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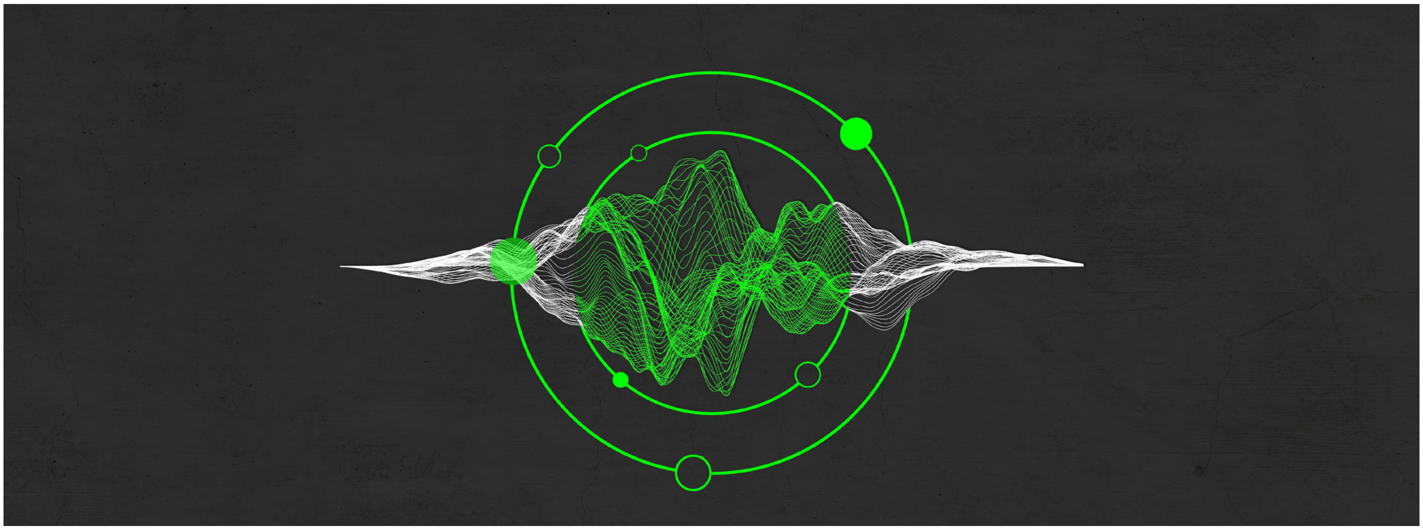

Quantum computing in 2022: Newsful, but how useful?

The future of quantum computing isn't quite here yet. But that doesn't mean that companies shouldn't prepare

Duncan Stewart, Scott Buchholz, Ariane Bucaille, and Gillian Crossan

THOUGH THE TECHNOLOGY is steadily improving, quantum computing will likely continue to boast more media coverage than practical applications in 2022. Deloitte Global predicts that the multiple companies making quantum computers (QCs) will double their QCs' quantum volume—the number and reliability of the quantum bits (qubits) available for computation—from what it was in 2021. VCs invested more than US$1 billion into the sector in 2021, and one company even went public with a multibillion-dollar valuation.[1] Further, investment in quantum by governments, including China, India, Japan, Germany, Netherlands, Canada, and the United States, will likely bring the total to more than US$5 billion for the year.[2] Although we expect these developments to attract a great deal of news coverage, we also predict that fewer than a dozen companies worldwide will be using QCs as part of their day-to-day operations[3] and only for a limited number of use cases mainly around optimization problems. The 2022 revenues for QC hardware, software, and QC-as-a-service will likely be less than US$500 million.[4]

Quantum has great potential, but it's hard to execute

Current QCs are roughly where heavier-than-air flight was on December 17, 1903. Nobody doubted that there were multiple uses for airplanes, and everyone was excited that powered flight had been achieved … but the Wright Flyer's best flight that day covered 255 meters in about a minute, a speed of about 15 km/h, with one pilot, no cargo, and no turns. It was a historic achievement, but not useful.

That said, a little more than a decade later, airplanes were instrumental in World War I, and technology advances faster now than it did then. It's an open question, however, whether quantum computing will follow the same path.

Although QCs are orders of magnitude better than they were five years ago, they remain uneconomic for solving real-world problems. Many of the tasks that they currently do can be replicated on a standard laptop computer at a fraction of the cost.[5] The problem with QCs' usefulness is not a lack of use cases, money, effort, or even progress. It's that current QCs are not yet powerful enough to tackle problems that *can't* be performed by traditional computers. We don't yet know the "magic number" of quantum volume—a measure of the combined quantity and reliability of the "qubits" that drive a QC's computing capacity—that will make QCs useful in the real world.

Companies vary in the way they measure quantum volume, but it seems to be a sign of progress that apples-to-apples quantum volumes are doubling, or even growing more quickly, every couple of years. But it is unclear if we need a quantum volume of a thousand or a million or a billion to make QCs that can be used for multiple real-world applications.

Normally, this is the part of our prediction where we discuss which readers should care and why. Some industries do need to pay attention and get their foot in the quantum door: For them, having small teams doing pioneering work may be useful as a risk hedge. But unusually, the key takeaway for most readers in many industries is that they do not need to care about the likely news announcements coming from various quantum computing companies over the next year or two.

Don't get us wrong. Those companies are investing billions of dollars in research and development; they are pushing the boundaries of engineering and science, and when a useful QC is built at some point, the advancements in 2022 and 2023 will turn out to have been critical steps on the path to utility. But it is not likely that making more qubits, making more stable qubits, or even doing both at the same time will produce a broadly useful QC in the next couple of years.

