Get ready for the quantum impact

Start planning and experimenting with quantum computing today.

accenture

Quantum computing technology is advancing rapidly, on track to enable vastly more complex business problems to be solved through enhanced optimization, machine learning and simulation.

This is bringing transformation potential to multiple industries, making it possible to discover new remedies in life sciences, improve wealth management scenarios in financial services, reroute supply chains in real time and more. However, a haphazard enterprise approach to quantum—such as researching only a single use case or proceeding without a cohesive strategy—yields exactly what you would expect: innovative sparks with no lasting business value.

Innovation is now table stakes for the modern business; companies must harness technology to outmaneuver uncertainty and meet new customer and business ecosystem expectations. Quantum computing stands to be one of the most disruptive technologies of all time, and competitive advantage will be based on which companies can leverage the potential of quantum to solve key business problems and generate important insights about customers, operations and strategies to transform their business.

According to Tractica, spending on quantum computing will surge from

$260M

in 2020 to

→

$9.1B

by 2030[1]

Enterprises should start preparing now as the technology continues to mature. Waiting until quantum computing is mainstream will be too late. Your preparation should include developing a business and IT strategy that enables quantum innovation at speed and scale.

To capture value while reducing risk, consider these steps:

1.

Learn what quantum can do and decide where it applies to your business

2.

Build a quantum innovation roadmap

3.

Evaluate quantum hardware and software and start experimenting

4.

Source or develop quantum talent

True innovation—both visionary and applied—requires a comprehensive approach and the right partnerships across the quantum ecosystem. Now is the time to shape and accelerate your enterprise journey to improve performance in a quantum-powered future while creating lasting value.

Two approaches, three fields of application

Quantum computing contains two high-level approaches for leveraging quantum-mechanical phenomena to run computations:

In **analog quantum computing,** information is processed continuously. Analog quantum simulation is a well-known application, in which a fully controllable analog quantum computer is used to efficiently simulate the complex evolution of a targeted quantum system. Adiabatic and quantum annealing computers belong to this category.

In **digital quantum computing,** information is processed by a quantum algorithm, which is a discrete sequence of logical quantum gates. Many existing quantum algorithms are known to hold advantage in algorithmic complexity over their classical counterparts. Information in digital quantum computers can be protected by quantum error-correcting codes, which lays a promising future for a fault-tolerant quantum computer.

In addition, specially designed classical computers known as **quantum-inspired hardware** are able to process problems that are natural to certain quantum computational methods, but they do not use any quantum-mechanical phenomena to arrive at a solution.

In terms of fields of application, quantum business experimentation provides a path to solving intractable business problems that are too complex for classical computing systems in three areas:

Optimization
(traveling salesman, decision/planning in logistics, scheduling)

Machine Learning Algorithms
(feature mapping, solving linear equations, clustering, regression)

Sampling and Simulation
(chemistry, material science, structural design)

Some enterprises are taking a hybrid systems approach, deploying quantum hardware to solve certain parts of a large business problem and using high-performance classical computing to address the rest.

