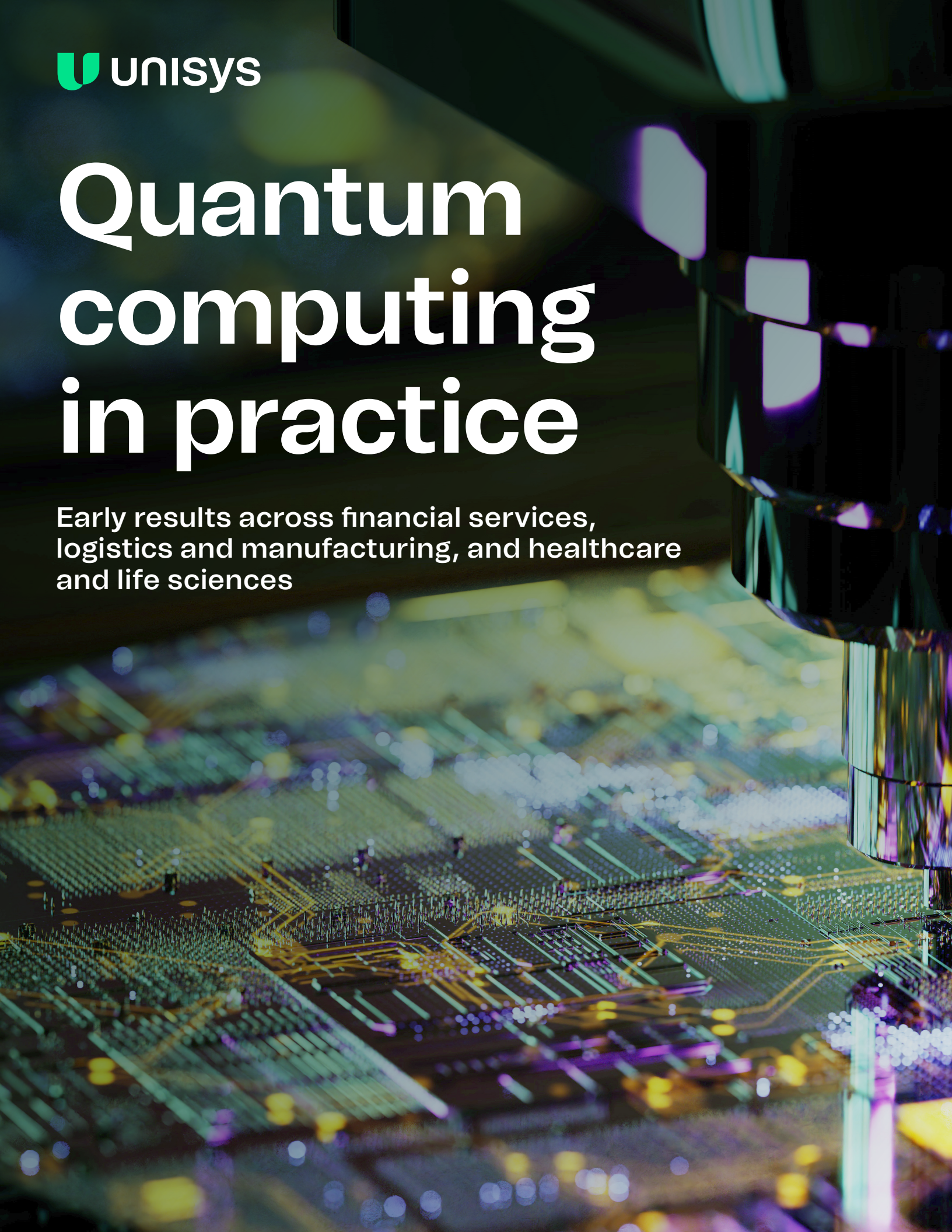
unisys

Quantum computing in practice

Early results across financial services, logistics and manufacturing, and healthcare and life sciences



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Executive summary

Quantum computing is moving out of the research lab and into real-world pilots aimed at specific business problems, particularly where complexity, uncertainty, and tight constraints overwhelm classical approaches. This white paper draws on Unisys' client engagements, applied research, and hands-on experimentation to give business leaders a grounded view of where quantum computing stands today and where it's headed.

We look at three industries where the opportunity is clearest: financial services, logistics and manufacturing, and healthcare and life sciences. In each, we share how aquantum-inspired methods to real problems, including fraud detection, air cargo loading, and vehicle routing, and what the early results tell us. We also look deeply at the technical limits of today's quantum hardware and the governance questions that come with it.

