QT Quantum.Tech

The Road to Quantum Supremacy

Produced by Quantum.Tech

In Partnership with Honeywell

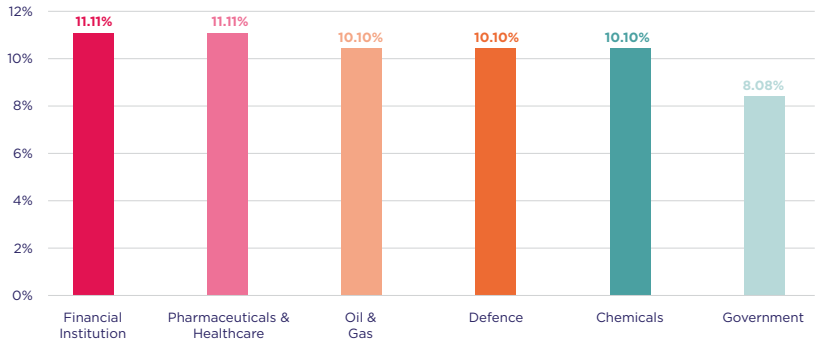
Contents

Methodology

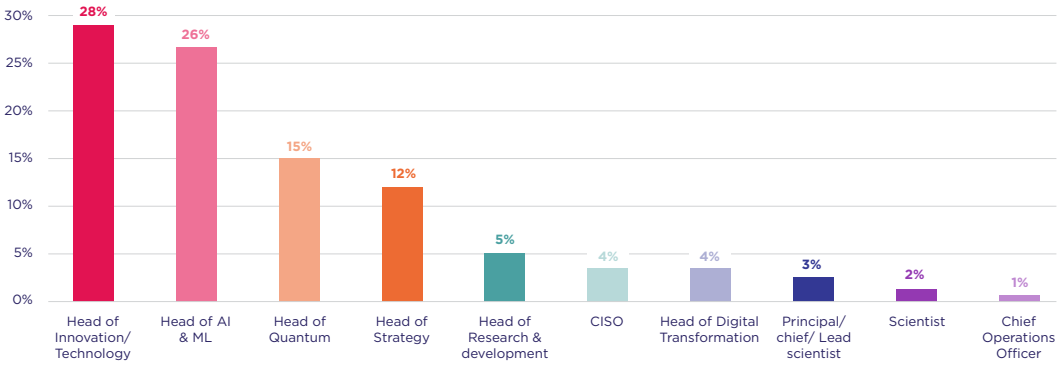
In Q3 of 2021, Quantum.Tech surveyed 100 Head of Quantum, Quantum Lead, Head of Quantum Technology, Quantum Computing Scientist, Quantum Programs (Head/Lead/Director) from across the US and North America, the EU and beyond.

The survey was conducted by appointment over the telephone. The results were compiled and anonymised by Quantum.Tech and are presented here with analysis and commentary.

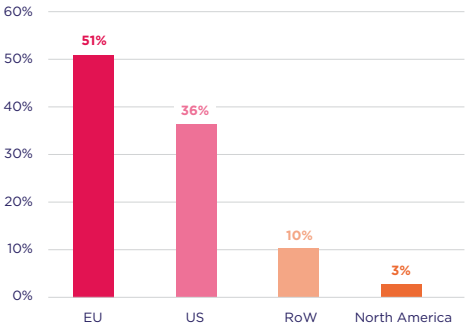
Industry



Seniority



Region



Key Findings

Super conducting to beat classical in practical problem solving

55% say super conducting quantum computers will be first to trump classical counterparts.

Cost is the biggest quantum barrier

23% say cost is holding quantum tech back.

Quantum supremacy by end of decade... or not

40% say it's doable, 38% say it's all hype.

Pharma & Labs to adopt quantum tech first

Two industries will be the earliest adopters.

Healthcare to see biggest impact

28% say greatest benefits of quantum tech will be seen in health.

Government should get behind quantum

Over half say state support is needed to drive progress.

Lack of governance the major barrier to deployment

21% say issues around risk, access and trust delaying deployment.

Quantum algorithms is the hottest topic

20% want to see them on the industry agenda.

