards AI and enterprise machine learning solutions***, **and a SPAC**

Black Brane Systems *(2017 – 2024, Canada)*

Focused on quantum machine learning, received undisclosed funding and remained highly

*Struggled to find customers willing to pay, lack of transparency and stealthy operations may have deterred investors and partnerships, **unclear business model***

NextGenQ (*2019-2021, France*)
Building in this field without quantum physics expertise or funding is highly challenging, breakthrough innovation or strategic support is important

Atomtronics (2015, Italy)
Focused on atomtronic circuits (ultra-cold atoms in artificial lattices), *highly experimental and **difficult to commercialize***

Source: Olivier Ezratty

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Investment Insights

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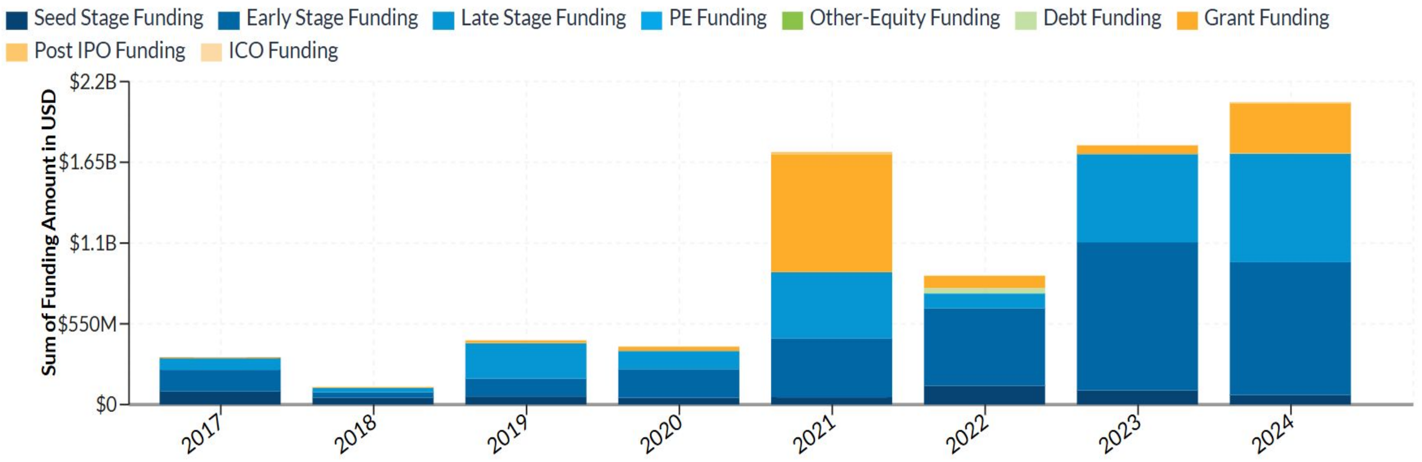
Global Investments – stages and timeline

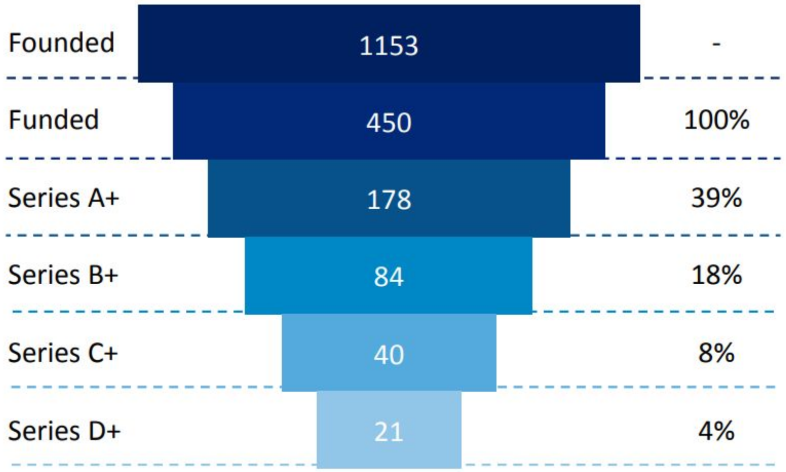
Quantum computing attracted $2 billion funding in 2024, underscoring continued investor confidence in its future. But clear results and success of exit strategies will be visible at around 8 years from now



The industry is in its early stages, there are <10 unicorns in the sector. We are yet to observe any trends in revenue multiples and valuations as **more than 60% quantum computing investments have been done 2021 onwards**

Median time between rounds (in years)

Founded – Seed	**2.08**
Seed – Series A	**2.41**
Series A – Series B	**2.16**
Series B – Series C	**1.33**