The takeaway for executives: quantum computing is not yet a wholesale replacement for classical computing, and it won't be for some time. But for a specific set of high-value, high-complexity problems, it's already worth exploring, and the organizations that start building capability now will be better positioned when the technology matures.

Introduction to quantum computing

What quantum computing is and why to act now

Quantum vs classical: what's actually different

Quantum computing introduces a fundamentally different model of computation that draws on the principles of quantum mechanics to tackle certain classes of problems beyond the practical reach of classical systems. Instead of relying only on binary states, it uses qubits, which can represent and process information in ways that reflect quantum phenomena such as superposition and entanglement. As the field has matured, quantum computing has moved from a primarily theoretical concept toward an emerging technology with practical relevance across areas such as science, optimization, machine learning, finance, and medicine, particularly where conventional computing struggles with scale, complexity, or simulation intensity.

Classical systems process information as bits (0/1) and remain essential to enterprise operations. They are well-suited to deterministic workflows such as ERP and reporting, support large-scale transaction processing including payments and claims, enable machine learning training and inference at scale, and power automation and orchestration across business processes.

Quantum systems process information as qubits and are designed to address problem classes that are difficult for classical systems to solve efficiently. They are particularly relevant for complex optimization, molecular and materials simulation, and selected cryptographic and probabilistic problems, where quantum effects such as superposition and entanglement can provide a computational advantage.

Where quantum creates business value

Quantum value is most likely to show up in a small set of high-impact areas. One is optimization, where organizations need to improve schedules, routes, portfolios, or resource allocation under tight constraints. Another is simulation and advanced sampling, particularly for risk analysis, uncertainty modeling, and scenarios that require repeated probabilistic evaluation. A third area is machine learning, where quantum methods may strengthen selected tasks such as feature representation, kernel-based modeling, and other probabilistic approaches. The fourth is chemistry and materials, where quantum techniques are especially relevant to molecular modeling, catalyst design, battery innovation, advanced manufacturing materials, and aspects of drug discovery.

In practice, the business benefit of quantum is not usually defined simply by raw speed. More often, the value comes from reaching stronger decisions in complex environments, identifying better-quality solutions sooner, lowering the cost of exploring difficult problem spaces, and improving performance under uncertainty. Over time, this can translate into measurable operational gains and strategic differentiation, especially when quantum capabilities are combined with classical and high-performance computing in hybrid workflows.

A use case becomes more attractive for quantum exploration when the solution space grows too quickly for conventional methods, when hard constraints must be balanced against competing objectives, or when the cost of a suboptimal decision is materially high. It is also a stronger candidate when uncertainty forces repeated simulation or scenario analysis, and when the objective is to achieve a meaningfully better outcome, not a faster version of the same result. These characteristics align closely with the problem types most often highlighted in enterprise quantum discussions around optimization, simulation, and scientific discovery.

Industry landscape and market trends

The quantum technology sector has grown sharply since the early 2000s, drawing rising levels of global investment and a broad startup ecosystem across multiple regions. This growth reflects increasing confidence that quantum technologies could reshape industries over time. The market is no longer defined only by research activity. It now includes a substantial base of emerging companies, established technology players, and collaborative industry groups working to turn technical progress into commercial capability.