From Exploration to Industrialization

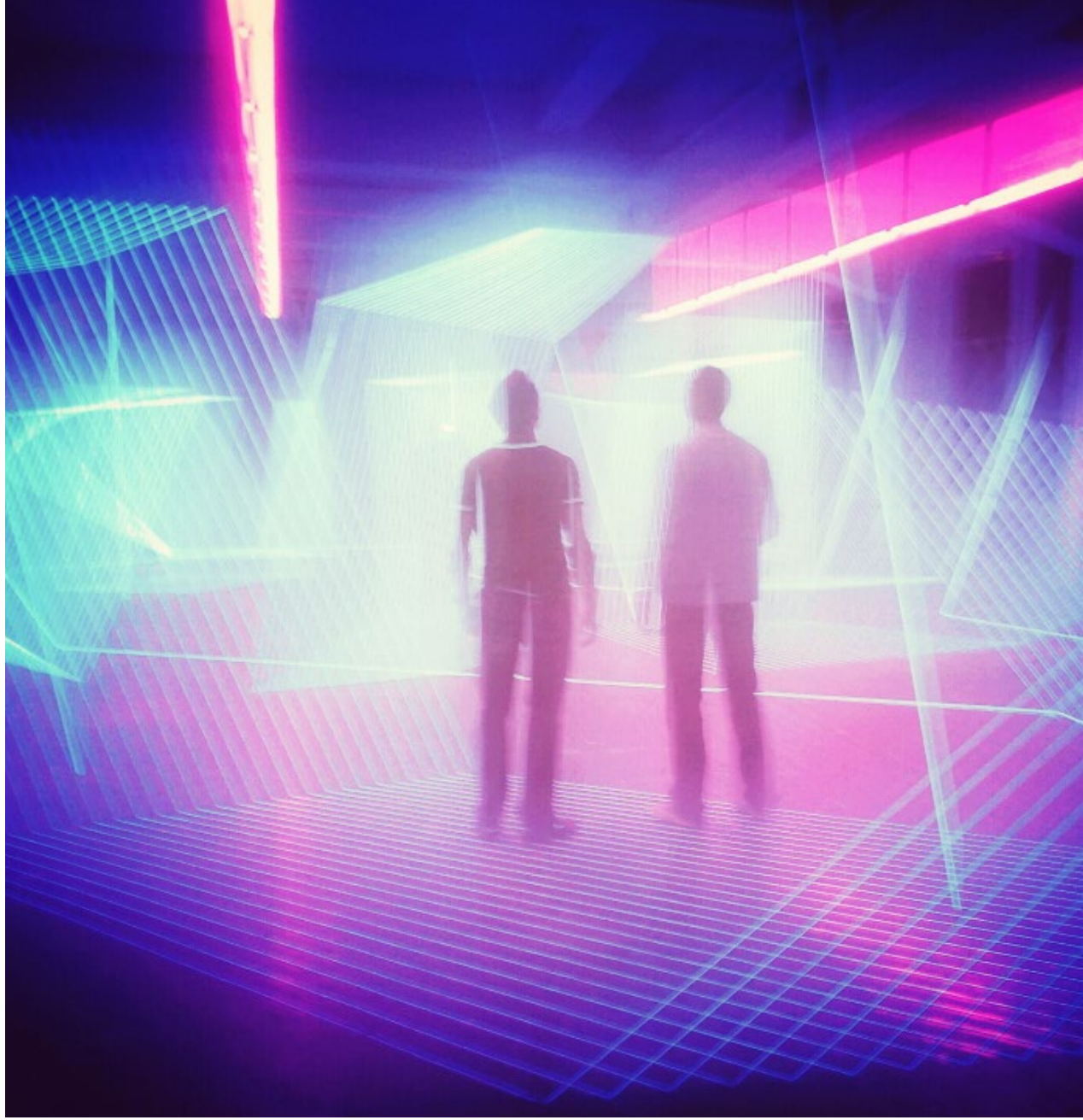
Before diving into the specific steps, consider why haphazard quantum exploration produces only short-term sparks, not long-term business readiness. Such exploration requires a shift in enterprise approach.

To date, most companies that have begun exploring quantum computing have conducted niche R&D in lab settings.

They usually make a bottom-up request for funding and start with a single business challenge that defies existing computing models or takes too long to solve with classical computing. Currently, this exploration is done in conjunction with a small ecosystem of companies with true quantum hardware that they make available for other companies to test solutions. For example, a pharmaceutical company might invest in quantum within its computational drug research lab and try teaming with a quantum hardware vendor to build knowledge. Or a financial services company might invest within its quantitative analysis group (because an expert in the area has started to research quantum) and seek a quantum hardware company to help test assets for future use.

While this approach can be educational, it tends to produce "hit-and-miss" sparks.
On the plus side, it may generate intellectual property in the form of research papers. Or it may inspire a new approach that can be run today with classical computing hardware.

However, exploratory R&D is labor intensive, time consuming and siloed. It does not consider the larger applicability of quantum across many other aspects of a corporate strategy, and the outputs are generally not reusable by other parts of the company.



Today, Accenture sees increasing enterprise demand for quantum computing programs that provide long-term business value, beginning with a detailed understanding of how quantum impacts companies in a broader sense—across the business, R&D, IT and security practices.

In order to solve real-world business problems at scale—for example, in financial portfolio optimization, manufacturing efficiencies and more—the management of quantum computing must shift toward IT services that are integrated into the enterprise infrastructure.

Ideally, this business-centric, IT-driven approach will use a modern consumption model that is abstracted from the underlying hardware and fully integrates with enterprise services and data sources. Designating quantum leads from both the business and IT departments and extending the availability of quantum methods across the organization will encourage engagement, increase understanding and create more opportunities for innovative sparks that can turn into fire (i.e., business value). In the future, this approach could also use quantum architecture stacks that automatically select the most appropriate compute power to solve a given problem. Taking this top-down and industrialized approach to quantum computing is the pathway to innovating at speed and scale.

90%

of organizations will partner with consulting companies or full-stack providers to accelerate quantum computing innovation through 2023, according to Gartner.[2]

Respondents to a 2020 IDC survey about quantum adoption shared where they are focusing their attention, saying they are using or plan to use the following in the next 24 months:

65%

cloud-based quantum computing

45%

quantum algorithms

(which includes simulators, optimizations, artificial intelligence, machine learning and deep learning)

44%

quantum networks

40%

hybrid quantum computing

IDC, Quantum Computing Adoption Trends: 2020 Survey Findings, February 2020

Quantum Moves in the Marketplace

Enterprises in every industry are forging ahead with a more industrialized approach to quantum computing as these examples show. Preparing now can help your company leapfrog the competition.