Source: Tracxn, Blume analysis

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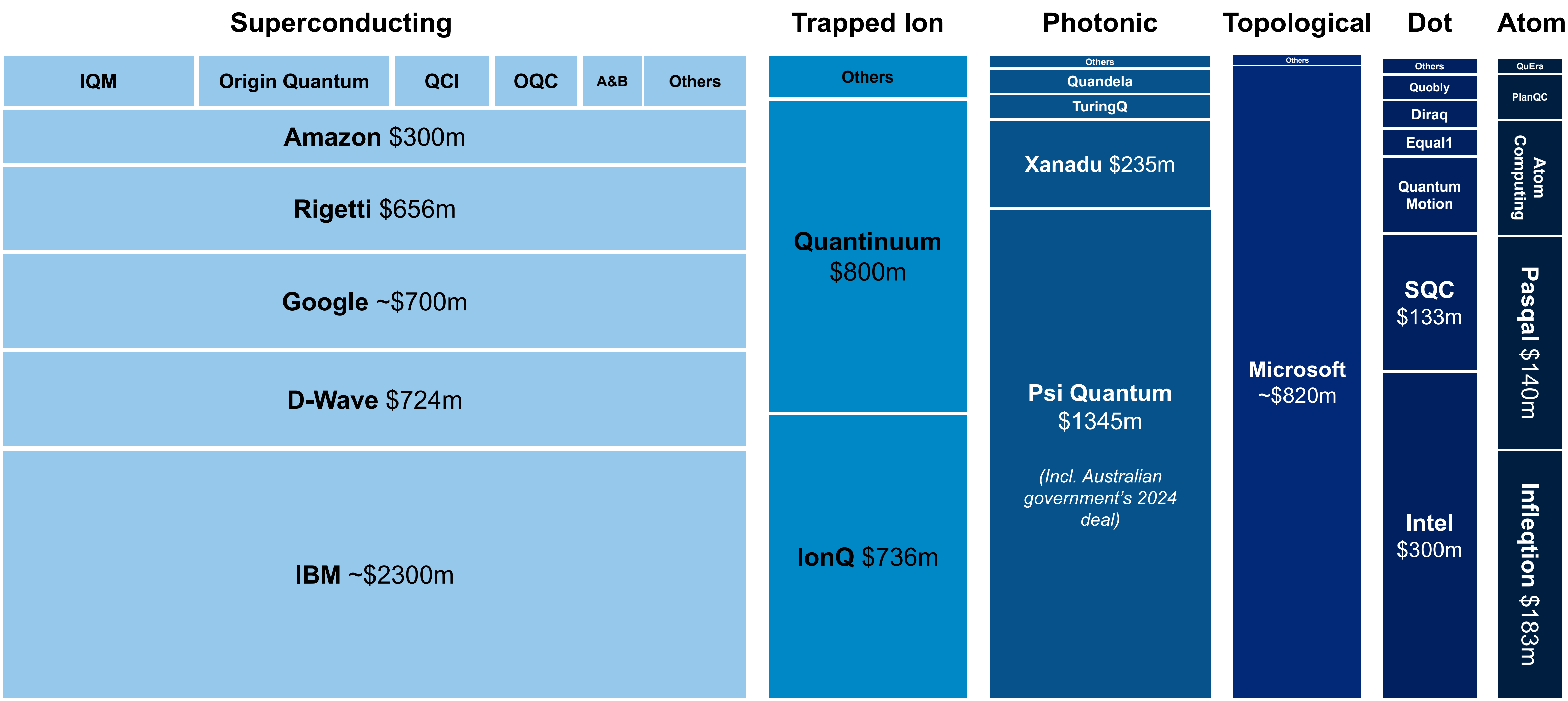
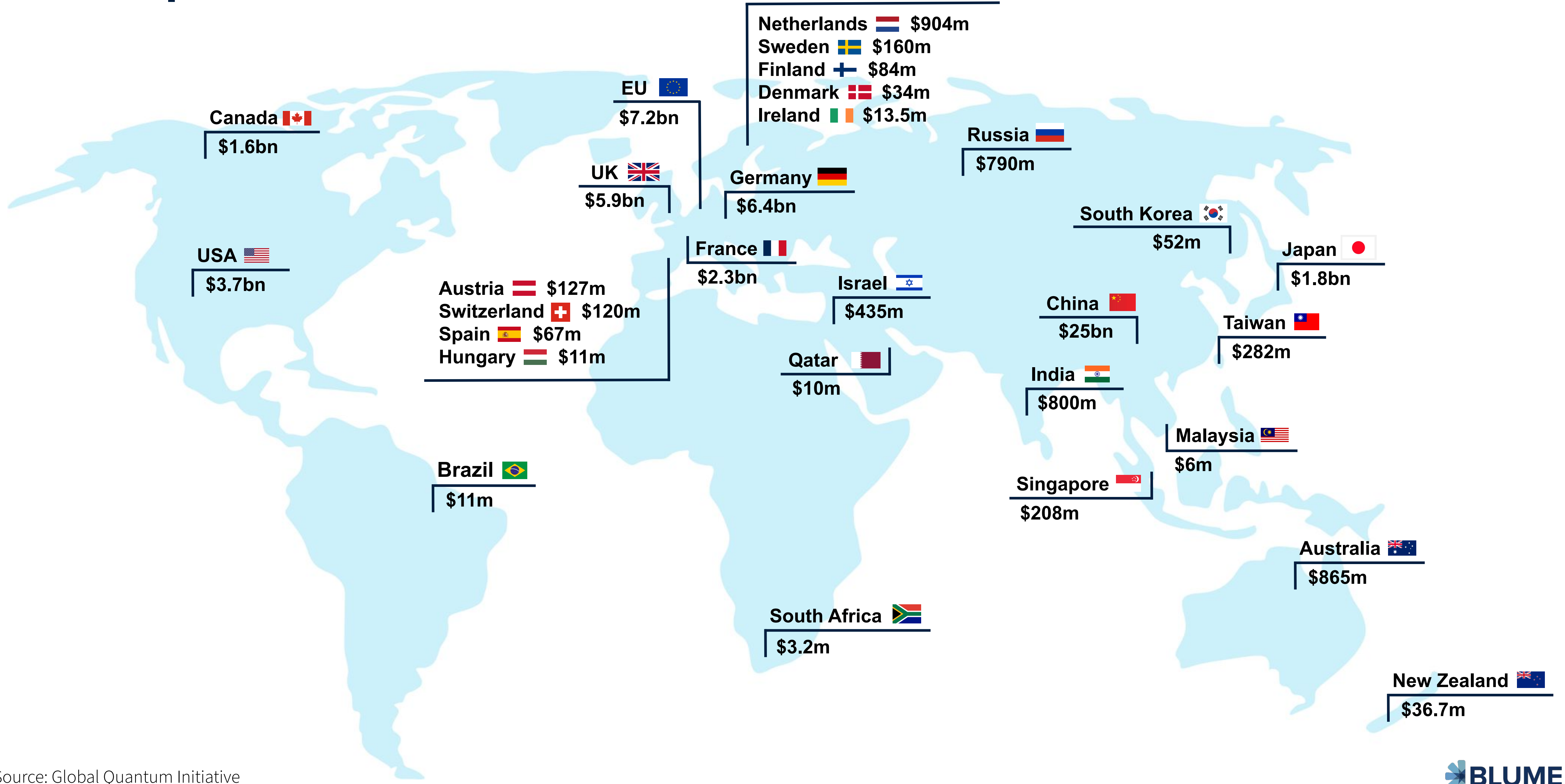
Global Investments: What tech has gained the most confidence?