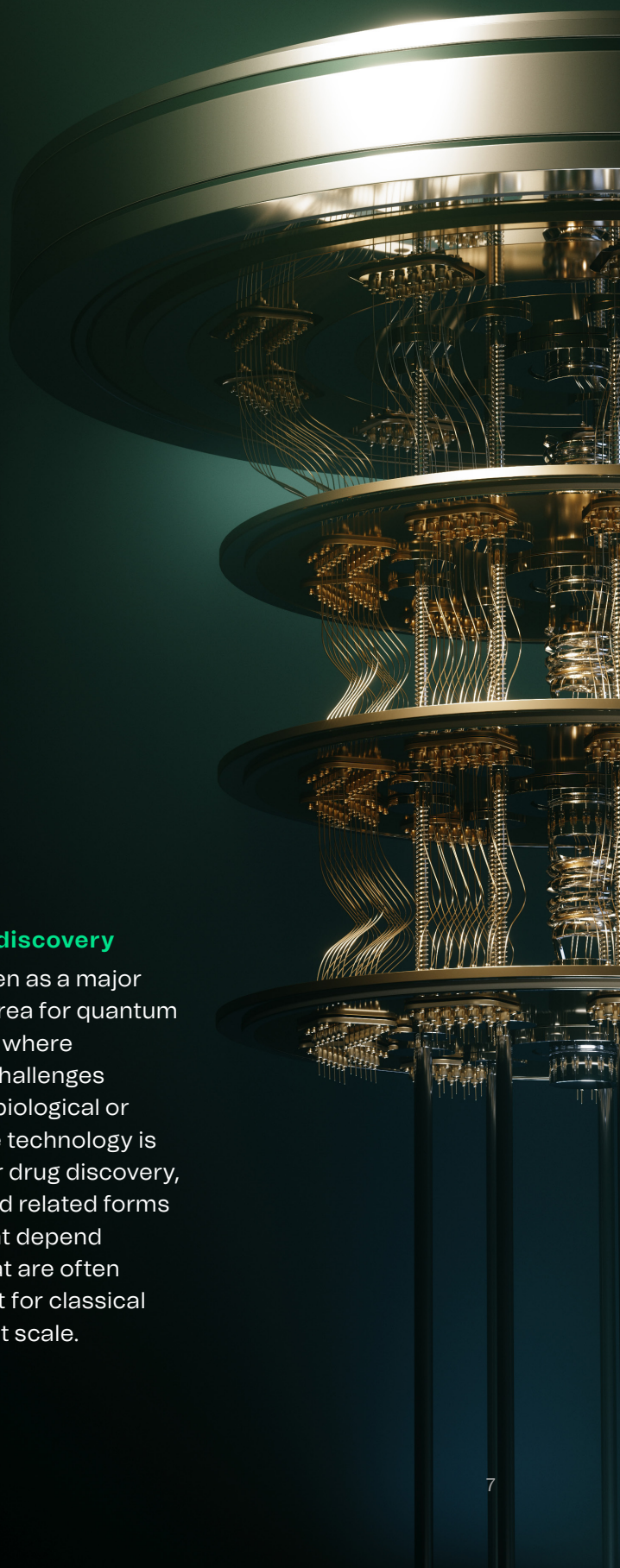
Activity across the industry generally spans five segments: quantum computing, communication, sensing, hardware, and software. Progress is being shaped by specialized startups as well as large technology companies and multi-organization consortia, underscoring how much of this advance depends on partnership. Current investment patterns and the geographic spread of new ventures suggest the industry remains on a strong growth path, with continued expansion likely to drive further advances in practical applications and ecosystem maturity.

In practice, quantum systems are becoming a complement to classical computing, with the strongest near-term value in hybrid environments that combine quantum, classical, and high-performance computing resources.



Applications across industries

Quantum computing has potential relevance across a broad range of industries, reflecting both the technology's flexibility and its ability to address problems that conventional systems struggle to solve efficiently. Its application landscape extends from foundational computing domains, such as cryptography, machine learning, deep learning, and quantum simulation, to practical business and scientific challenges, including risk analysis, logistics, and advanced communications. This range of use cases highlights why quantum is increasingly viewed as a cross-industry capability with long-term strategic importance.