US ecosystem is outgrowing all others

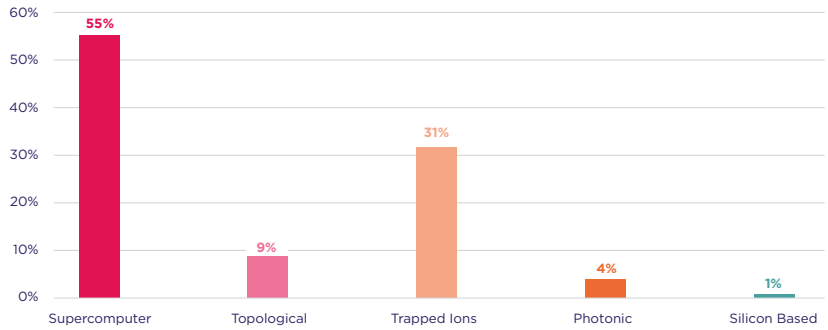
46% say the quantum ecosystem is booming in the States.

The quantum community wants to go hybrid

Mixture of in-person and online events preferred by 45%.

Solving Practical Problems:
Which Quantum Tech Will be First?

Which techology do you believe is scaling the quickest and will support the milestone of a quantum computer being able to solve a practical problem that a classical computer can not?



Amidst all the buzz that surrounds quantum tech, one question resurfaces time and again: when will we see a quantum computer beating out a classical counterpart in a practical (read commercially valuable) problem? As the field of quantum tech is widening, we thought it was time to complement this important question with another: ***which tech*** is scaling fast enough to support the achievement of this milestone?

Over half of our respondents (55%) say that supercomputers are scaling fastest, and there is undoubtedly evidence to support this view. Most recently, China's Zuchongzhi, a 66-qubit quantum supercomputer named in homage to the pioneering 5th century mathematician, achieved quantum supremacy. While replicating a quantum benchmark already attained by Google's Sycamore, this still falls far short of solving a practical problem. Yet it demonstrates the strides that are being accomplished in the field of quantum computers using superconductors and reminds us that successfully running complex quantum algorithms is still a necessary precursor to tackling practical challenges.

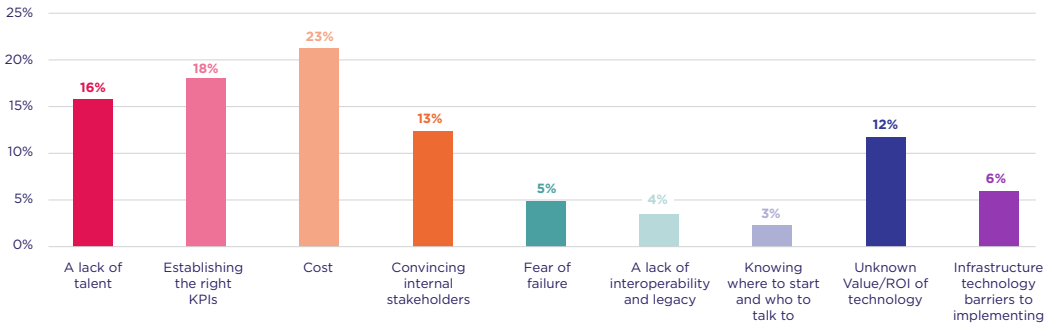
However, **almost a third (31%) of our participants say that trapped-ion quantum computers are gathering pace in the race to scale.** By no means a new technology, trapped ion quantum computers were around long before superconducting loops, yet it is only relatively recently that they are having a 'moment'. While their operations are less error prone, there are still challenges to overcome in terms of scaling, and it will be interesting to see how developments proceed over the coming years.

Topological quantum computing, unsurprisingly, comes next in third with 9%. Despite Microsoft betting heavily on topological quantum computing, working on research and development for over a decade, there is still scepticisim about its viability, which no doubt accounts for its comparatively low ranking.

Given the stiff competition, it is perhaps unsurprising that both **photonic (4%)** and **silicon-based (1%) approaches** sit at the bottom of the table, but many industry watchers would be reluctant to write them off completely, in particular in such a dynamic field.

Barriers to **Implementation**

What is your biggest barrier to implementing quantum technologies?