Superconducting remains the most advanced and matured technology with highest investments done till date. Extensive R&D by companies early on will prevent new startups from entering due to high capital requirements, patents and IP barriers and breakthrough research being the entry point



Source: Olivier Ezratty

Governments have invested $58bn through 29 national initiatives to drive quantum innovation



Source: Global Quantum Initiative

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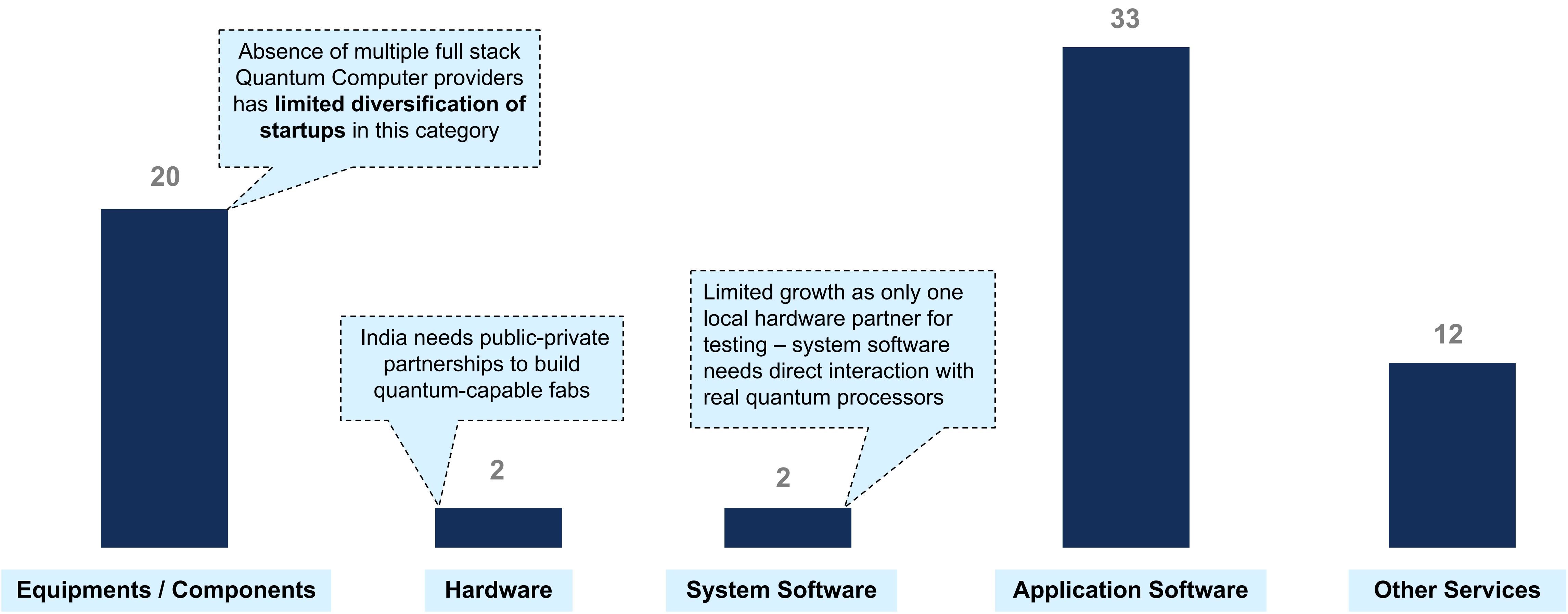
India's quantum tech is leading in software, only two startups building full stack quantum computing hardware