Life Sciences

Amgen, a biopharmaceutical company, is using quantum computers for molecular simulations.[3] Biogen collaborated with Accenture and 1QBit to accelerate drug discovery, developing a proof of concept that validated a quantum-computing molecule comparison approach and building an enterprise-ready, quantum-enabled application with transparent processes that generates molecular comparison results with deeper insights about shared traits.[4] **(Read case study)**

Financial Services

BBVA considers collaboration with public and private entities vital to its progress, and the company is researching six financial use cases, including proofs of concept with Accenture to test dynamic optimization of portfolios, as well as credit scoring processes and currency arbitrage.[5] JPMorgan Chase & Co. partnered with IBM to perform business experiments with quantum computation, testing algorithms and applications that could be beneficial in portfolio management and fraud detection.[6] Financial institutions including Royal Bank of Scotland, Goldman Sachs and others have funded quantum computing startups directly.

Products

The Volkswagen Group is the world's first automaker to invest in a well-structured quantum computing project, combining its research capabilities with delivery of working prototypes.[7] VW's activities include cooperating with D-Wave Systems on a research project for traffic flow optimization, contributing to the co-creation of the open source TensorFlow AI library and committing to using quantum computing via the cloud. Daimler has had partnerships with Google and IBM, to use quantum computing and relevant simulation techniques to research and design better vehicular batteries.[8]

Communications, Media & Technology

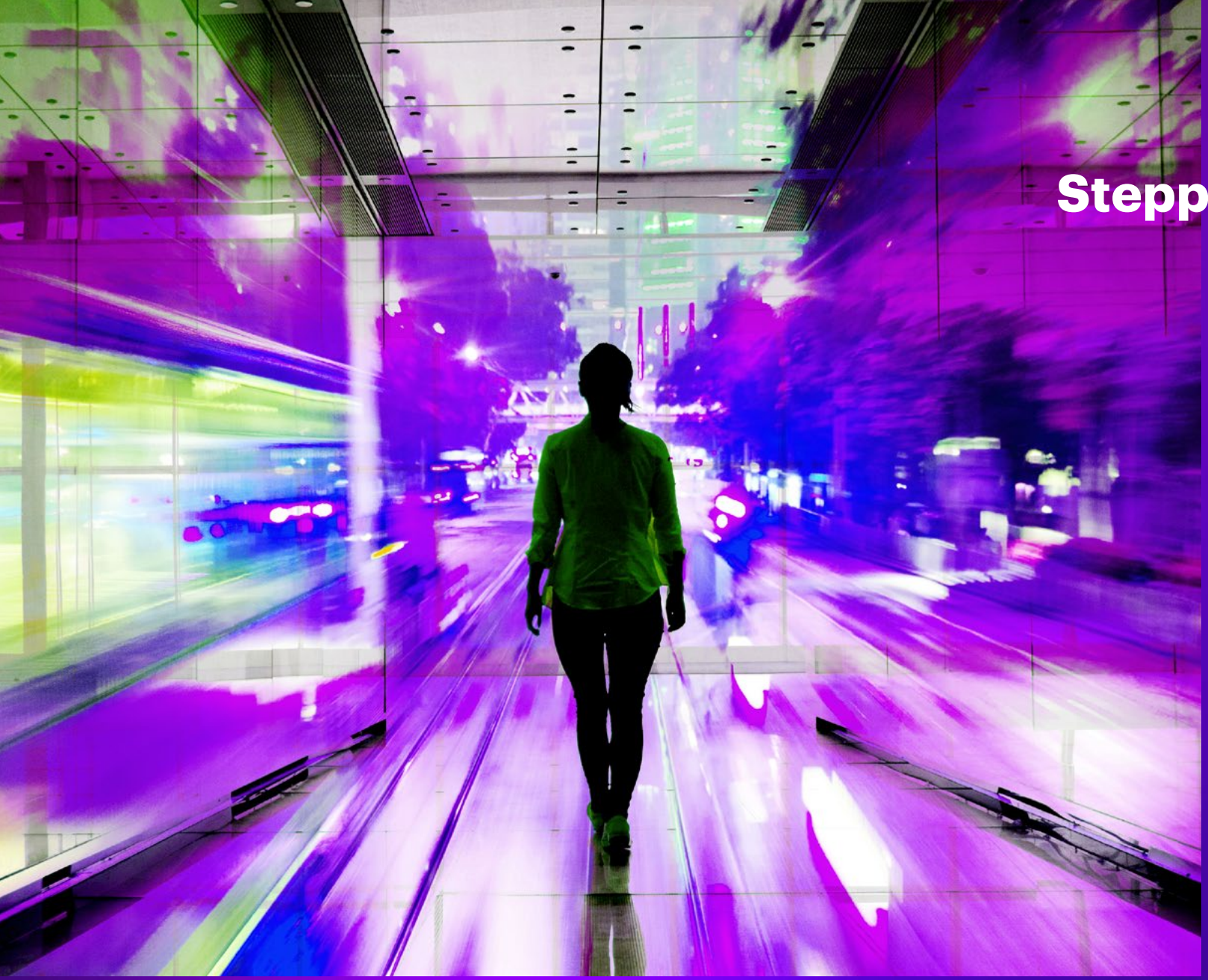
Telstra, a major Australian telecommunications company, provided investment that contributed to the establishment of Australia's first quantum computing company, Silicon Quantum Computing. Samsung's Galaxy A Quantum is the first smartphone containing a quantum random number generator for secure encryption.[9]

Federal

NASA established the Quantum Artificial Intelligence Laboratory (QuAIL) at Moffett Field; the agency has also collaborated with Google and D-Wave on quantum research.