Quantum advocates face hurdles in every industry. As is to be expected with the emergence of a new technology, there are numerous barriers to getting up and running and, importantly, delivering value. Ranging from the technological to the cultural, our respondents rank them in order of their effect on slowing quantum's take off.

It is unsurprising that **cost (23%)** represents the greatest barrier to implementing quantum technologies: the investment case is made difficult by the limited range of tried and tested applications compared to other nascent technology sets. As forecasting expected ROI will remain difficult for the foreseeable across multiple sectors, cost will likely endure as a significant barrier.

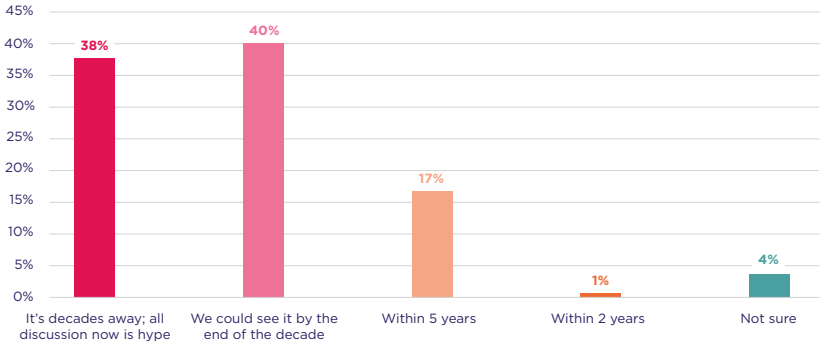
Interestingly, our survey participants regard **establishing the right KPIs (18%)** as the second largest barrier to quantum implementation, pointing perhaps to a lack of strategic focus. Without a clearly defined strategy for the use of quantum technologies, tracking progress against set goals is made infeasible. In a similar vein, the fifth-ranked barrier, namely **unknown value / ROI of the technology (12%)**, also suggests many have yet to determine what their organisations can get out of quantum, which in turn makes the task of **convincing internal stakeholders (13%)** exceedingly difficult.

Recent years have seen huge commitments from national governments to invest in closing the quantum skills gap. Driven by the imperatives of both national security and economic competitiveness, these initiatives have yet to bear fruit, leading to a substantial talent shortage in the labour market. This shortage is keenly felt by **16%** of our respondents.

Quantum enthusiasts can take some consolation in the relatively low rankings for barriers related to technology – such as concerns around **infrastructure (6%)** and **interoperability (4%)** – culture, seen in **fear of failure (5%)**, and awareness of **where to start (3%)**.

Quantum Supremacy: **How Soon?**

What is your opinion on quantum supremacy?



Few concepts in the quantum sphere have captured the imagination as strongly as quantum supremacy. So much more than a memorable phrase, it represents a pinnacle of achievement; the moment when quantum evangelists can celebrate its true arrival. Which is why, of course, several major players have already claimed to have achieved it.

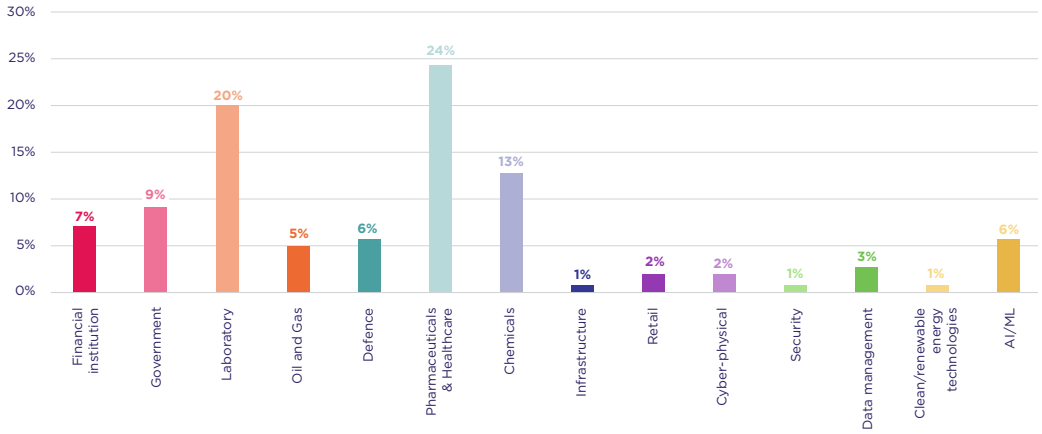
Setting aside those contested, early claims of quantum victory, we asked our respondents to give us their view on quantum supremacy and discovered that those who believe it is on our doorstep are in the minority. **Fewer than 20% of survey participants believe we'll see it within 5 years.**