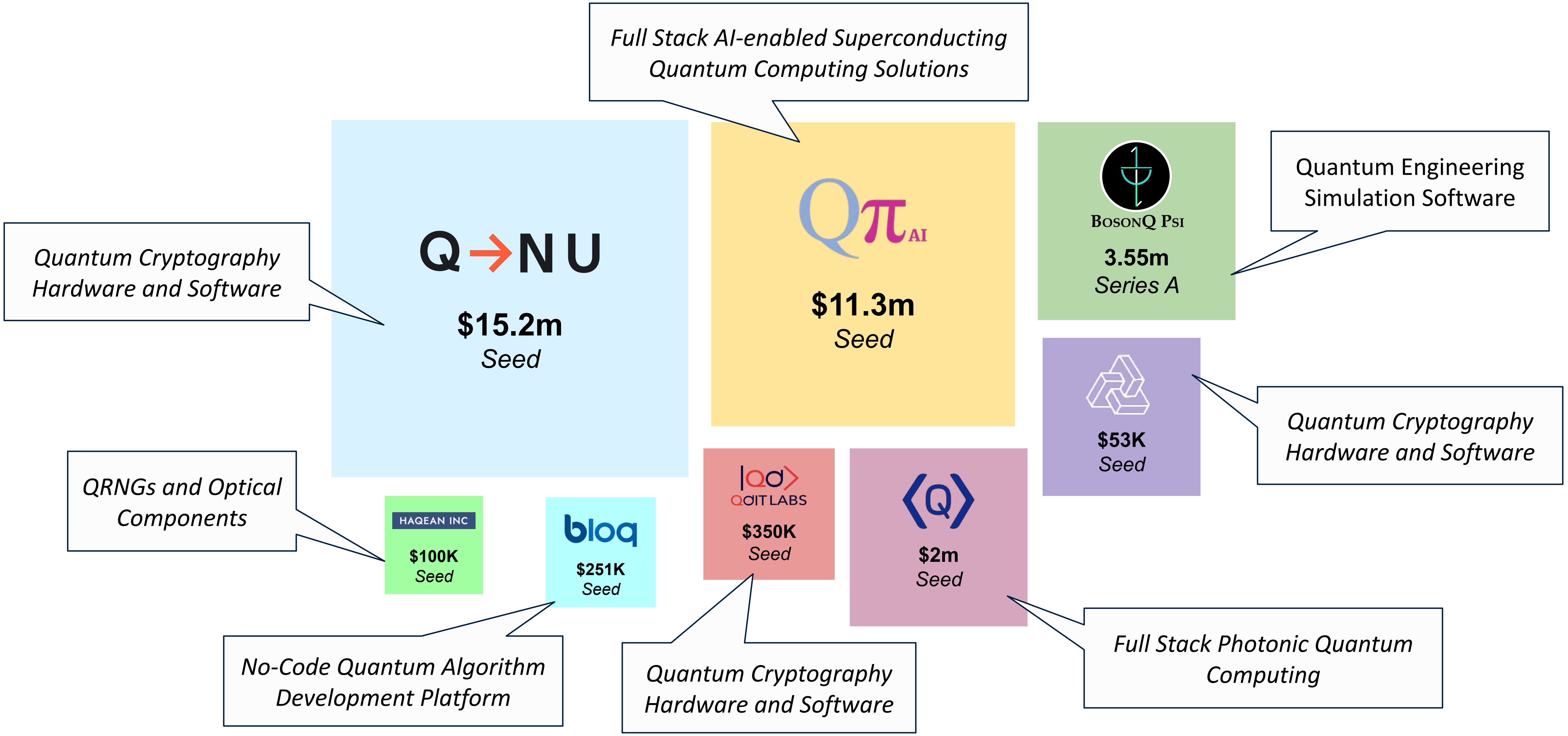
*While **67% of Indian startups are primarily working on application based software solutions**, only a few startups are focused on R&D and Hardware in Quantum Computing due to high capital, infrastructure investment and lack of specialized talent among other reasons*