Should people ignore QCs entirely, then? Not quite. There are a few areas where QCs' usefulness and dollars are here already. These include:

- **Optimization.** There have been some public announcements of a special type of QC solving real-world optimization problems, such as bus routing and radio cell planning. Most of these appear to have been more proof-of-concept trials rather than large-scale or active deployments:[6] The technology worked, benefits were seen, but the solutions do not appear to be being used on an ongoing basis, as it is possible to do similar optimizations much more cost-effectively using classical technologies. However, more recently, a Canadian grocery chain used a QC to reduce optimization computing time "from 25 hours to seconds" and plans "to apply quantum in production daily."[7] It is possible that we will see more logistics and supply chain real-world implementations over the next few years.

- **Quantum chemistry and materials science.** Designing new materials atom by atom is too hard for classical computers, but

QCs may have a head start at modeling quantum effects, whether for new semiconductor materials, catalysts in industrial production, or health care applications. It was first thought that studying a usefully large molecule with hundreds of atoms would require a QC with 800–1,500 qubits, which would be many years away.[8] But more recent innovations in hardware and software suggest this may be conservative, and that real-world applications may be possible in the 3–5-year horizon.[9]

It's worth noting, too, that QCs aren't the only quantum devices that are useful and economically viable for certain purposes. In particular, quantum technology is being used in two applications that, because they were developed earlier than QCs, are bigger markets, at least for now:

- **Quantum sensing.** Subatomic particles can be used to make very responsive sensors whose accuracy and performance exceed that of conventional sensors. These quantum sensors

FIGURE 1

Quantum computing has many uses across industries

Examples of QC applications and industries

	Optimization algorithms	Quantum chemistry/materials science
	Identification of the best solution or process among multiple feasible options	*The simulation and modeling of molecular, atomic, and subatomic systems*
Cross industry	Supply chain optimization Logistics optimization and vehicle routing Process planning and optimization	Reduced data center energy consumption Materials discovery
Consumer	Distribution supply chain Pricing and promotion optimization Product portfolio optimization	Quantum LIDAR/improved sensors
Natural resources and industrial production	Fabrication optimization Energy distribution optimization	Surfactants and catalyst discovery Process simulation/optimization
Financial services	Financial modeling and recommendations Credit origination and onboarding Insurance pricing optimization	
Government	City planning and emergency management Case assignment optimization Command logistics	Advanced materials research
Health care and life sciences	Medical/drug supply chain Improving patient outcomes Protein folding predictions	Precision medicine therapies Protein structure prediction Molecule interaction simulation
Technology, media, and telecommunications	Network optimization Semiconductor chip layout	Semiconductor materials discovery Materials process optimization

Source: Deloitte analysis.

have the potential to replace existing sensors in many applications, including locating and monitoring oil, gas, and mineral deposits; surveying construction sites; and detecting the slightest environmental, seismic, or weather changes. Due to these current and imminent real-world uses, the quantum sensing market was over US$400 million in 2020, has been growing, and will likely be larger than the QC market in 2022[10]—and it is growing.

- **Quantum communications.** Quantum communications is a hardware-based solution leveraging the principles of quantum mechanics to create secure, theoretically tamper-proof communication networks that can detect interception or eavesdropping. Quantum key distribution (QKD) is currently the most mature, and it provides a very high level of security. Communication using QKD can be delivered through fiber-optic networks, over the air, or via satellite.[11] Though it has limitations in speed, distance, the need for repeaters, and cost, QKD is being used in multiple countries by both public sector (military and government) and private sector groups.[12] The QKD market is still niche, but it is expected to be worth US$3 billion by 2030.[13]

THE BOTTOM LINE

As with other emerging technologies such as homomorphic encryption and federated learning (discussed elsewhere in *TMT Predictions 2022*), companies should start putting some thought into QC's implications now, even though most are unlikely to find QCs useful in 2022:

Understand industry impact. What repercussions could quantum have on one's own industry as well as adjacent industries? QCs may be able to solve complex problems uncrackable by traditional computers; what would this mean from a strategic, operational, and competitive standpoint? To understand this, leaders should keep abreast of the technology's progress, and they should monitor how peers, competitors, and ecosystem partners are investing in and experimenting with it.[14]

Create a strategy. Leaders should convene appropriately knowledgeable people to develop a quantum strategy. The strategy may well be to do nothing for now, but to prepare for the future by identifying a trigger event—such as a competitive or technological development—that signals the need to begin or increase quantum investments and exploration. It's important to put someone in charge who has the skills, knowledge, and organizational status to execute the strategy when the time comes.[15]

Experiment. There are various affordable and flexible services that allow companies to play around with quantum algorithms and even compare different quantum hardware architectures.[16]

Monitor technology and industry developments. The quantum strategy should evolve as the state of the technology and market changes. Leaders should adjust the strategy to reflect these changes and be sure not to allow their trigger event to pass by without acting on it.[17]

People sometimes say that quantum computing becoming useful is a marathon, not a sprint. That's both true and untrue at the same time, which makes sense given that we're talking about quantum mechanics. Like a marathon, QC technology's development and commercialization will likely be a long, hard road. But in a real marathon, though we often don't know who will win until the last 100 meters, we do know how long the race is, where the halfway mark is, and that if a runner can run the first 21.1 km in an hour, they're likely to be able to run the whole thing in about two hours. None of that is true about the quantum usefulness marathon. We don't know if we've passed the halfway mark, and the finish line is not in sight.

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