Resources

Dow Chemical is collaborating with 1QBit to build quantum computing applications relevant to the chemicals and materials science technology sectors.[10]



Stepping toward Quantum Innovation

The enterprise quantum computing journey has many phases. In order to progress, your quantum business and IT department leads need to gain an overall understanding of quantum computing concepts, improve the level of business acceptance and organizational readiness, and develop a plan for technology integration and infrastructure.

Four initial steps will help you plan your journey and find ecosystem partners to accelerate it, whether considering an internal quantum practice or a collaboration with a quantum innovation and integration partner.

Step 1: Learn what quantum can do and decide where it applies to your business

Your organization's innovation ability rests on breaking self-imposed limits. Imagine how you could improve your business strategies if you were increasingly able to solve problems once thought intractable. That's what quantum makes possible—so, start by understanding the implications of quantum computing on your industry and business.

Identify and prioritize the business problems in your enterprise that are best attacked by quantum through optimization, machine learning or sampling/simulation. Use your current implementation as a reference or find an academic model for the problem. Be sure to understand the data requirements and document your current limitations. Choose one or a few quantum use cases based on strategic fit and potential for business value.

Use your own data and existing algorithms as the benchmark for your business experimentation and select or tailor the right quantum algorithms to test your chosen use cases. Then survey the quantum ecosystem to identify a short list of strategic partners with quantum assets and methods to help your enterprise build the necessary capabilities to pursue your quantum initiatives.

Acceleration tips

Find an innovation partner with a deep industry understanding to formulate the right questions to ask and the know-how to transform your business based on the answers.

Ideally, your provider should be able to offer access to applied R&D in quantum technology and guidance on relevant business use cases by industry.

In the best-case scenario, your partner will also have proven experience across a wide range of quantum use cases and provide frameworks for business architecture and quantum DevOps practices.

Step 2: Build a quantum innovation roadmap

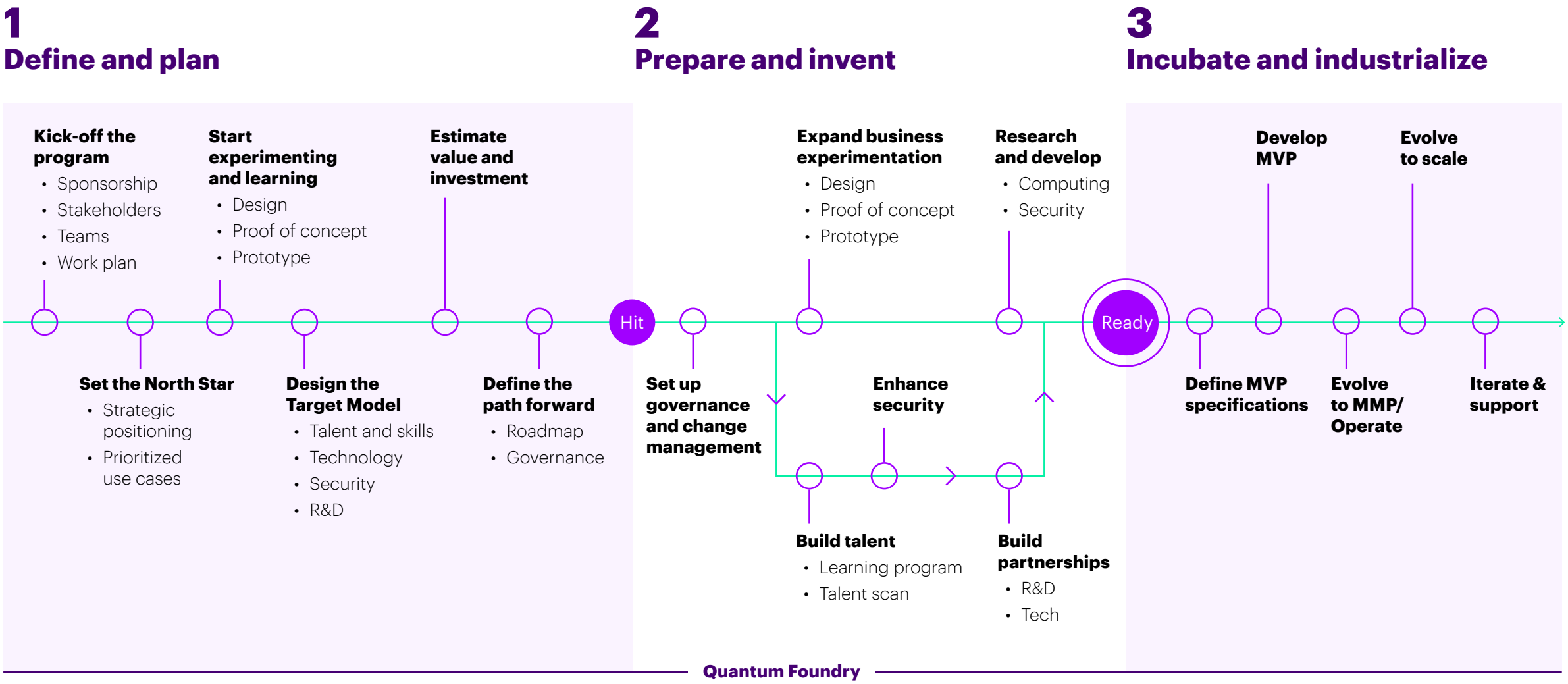
Given the complexity of quantum computing, companies tend to enter the field in short bursts that they deem to be cost effective, such as the niche R&D described earlier. However, taking a longer view of the enterprise quantum computing journey will yield more benefit and business value.