Yet a significant proportion - **40% - are holding out hope for quantum supremacy to materialize by the end of the decade.** However, an almost equally large segment of our participants – **38% -take the more sceptical view** that quantum supremacy is decades away, and that any suggestion to the contrary is simply hype.

While it is true there have been high profile cases of programmable 50-qubit devices outperforming super computers in specific tasks, disagreement remains over the meaning of 'quantum supremacy' itself. It is likely that this disagreement underpins the split amongst our respondents – and will continue to animate debate across the industry in the coming years.

Industry Applications
Who Will the Early Adopters Be?

Which industry vertical do you see as the most likely to benefit from early adoption of quantum technologies?



Setting aside the debate on the exact timeline of quantum's maturity, it is widely agreed that quantum computers will soon be equipped to solve problems at a greater speed than their conventional counterparts. Of course, these new computing capabilities carry with them the prospect of exciting real-world applications, and industries as diverse as logistics and laboratories are eager to profit from them.

Interestingly, according to our respondents, the three front runners for the early adopter crown are in adjacent industries. A **quarter (24%) believe that the Pharmaceuticals and Healthcare industries will be the first** to extract value from quantum technologies. The applications here are promising and are already attracting a great deal of investment: drug discovery may be accelerated by simulating complex molecular interactions and by predicting the effects of medications on candidates for treatment; more accurate modelling of protein folding could likewise support the development of powerful drugs; and quantum-powered genome sequencing offers the possibility of hyper-personalised medicine. All combine to make this one of the most exciting frontiers in quantum exploration.

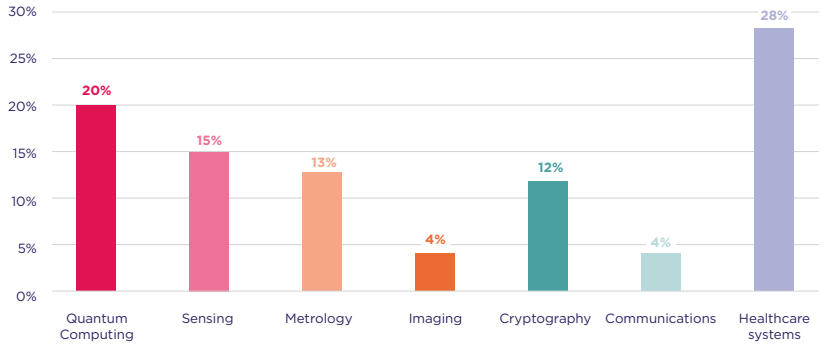
As the first use case for quantum simulation was, famously, the direct study of molecular behaviour, it is unsurprising that our participants also see the **Laboratory industry (20%)** amongst the first to reap the benefits, followed by the **Chemicals industry (13%)**.

Clustering in the middle of the pack is a diverse array of industries: **Financial institutions (7%)** are tipped to benefit from use cases such as portfolio risk optimization, forecasting and fraud detection; **AI and Machine Learning players (6%)** will likely draw upon quantum's advanced data analysis and simulation capabilities to drive the next wave of AI-enabled tech; and the **Defence industry (6%)**, which is attracting huge investment off the back of national security concerns, is eager to exploit quantum's power in areas like code breaking and battlefield simulations.

Finally, it is noteworthy that our participants take a dim view on the prospects of several industries to start seeing value from quantum in the near term, ranging from **Logistics to Materials (0%)**. With all the research and investment activity around quantum, it will be interesting to observe the use cases mature for these sectors.

Quantum Impact: **Where Will the Biggest Impact Be Felt?**

What do you think will be the most prominent utilization of quantum technologies in the future?