Source: Tracxn, Blume Analysis. Note: Chart depicts number of startups offering products and services in each category of quantum computing technology, involves startups with multiple category focus. Only full stack quantum computing or processor chip providers are considered under the Hardware category, startups providing partial systems or equipments & components are separated into Equipments / Components.

India’s private funding scenario is in it’s nascent phase

*India has **45** known quantum computing startups. Around **30%** of which are funded with **only one series A round** in the sector and all others are either at seed stage or have received grants*



Source: Tracxn

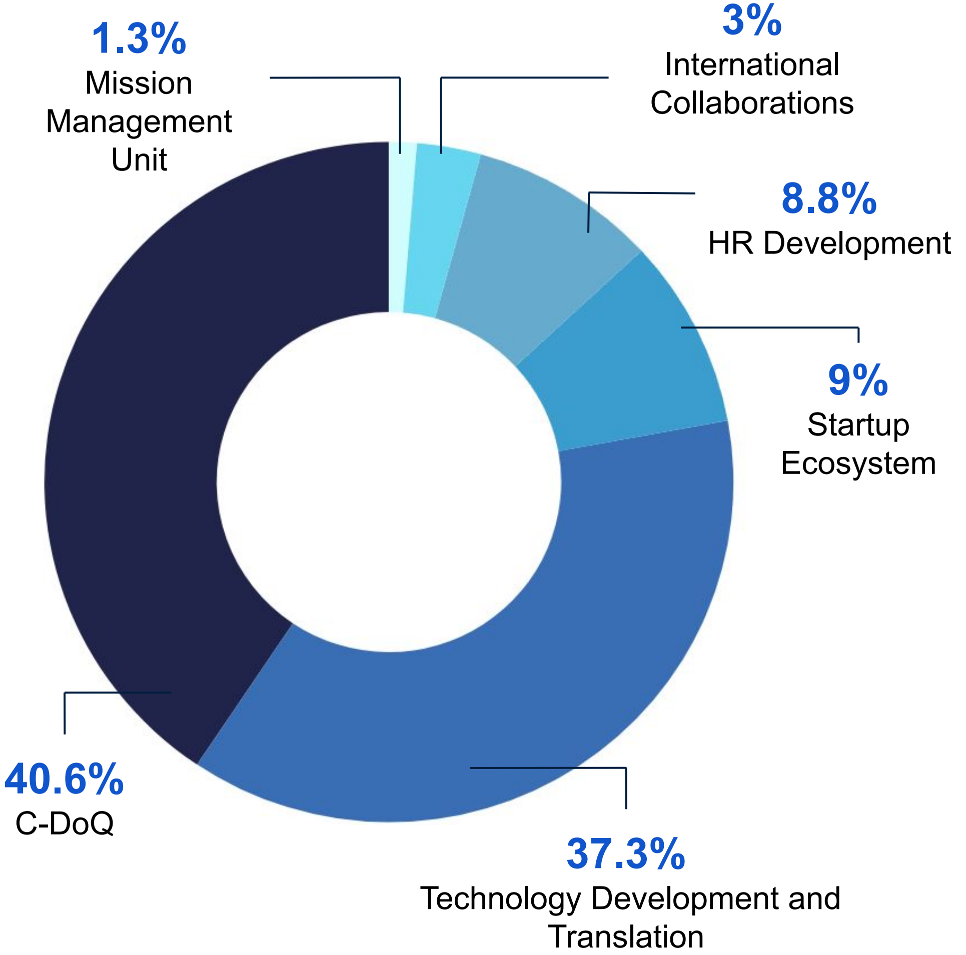
India's National Quantum Mission

Mission objectives include developing quantum computers with 50-1000 physical qubits in 8 years, satellite-based secure quantum communications between ground stations within India, long-distance secure quantum communications with other countries, and inter-city quantum key distribution

The National Quantum Mission with a budget of nearly **$730 million** for the period 2023 - 2031 has the following key objectives

- Multi-nodal quantum communication infrastructure - Fiber and satellite based QKD
- Establish 4 Thematic Hubs – dedicated centers focusing on areas such as quantum computing, communication, sensing and materials
- Funding joint research and development projects between Indian startups/companies and research labs (IITs, IISc, TIFR)
- Homegrown quantum hardware with superconducting or photonic technology
- Supporting PhD and postdoctoral programs in quantum technologies