It's important to define the linkage between your organization's quantum program and broader business strategies. The highest performing companies will have a constant feedback loop whereby business strategies are helping to prioritize quantum program outcomes, and the quantum program will inform new strategies to consider.

This longer-term view includes building a multi-year quantum innovation roadmap with ongoing initiatives, such as the sample in Figure 1 derived from Accenture's Quantum Foundry approach. Developing a roadmap will help you formulate and execute your business-centric, IT-driven quantum strategy and begin realizing value as the technology matures.

Identify leadership support and governance for the journey based on your roadmap. If building an internal practice, define the target operating model required to launch and run quantum initiatives, including security and change management. Design quantum proofs of concept/prototypes and expand business experimentation for your selected use case(s) to the point of developing a minimum viable product (MVP). And incorporate long-term quantum objectives into your overall IT agenda, so that the initiative is prioritized and industrialized throughout the enterprise.

Figure 1: Sample quantum innovation roadmap



Acceleration tips

Work with your innovation partner to customize your quantum roadmap for your organization's unique business objectives. Agree on a timeline for when business value can be created.

Do not be afraid to start your quantum business experimentation while still setting up your roadmap. There are going to be obvious use cases that will benefit the business, as well as provide more perspective to the planning process. Leverage your partner's network in the quantum ecosystem to expedite this experimentation.

Work with a partner that has deep experience mapping business problems to quantum algorithms (or quantum plus classical algorithms) and then mapping these same algorithms to hardware. Both connections need to be made for validating a use case.

Remember to include security executives in your discussions about quantum computing and the ecosystem. As your company pursues quantum-related efforts, you will need to develop quantum-relevant security protocols, implement quantum-safe technologies and track the performance improvements of quantum systems as part of threat monitoring. Working together will lead to more informed and strategic decisions, such as consolidating with a cloud provider that offers both quantum safe key management and quantum computing, rather than using multiple vendors.

33%

of respondents to a 2020 IDC survey about quantum adoption said they are using or planning to use quantum cryptography in the next 24 months on **quantum cryptography**.

IDC, Quantum Computing Adoption Trends: 2020 Survey Findings, February 2020

Step 3: Evaluate quantum hardware and software and start experimenting

Accessing the right quantum system to test your use case(s) is an important milestone in your quantum journey. But navigating the rapidly evolving quantum ecosystem is difficult with an increasing variety of hardware vendors, middleware companies, software providers, academic institutions, startups and cloud-based service providers. Many of these ecosystem members focus on different aspects of quantum technology (i.e., digital, analog, annealing, gate), which means selecting the right company requires not only identifying which ones can understand your specific business use case(s), but also can provide the type of quantum technology you need. The proper combination will depend on your quantum strategy.

While free online quantum systems may look tempting, the terms of use will most likely require your company to give up intellectual property (IP) rights. The recommended method is to contract with a quantum vendor for device access to help protect your innovations. When contracting, there are two approaches to accessing quantum hardware: 1) align early with a specific hardware vendor and use its recommended software stack; or 2) work with an agnostic provider and conduct an up-front use case evaluation before selecting a hardware vendor or software stack. There are pros and cons to both approaches in terms of learning curve and ramp-up time.

It's perfectly normal to create a long-term business strategy; however, it can be another challenge to commit implementation of the entire plan up front.

Many companies are having trouble making the business case to enter long-term commitments to do quantum work. For the past several years, hardware and software providers, who are in quantum for the long haul, have rightfully been looking for a few high-value strategic collaborators. This has been reflected in their access contracts or licensing terms, lengthy subscription models or research programs.

Generally, vendors offering hardware subscriptions also provide access to quantum experts if you are not bringing your own through a software partner. This is an excellent model for the handful of companies that are developing quantum expertise internally or have researchers capable of advancing the field. However, this model excludes most companies that have great strategies but prefer to engage through innovation programs—short-to medium-term projects to test technology hypotheses without long-term technology commitments until viability is proven.

Luckily, hardware vendors are now beginning to offer pay-per-use models through major cloud service providers. Just as software abstraction layers from quantum hardware increased accessibility to quantum machines by decreasing requirements for "unicorn" quantum information scientists a few years back, pay-per-use has again lowered the barriers for businesses to experiment with quantum today.