Almost 3 in 10 (28%) of our respondents say that healthcare systems will see the biggest impact from the deployment of quantum technologies. This is an unsurprising result, given the possible applications and their outcomes on human health and longevity. Quantum simulation presents the ability to model even the most complex molecules in our bodies – a capability prized by scientists eager to develop new drugs and revolutionary cures. Coupled with the prospect of personalised medicine backed up by quantum-powered genomic sequencing, the outlook for healthcare in a quantum-enabled future is undoubtedly exciting.

For a fifth of our participants, it is computing itself that will see the greatest impact from the proliferation of quantum technologies. Advances in superconductivity, temperature management and, ultimately, increases in qubits are required to unlock the future of quantum computing. All of these elements will combine to enable a radically different approach to computing itself, allowing the industry to solve the previously unsolvable and generate real-world value.

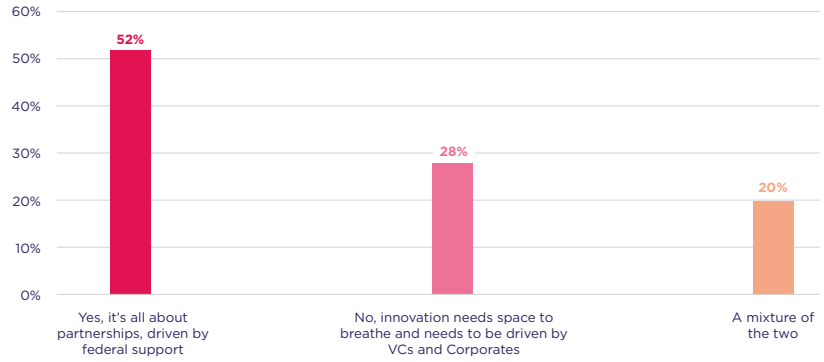
In third place come advances in **sensing (15%)**, a field that is often overlooked but is likely to be profoundly transformed by quantum tech. Indeed, quantum sensing promises to unlock, amongst other things, perfectly accurate navigation, improved autonomous driving and advances in geological exploration.

Beyond our top 3 areas for impact, we find **metrology (13%)**, a field that is inextricably linked with that of quantum sensing, and **cryptography (12%)**, an area that continues to be keenly watched, as quantum cryptographic methods will be required in order to secure systems in the future.

It is noteworthy that our respondents see **imaging (4%), communications (4%)** and **travel, transport and logistics (0%)** as seeing little to no impact from quantum in the foreseeable future.

Support for **Quantum**

Do you think governments should work to support the Quantum industry more?



What is the role of government in fostering technological innovation? Is it a case of 'back it' or 'butt out'? This topic provokes heated debate across many tech verticals and quantum is no different.

For a slim majority (52%) of our respondents, government-backed partnerships are crucial to the quantum industry's progress, and this view could be said to be borne out by recent global developments. The major geopolitical players, such as the US, China and Russia, have been at the forefront of state-backed quantum initiatives, with eye-watering sums committed to investment in research, tackling skills gaps, commercialization and defence applications.

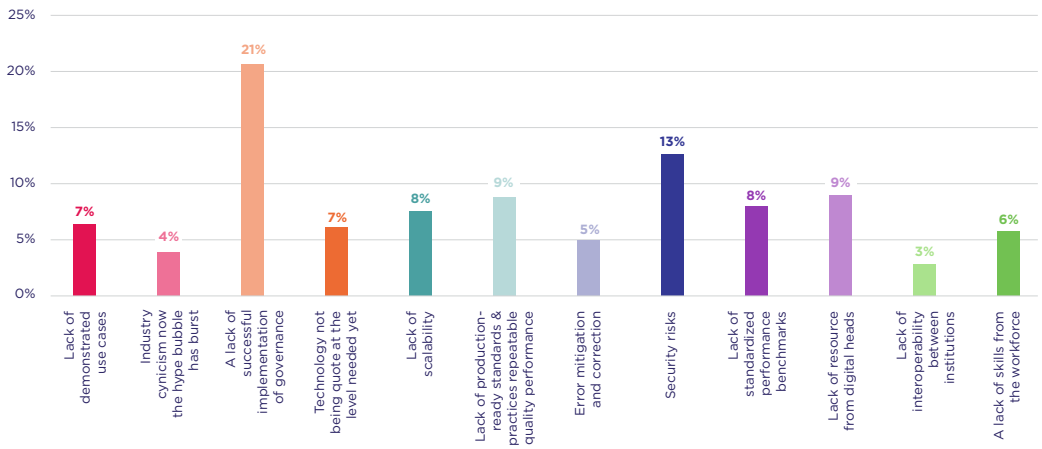
Many other nations, guided by similar concerns around national security and economic competitiveness, are now following suit: from Israel to India and the UK to Germany, quantum initiatives are gathering pace and drawing significant investment. The quantum race is undoubtedly on, and government support looks set to continue as one of the primary motors of change.