Budget allocation under NQM

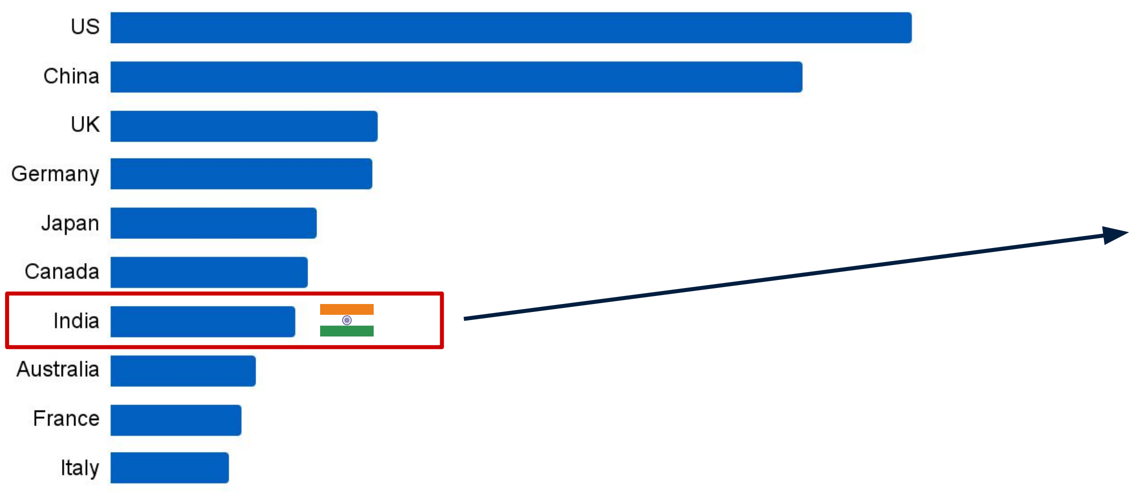


India's scientific progress and quantum talent looks positive

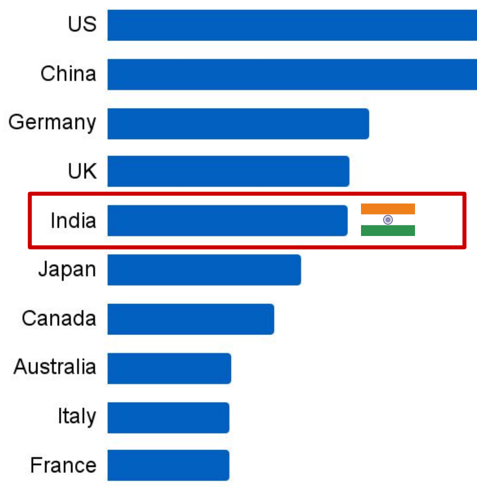
India has a right to win in the quantum race owing to the efforts in scientific research and the high number of papers being published

Global share of peer reviewed scientific publications in quantum compute

2020 - Publications breakdown by country (%TP)



2023 - Publications breakdown by country (%TP)



India had **5th highest** number of papers published in 2023

>60% quantum jobs require at least a doctoral degree in quantum computing

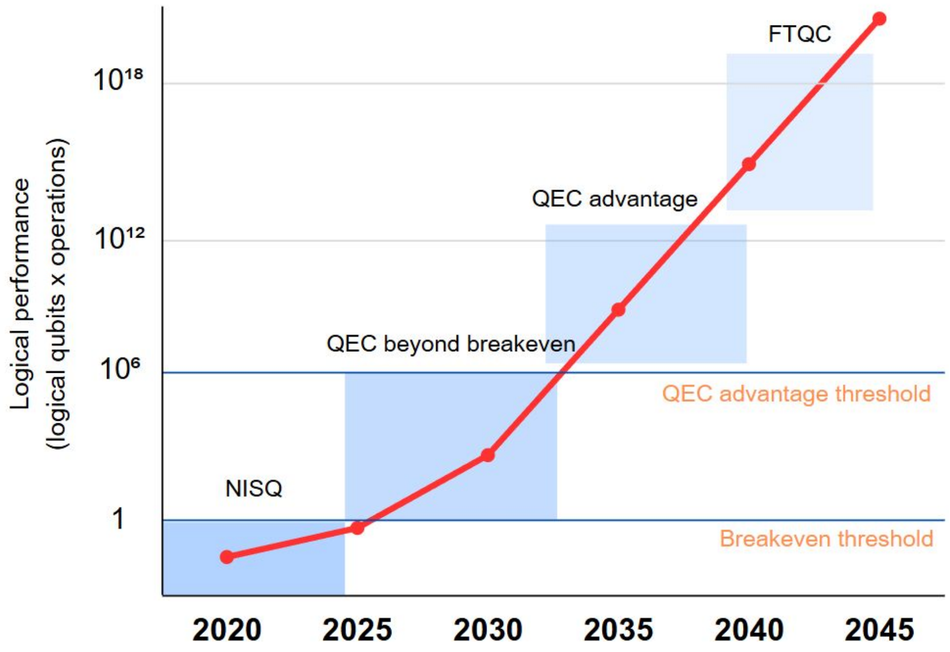
- **India produces more than 24,300 doctoral graduates each year**, the number lies among the top PhD producing countries.
- This abundant academically qualified individuals can be easily trained to take up quantum computing jobs with specific training. India can be one of the leaders in the sector if we leverage our academic institutions, human resources and research infrastructure to do so.