Keep in mind this hardware and software selection process is not a "once-and-done" step. The optimal approach will include a technology stack that abstracts the specific hardware selection, allowing your organization to focus on the business problem. The technology stack will handle the question of which hardware is best for your particular problem.

Acceleration tips

The right innovation partner can help accelerate your journey with established ecosystem relationships across hardware, software, middleware and cloud-based service providers, as well as various types of quantum technology.

Selecting the proper combination of quantum hardware and software will make it faster and easier to conduct business experimentation. It will also kickstart efforts to develop prototypes or MVPs and build quantum-inspired applications.

Create a private code repository and capture your quantum innovations from day one. These reusable artifacts will increase in quality over time as more people contribute. Additionally, they will be valuable for training and education.

High-level quantum services are accessible through cloud APIs, so you can start with the programming language of your choice; however, as your company gets more sophisticated, your innovation partner can help select a quantum-focused programming language and development environments.

Data scientists and quantum information scientists are going to be developing in notebook interfaces, so it is important for IT to have the infrastructure to support this, such as analytical model management tools. Remember, these are modern development techniques; standard DevOps/ModelOps practices should be used for automated testing, configuration and change management, continuous integration and deployment.

Step 4: Source or develop quantum talent

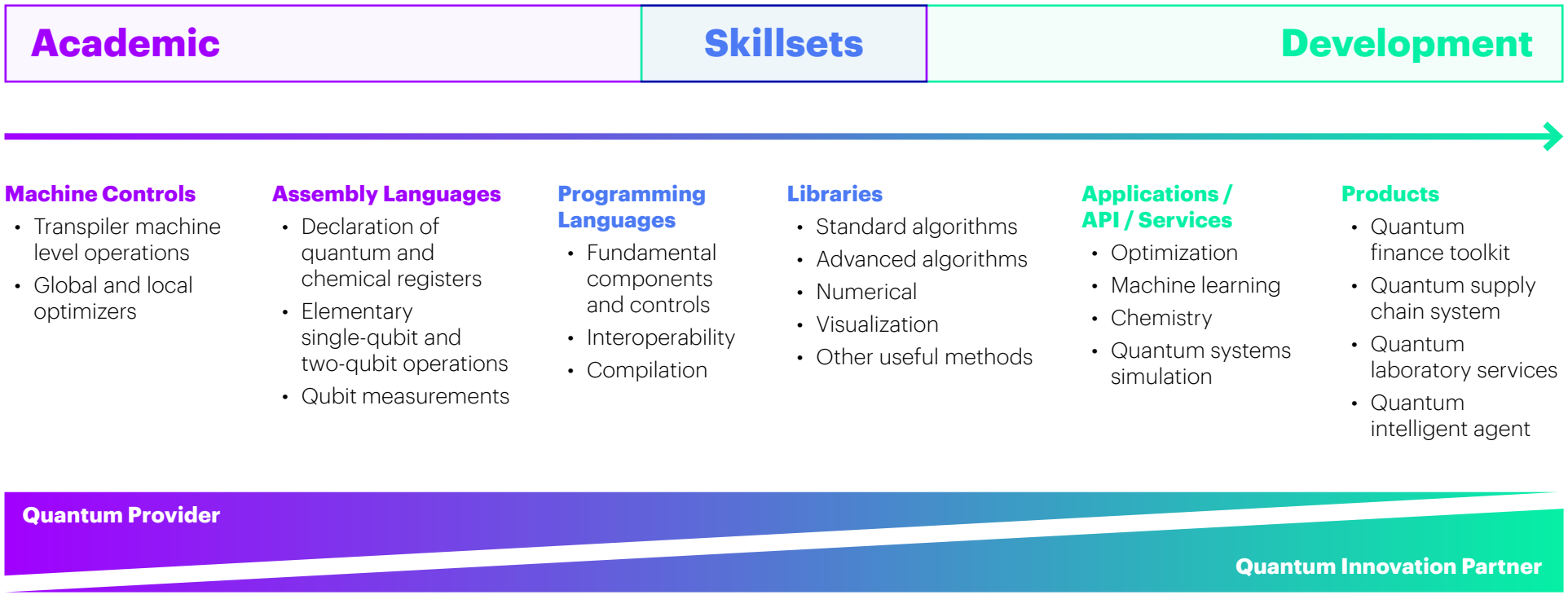
Quantum skills and capability, plus the industry business skills to guide the questions and insights, are well-documented gaps globally. As shown in Figure 2, the necessary skillsets are divided into two pools: academic and development. The academic pool consists of quantum physics scientists and researchers who understand the hardware, algorithms and system interfaces. The development pool includes software coders who can connect the algorithms, libraries and services and build the enterprise applications or products that deliver value for selected business use case(s).

While there is some overlap between the two talent pools, quantum hardware and software providers focus on the more complex and fundamental aspects of quantum. In contrast, a quantum innovation partner will focus on enterprise adoption--using libraries and APIs to develop applications, services and products.