However, **almost 3 in 10 (28%) of our respondents believe that innovation needs room to breathe** – and that corporate players and investors should take the lead. This view may stem from a belief in the ability of VCs and corporates, by virtue of their closer proximity to the quantum industry, to more efficiently allocate resources, or, to put it more simply – to identify and back winners.

Of course, only time will tell which approach comes to dominate and yield the best results, but **a fifth (20%) of our participants hope for a combination** of government initiatives and private investment to support the quantum industry into its exciting future.

Quantum Blockers: **What are the Biggest Barriers?**

What do you see as the biggest barrier(s) to the successful proliferation of quantum technologies?



By anyone's measure, quantum computing is a complex technology, and that means it is unlikely to arrive one day out-of-the-box ready and be adopted widely the next. There will inevitably be barriers: the expense and technical expertise required to develop and operate a quantum computer alone exclude many.

Yet when we asked our respondents to identify the biggest barriers to the successful proliferation of quantum tech, there was a clear frontrunner. Just **over a fifth (21%) believe that it is a lack of governance that is getting in the way of progress.** Questions around risk, access, and trust will have to be addressed if this powerful set of technologies is to develop in a way that is consistent with the ethics of the societies it will undoubtedly transform.

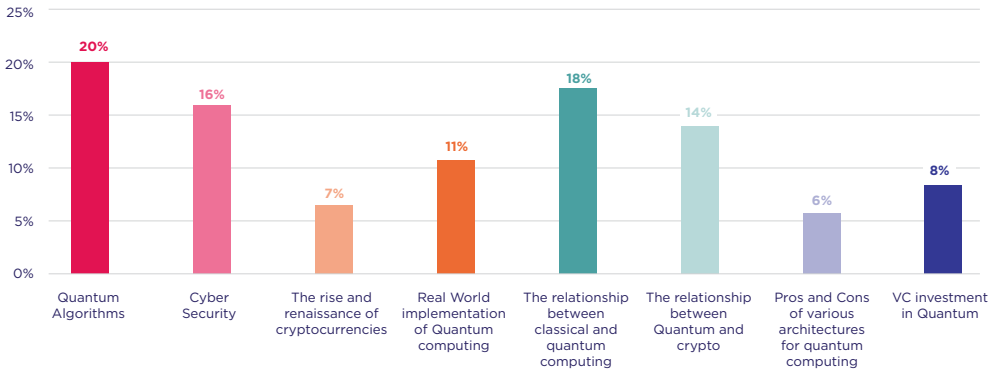
Given this, it is unsurprising that **security risks (13%)** take second position. While today's quantum computers have yet to acquire the power to break standard encryption methods, this capability could arrive within 10 to 20 years, and this naturally creates worry. Luckily, there is growing interest in the area of quantum cryptography, which could head off some of this emerging security risk.

Clustered around the middle of the table are all those pieces of the puzzle that, for many, are missing in order for quantum to take off, ranging from lack of **digital resources (9%), standards (9%), scalability (8%), performance benchmarks (8%) and demonstrated use cases (7%)**. Together, these point to the fact that quantum has a long way to go before it can be said to be mature enough for all but the most cutting-edge players to take part.

Lastly, it is worth noting that **industry cynicism (4%) is not held up as a significant barrier** to progress, suggesting that enthusiasm remains high and participants are eagerly anticipating the quantum future.

Quantum's **Hot Topics**

What are the standalone topics you would like to hear and learn more about?