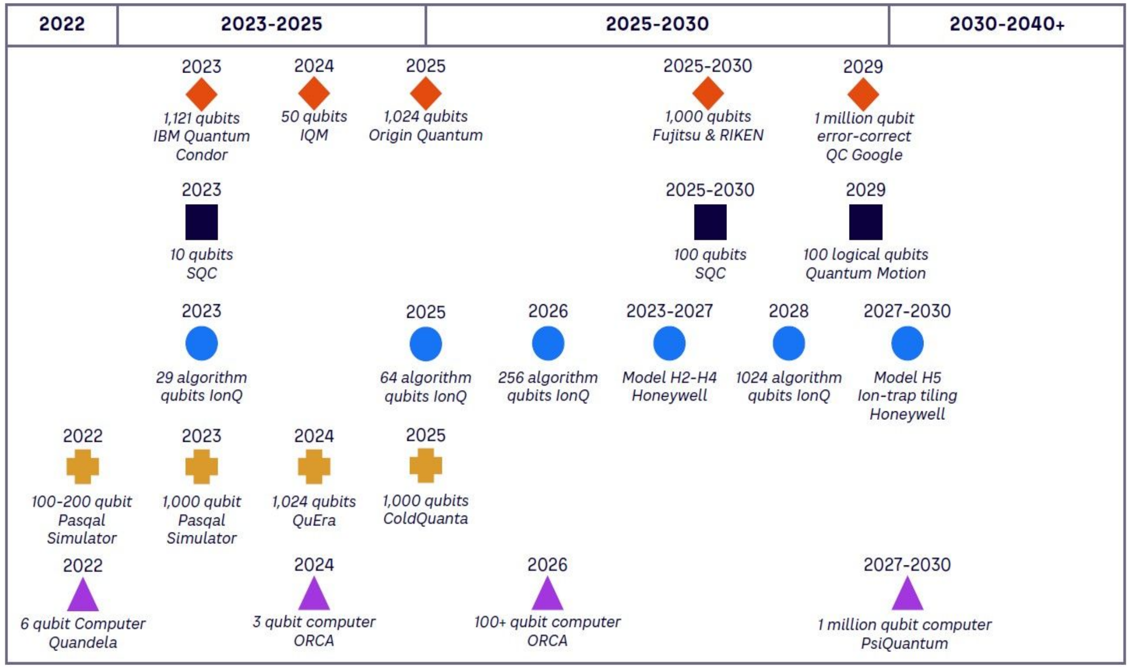
Source: McKinsey, Michel Kurek

Quantum Adoption Timeline

The road to quantum advantage: How close are we?

Quantum computing technologies and industry is currently immature and has some uncertainty for viability and value of use cases, significant industry adoption will be seen after the QEC advantage threshold is surpassed





- Currently in the **Noisy Intermediate Scale** (NISQ) Era – limited qubits, prone to errors, lack full error correction capabilities. Hardware constraints and competition from advanced classical computing methods like AI, will keep immediate commercial value under wraps
- **Broad quantum advantage** in the next decade – increased qubits, reduced error rates, quantum systems will begin to outperform classical computers in material discovery, optimization problems and risk modelling
- **Fault-Tolerant Quantum Computing** (FTQC) will have fully error corrected and reliable execution of complex algorithms over extended periods.

Source: BCG, Quantum Computing Report , Olivier Ezratty

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Slow unlocking of algorithms and applications on the way towards fault–tolerant quantum computing

The wave of quantum technologies is unique in that it is even more unpredictable and difficult to grasp than the other digital technology waves. Investors need to take some time and effort to check the claims made and find out the real technology readiness, computational and economic quantum advantage.

quantum advantage
some useful cases
no useful case so far

	classical computers	quantum annealer	quantum simulators	gate-based quantum computers	
				NISQ	FTQC
search algorithms	hybrid algorithms				polynomial speedup
optimization algorithms	hybrid algorithms			QAOA	may require qRAM
quantum machine learning	hybrid algorithms				may require qRAM
physics simulation	hybrid algorithms	Ising models	Ising models	VQE, Ising models	100 to 10K logical qubits
organic chemistry simulation	hybrid algorithms	hard for fermionic simulations	hard for fermionic simulations	VQE not scaling well	100 to 10K logical qubits
integer factoring	hybrid algorithms	6-digit record to date		15-digit record to date (QAOA, China)	4K-6K logical qubits
quantum inspired algorithms					
	now	now	soon	later	much later

« quantumness » and arrow of time availability

Recent Headlines

Reuters

Google says commercial quantum computing applications arriving within five years

February 5, 2025 9:45 PM GMT+5:30

Reuters

Microsoft creates chip it says shows quantum computers are 'years, not decades' away

February 20, 2025 5:10 AM GMT+5:30

Source: Olivier Ezratty, Reuters

Investing in quantum computing – when and where?