It is also important to be aware of inherent "blind spots" that each of these skill pools may possess. Scientists and researchers need to partner with developers and the business to stay aligned to the goal of the quantum program: to achieve strategic business objectives previously considered to be exceedingly difficult if not impossible.

If developing talent, start by determining the combination of skills your enterprise will need to architect quantum solutions, and be prepared for a steep investment in training over multiple years. Undoubtedly, some companies will attempt to train existing data scientists and engineers on quantum algorithms and development kits. However, quantum courseware for internal training is limited currently. Case in point: Even though machine learning could be one of the best uses for quantum computing, there are few (if any) viable quantum machine learning courses available for enterprise use. It can take several years to fully upskill a team to the level needed to develop enterprise-grade quantum applications.

Figure 2: Quantum talent and skillsets



Your quantum information scientist and quantum developer will not be successful on their own, so an internal practice should prepare for a multidisciplinary team, including quantum system architects with the technical skills to develop new quantum applications from the ground up (e.g., select algorithmic approaches, determine required data and hardware attributes, and apply the high-performance computing experience to map these into a runtime architecture and solution); a delivery lead who is knowledgeable about the quantum project management lifecycle; and an industry expert who can provide input, direction and quality assurance.

A faster option is to source external talent from the quantum ecosystem through partnerships with academia, vendors and your innovation provider. Ideally, the quantum development group will take a reusable approach to quantum components—bringing deep knowledge and DevOps to reliably utilize existing components while establishing an enterprise library to capture and retain collective knowledge.

Acceleration tips

Find an innovation partner that can supply skilled resources in two talent segments that are in particularly short supply:

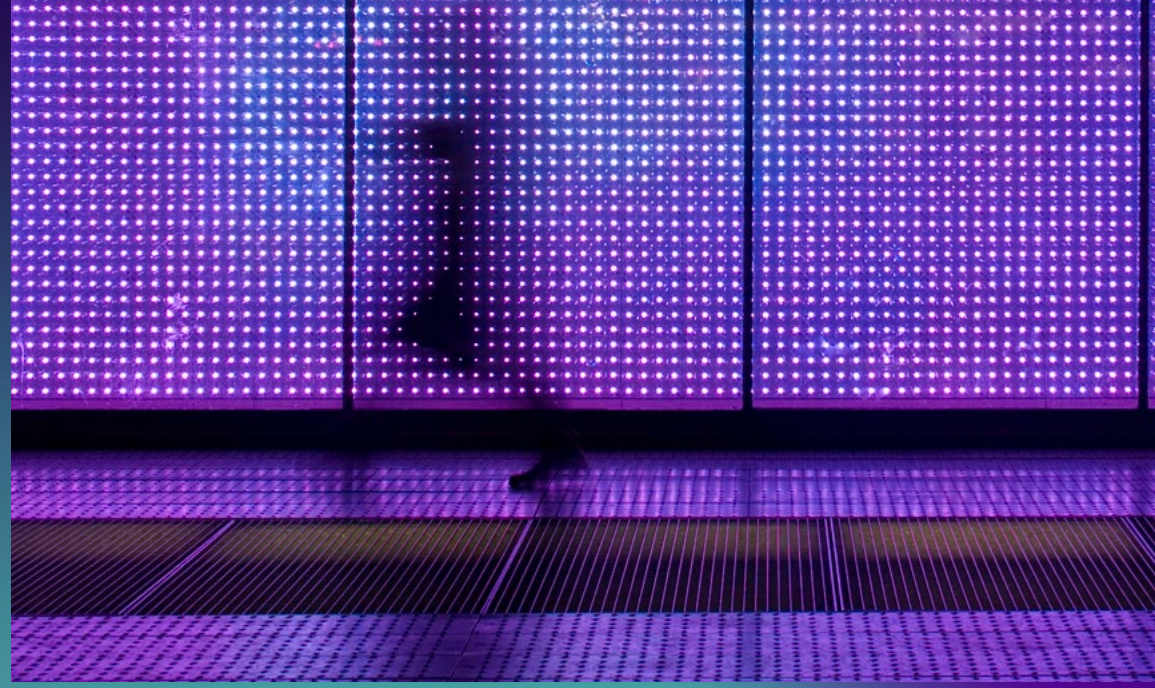
- Quantum system architects, who are skilled in designing and developing quantum and quantum-inspired applications and can ask the right questions about the technology for enterprise planning purposes.
- Quantum integrators, who can pull all the pieces of the solution together leveraging the cloud.

Invest in an industry-relevant quantum training program for your employees and be ready to create a portion of the training content internally since education programs are hard to find.

Consider a flexible model and talent plan for buying, building or borrowing quantum skillsets, augmented with automation and AI.