What's hot in quantum? We asked our respondents, 'what are the big topics you want to hear more about?', and the results suggest that the time for 'big picture', aspirational discussions of quantum computing is passed. Our participants want to understand the nuts and bolts, learn about the potential consequences, and see where value is being realized now.

When we talk of real-world applications for quantum computing, we are really talking about areas where **quantum algorithms** can be applied, and so it is that a fifth of our respondents are eager to learn more about these algorithms specifically, crucial as they are for things as diverse as designing new medicines to optimising financial portfolios.

That so many respondents are also hungry for content on **the relationship between classical and quantum computing (18%)** demonstrates that it is still early days for some. Beyond introductions to the concepts underpinning both fields and where they diverge, there is also interest in their respective future roles. What tasks will quantum computers be delegated, for example, and what does that mean for everyday processing needs?

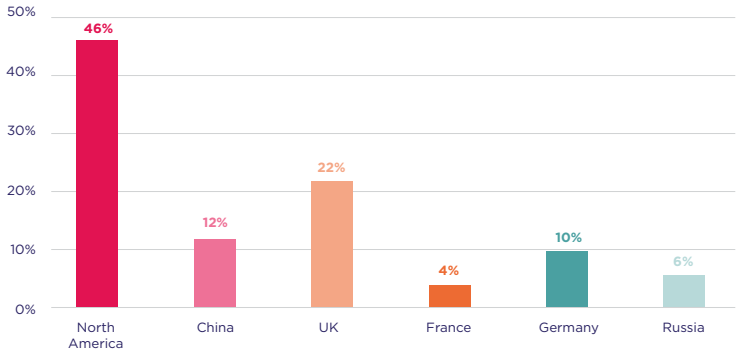
There is one fact about quantum computing that may be keeping business and government leaders awake at night: it threatens the cybersecurity systems relied on by almost every company operating today. Given its ability to break through today's standard encryption methods using its superior computing power, it is small wonder that **cyber security (16%) continues to occupy a top spot on industry watchers' agendas**.

It is interesting that this topic is closely followed by the **relationship between quantum and crypto (14%)**, as quantum's threat to encryption extends to blockchain-enabled cryptocurrencies, which themselves rely on encryption protocols vulnerable to quantum computing. Developments in this corner of the industry will be keenly watched, and rightly so, as the viability of blockchain-based systems could be cast into doubt.

Rounding out our top 5 hot topics is **real-world applications of quantum computing (11%)**, and there is little to be surprised about here. For years, industry experts have claimed we are in a quantum hype bubble, and the only way to navigate out of this supposed era of inflated expectations is to demonstrate tangible value.

Ecosystem Growth: **Who's in the Lead?**

What regions are seeing the strongest quantum ecosystem growth?



For almost half (46%) of our participants, the US takes the top spot. The scale of the resources committed to quantum technologies in the US is undoubtedly the foundation for its strong ecosystem growth. There is a dizzying number of initiatives, from the National Quantum Coordination Office, which sits in the White House Office of Science and Technology Policy, to the creation of the Quantum Economic Development Consortium, which aims to bring industry, government and academic stakeholders together to accelerate technological progress. High profile partnerships to create the quantum workforce of tomorrow, backed by tech giants like Microsoft, Google and Amazon, are both forward looking and a boon to current ecosystem building efforts. To top it all off, the US's enviable position in terms of startup activity and the expertise of its investment community shore up its advantage.

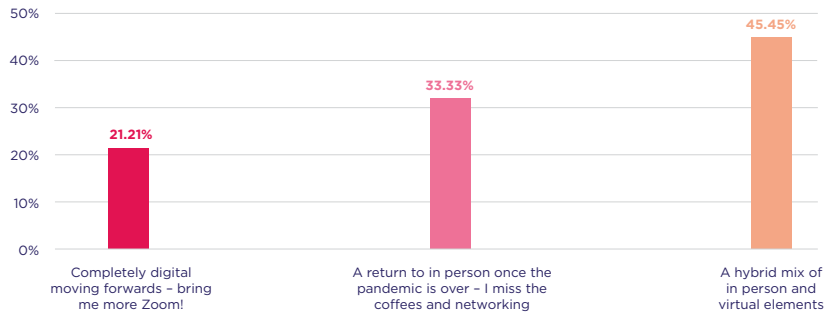
Our participants **ranked the UK in second place (22%)**, a firm indication that its quantum ecosystsem is thriving. Indeed, the UK's National Quantum Technologies Programme was launched as far back as 2013 and since then it has gained pace in the quantum race, moving to the fore of innovation. In addition, the National Quantum Computing Centre continues to carry out its mission to 'catalyse quantum readiness', while the UK's position as a tech and investment powerhouse means the talent and resources to drive further growth are at hand. For the UK, the future looks promising.