Ventures in application software, and cryptography are likely to receive venture investments in the near term, and fault-tolerant hardware and full-scale quantum networks will see more selectivity

0-5 years	5-10 years	10+ years
Software and early hardware wins	**Broad quantum advantage emerges**	**Disruption and deep hardware bets**
• Quantum software with focused applications in **optimization**, **material discovery** and **cryptography** • **Photonic** and **Quantum Dot** qubits offering easier and low cost fabrication with early scalability • Quantum **cloud services** offering hardware-as-a-service, development platforms and industry specific solutions	• Fault tolerant quantum processors • Quantum cryptography and secure communications using **QKD** and **PQC** • Industry specific quantum applications in finance, logistics, energy and more • Error correction software and hardware, noise resistant qubits	• Scalable, fault tolerant quantum computers with **1000+ logical qubits** delivering highly reliable computations • Global **quantum networks and internet** infrastructure • Quantum AI and autonomous decision systems
Software and cloud-based solutions will generate revenue before fault-tolerant hardware arrives	*Quantum hardware and middleware will start delivering commercial benefits at scale*	*The era of full-scale quantum computing will disrupt global industries, making early investments highly profitable*

Source: Blume Analysis

Quantum lingo decoder

Qubit: Imagine flipping a coin that stays in both heads and tails at the same time until you check - it's not just 0 or 1 like regular computer bits; it's both!

Superposition: The ability of a qubit to exist in multiple states at once. Imagine being in two places at the same time - quantum particles can do that!

Entanglement: A mysterious connection between qubits - change one, and the other instantly changes, no matter how far apart they are. Einstein called it *spooky action at a distance*.

Quantum Tunneling: Ever seen a ghost walk through walls in movies? In the quantum world, particles do something similar - skipping barriers instead of climbing over them.

Quantum gates: Like logic gates process bits in classical computing, quantum gates manipulate qubits to perform calculations. But they don't just flip 0s and 1s; they operate in complex ways using probabilities!

Quantum Interference: Imagine ocean waves colliding - sometimes they amplify, sometimes they cancel out. Qubits use this trick to compute faster and smarter than classical computers.

Decoherence: The buzzkill of quantum magic - when qubits lose their special state due to outside interference, like a perfectly stacked house of cards collapsing from a gust of wind.

Quantum Supremacy: Not a sci-fi villain's title! It's the moment when a quantum computer solves a problem no regular computer can handle in a practical timeframe.

Quantum Algorithms: Like secret recipes that only work in the quantum kitchen - special instructions that let quantum computers crack complex problems way faster than classical ones.

Quantum Annealing: Nature's way of finding the best solution - like a metal cooling into its strongest form, quantum computers use it to solve optimization puzzles efficiently.

Quantum Error Correction: Because qubits are finicky, we need quantum spellcheckers to detect and fix mistakes without ruining calculations.

Cloud Computing: Instead of owning a quantum computer (because they are complex and expensive), companies let you run quantum tasks remotely - like renting superpowers online!

QFT (Quantum Fourier Transform): A powerful math trick that helps process information super-fast - imagine solving puzzles at lightning speed instead of slow trial-and-error.

Quantum Sensors: Devices so sensitive they can detect gravitational waves, measure tiny magnetic fields, or even map the underground without digging. Future tech at its finest!

Deep tech valley of death: The level that all deep-tech startups must beat—where high R&D costs, long timelines, and skeptical investors test their survival skills.

Photon Number Resolving Detectors – PNRDs can count the exact number of photons in a quantum system, making them game-changers for secure quantum communication, optical computing, and ultra-precise sensors.

High-Performance Computing (HPC) – Supercomputers on beast mode. HPC systems use thousands (or even millions) of processors working in parallel to handle extreme-scale simulations, AI training, and crunch complex problems that classical computers can't.

Note: An LLM has been used for the descriptions.

Meet our author

Akhilesh Agarwal
akhilesh@blume.vc

Blume Ventures is among India's leading early-stage venture funds, investing in tech led ventures across sectors. We are presently investing our of our US $290m fund IV. We are sector agnostic investors and typically invest through Seed to Series A stages with a preference to come in early.

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Thank you!

While we are thesis driven, we are also open to questioning and changing our views as we learn from founders and the market. If you have any feedback on this thesis, or would like to push back on any view, please reach out!

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