Accelerate your Quantum Journey

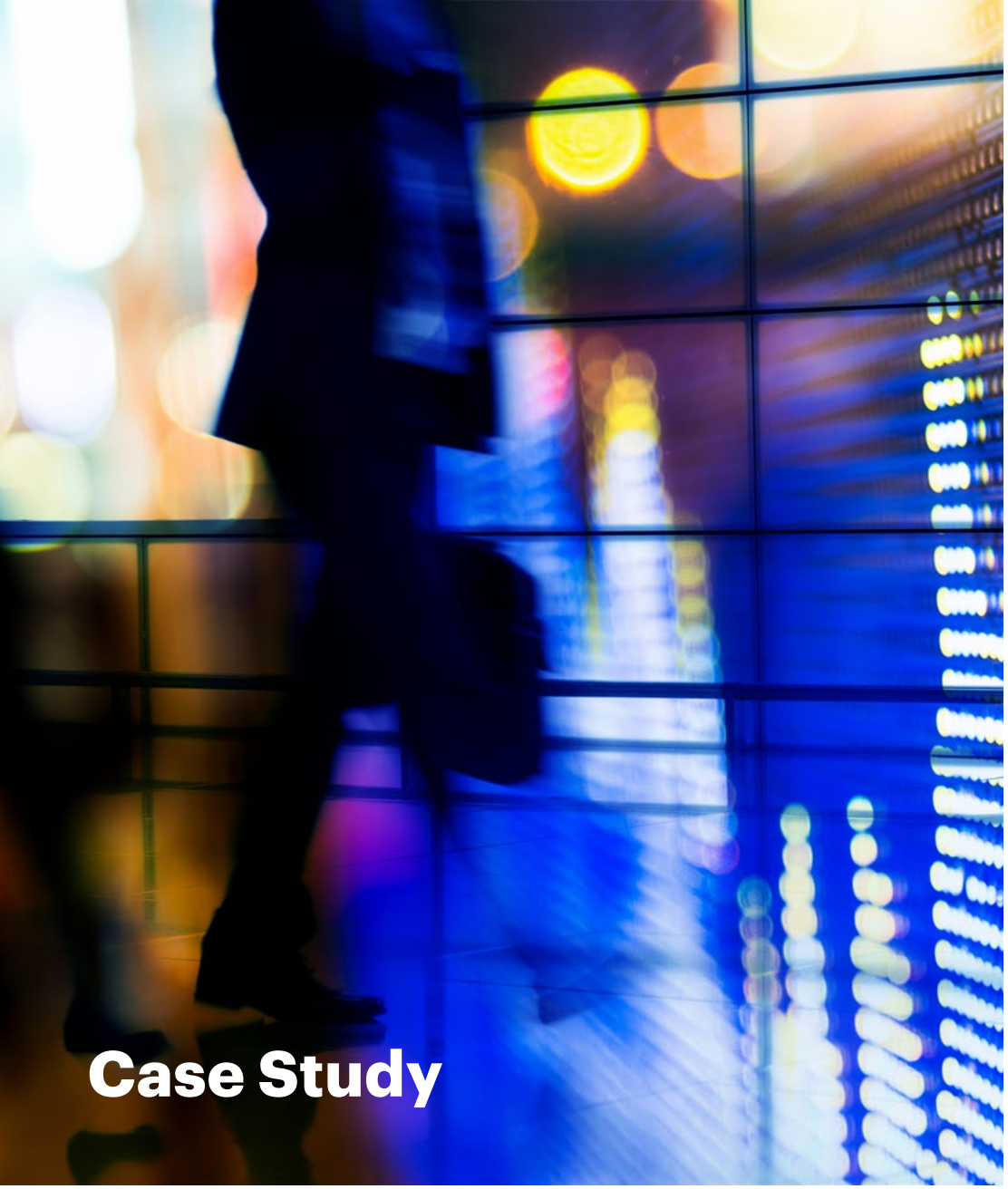
The quantum-fueled future will arrive with a sudden and rapid shift. Prepare your business now and take advantage of the growth potential the technology will provide as it continues to mature. Technology that has extreme disruption potential has historically proven to change the competitive landscape nearly overnight. Fast-track your journey with a cohesive strategy—including relevant use cases, an innovation roadmap, hardware/software partnerships and skilled talent—to gain an advantageous position for the quantum future.



Based on a 2020 Accenture survey in New York metro area,

97%

agree that **quantum computing will provide enormous growth for their companies** comparable to the growth they have experienced from artificial intelligence.[11]



Case Study

BBVA: Exploring the role of quantum computing in the future of financial services

Accenture is co-innovating and collaborating with BBVA, a multinational financial services company, to derive business value from quantum computing today.

As part of a larger project to jumpstart BBVA's quantum experimentation for financial services, three use cases were identified where the complexity of the data, variables and outcomes presented significant challenges for even the most modern computer systems and software packages: currency arbitrage, credit scoring and portfolio optimization.

A team of researchers from Accenture utilized D-Wave's quantum and hybrid quantum systems to successfully map these client-relevant, but computationally challenging, use cases to quantum formulations, enabling quantum readiness for future hardware.

This opens the door for the exploration of more complex use cases and eventual productive deployment, once the necessary hardware is available. Once live, the system will identify new areas of growth, and the resulting stronger trading portfolios will deliver better returns on customers' investments.

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