Interestingly, **China places third, according to our respondents (12%)**, despite announcements of, for example, US$10 billion in funding for its National Quantum Laboratory, and the success this year of Zuchongzhi, a quantum processor, in replicating Google's Sycamore experiments that led to the latters claims of quantum supremacy.

It would appear, then, that the quantum ecosystems of Germany, France and Russia have some catching up to do in order match the rate of growth of the trio at the top.

What's Next for **Events?**

As the organiser of one of the globe's largest and mort prestigious quantum technology conferences and exhibitions, we would like to ask what would you prefer moving forward?



When covid hit and the world went into lockdown, the curtains fell on event stages everywhere. Now, with the success of vaccination programmes and many people taking their first tentative steps back towards 'normal life', it is time for our industry to take stock too. We are conscious that the pandemic forced many to do a rethink around work-life balance, how they manage their priorities on the job and their professional development. So, we put the question to our respondents: what do you want from us?

For just over a fifth (21.1%) of our survey participants, Zoom fatigue has yet to set in: they favour a total switch to digital, with events taking place virtually from here on. Many learned during the pandemic that digital event platforms opened up new possibilities to attend conferences and online meetings that would otherwise have been squeezed out by tight schedules.

However, after almost two years away, **a third of participants crave the face-to-face interactions that bring that magic quality to events:** while digital events provide excellent one-to-one matchmaking features, it is difficult to compete with the chance encounters and networking opportunities that in-person events excel at.

Is a best of both worlds possible? That is the hope of 45.5% of our respondents. Such a hybrid approach may well be the future as we look to offer something for those who wish to log on, show up, or both. Wherever you find us, in person or online, you can still expect the same commitment to cutting edge content and helping you make the connections that matter.

Why collaborate with **Honeywell Quantum Solutions**

We are developing the highest-performing quantum computers available. Our trapped-ion technology leads the industry in precision, accuracy, and quality.

The System Model H1 has repeatedly set industry records for measured quantum volume since it was released in 2020.

Our technologies have the highest typical limiting fidelity in the quantum hardware industry for single and two-qubit gates.

We were the first hardware developer to incorporate mid-circuit measurement in all commercial offerings.

All-to-all connectivity and high-quality, natural qubits allow for deep circuits and algorithmic creativity.

About Honeywell Quantum Solutions

At Honeywell Quantum Solutions, we believe the future is shaped by what we do today. That is why we are developing the highest-performing commercial quantum computers available and making them accessible various platforms.

Our trapped-ion technology has repeatedly set industry records for demonstrated quantum volume, a measure of overall capability, and has the highest fidelity operations in the industry.

We believe quantum computing will transform business and industry as we know it, including within our own company.

We are collaborating with organizations to develop quantum-enabled solutions that will give users a competitive edge.

Connect with us to learn more about Honeywell Quantum Solutions and why our industry-leading trapped-ion quantum computing technology.

Honeywell

About Quantum Tech

The Quantum Tech conference is the only event which has been designed to bring together senior individuals from the FTSE 500, whom have been tasked with leading the Quantum programme for their respective organisation R&D, emerging tech, innovation, CISO's and Principal Scientists.

Content for Quantum Tech covers the entire Quantum ecosystem; Quantum hardware and software, cryptography & communications, sensing metrology and imaging with a focus on the commercialization of Quantum for enterprise solution applications and real-world user case studies.

The upcoming Quantum Tech events for 2022 are:

- **Quantum.Tech Boston**
  13th – 15th June 2022
- **Quantum.Tech London**
  27th – 28th September 2022

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