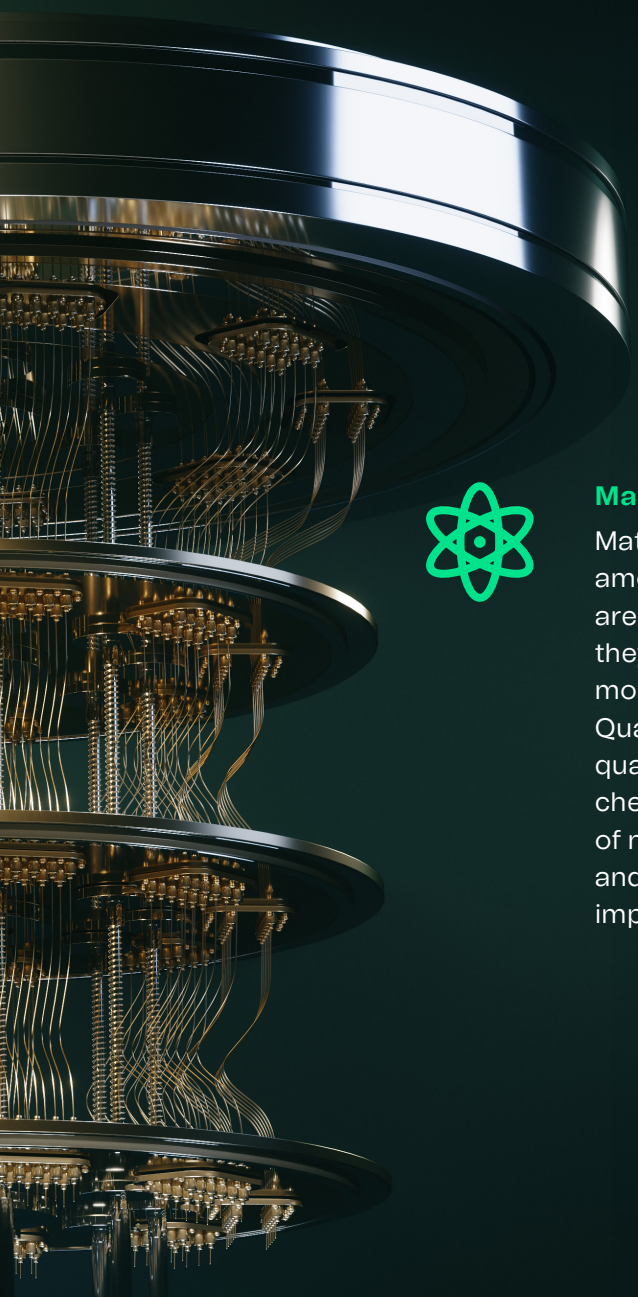


Cryptography and security

Quantum computing creates both disruption and opportunity in security. Quantum algorithms have the potential to weaken some existing cryptographic methods, raising the urgency of building security models that hold up in a quantum-enabled environment. At the same time, this shift is accelerating innovation in secure communication and post-quantum cryptography, making security one of the most immediate areas of quantum-related change.

Healthcare and drug discovery

Healthcare is widely seen as a major long-term application area for quantum computing, particularly where scientific and medical challenges involve highly complex biological or molecular systems. The technology is especially promising for drug discovery, molecular modeling, and related forms of medical research that depend on solving problems that are often computationally difficult for classical approaches to handle at scale.



Financial services and risk analysis

In financial services, quantum computing is relevant to demanding analytical tasks such as risk analysis, financial planning, and complex modeling. Its potential value is strongest in situations where institutions must process large numbers of interdependent variables, evaluate many possible scenarios, or optimize decisions under constraints. This makes financial services one of the sectors where quantum capabilities could eventually deliver meaningful computational and strategic advantages.

Materials science and chemistry

Materials science and chemistry are among the most compelling application areas for quantum computing because they rely heavily on accurate modeling of molecules, reactions, and material behavior. Quantum systems may help advance quantum chemistry, support industrial chemical innovation, and enable the design of new materials through simulations and optimizations that were previously impractical with classical computing alone.

Logistics and optimization

Logistics is another area where quantum computing could create practical value, particularly in solving difficult optimization problems. Applications such as supply chain management, routing, scheduling, and resource allocation often involve complex trade-offs that become difficult to manage efficiently at scale. In these settings, quantum approaches may improve decision quality and operational efficiency when conventional methods reach their limits.

Business models and commercial implications

The rise of quantum computing is beginning to shape new commercial models and broader business opportunities. One of the clearest examples is Quantum-as-a-Service, which enables organizations to access quantum capabilities through a service model, which avoids the need to invest directly in specialized hardware and supporting infrastructure. This approach lowers the barrier to entry for enterprises and research institutions, making experimentation and early adoption more feasible and enabling the integration of quantum resources into existing digital and analytical environments.

The commercial significance of quantum extends beyond delivery models alone. It also reflects a wider shift in how businesses approach complex problem-solving, advanced analytics, and technology-enabled innovation. As quantum capabilities evolve alongside AI and high-performance computing, they are creating new paths to value across industries. Over time, this could reshape competitive strategy, expand service offerings, and redefine how organizations address problems that were previously too complex, costly, or computationally demanding to solve effectively.

Technical challenges and current limitations

Despite the progress made in recent years, quantum computing still faces major technical barriers before it can be deployed broadly for practical use. Among the most important challenges are maintaining qubit stability, mitigating decoherence, and improving connectivity and coordination among qubits within a system. These issues directly affect reliability, scale, and the ability of quantum machines to perform complex computations consistently in real-world settings.

The current stage of development is often described as the Noisy Intermediate-Scale Quantum era, in which quantum devices continue to improve but remain constrained by noise, scale, and error rates. Milestones such as demonstrations of quantum supremacy have shown that quantum systems can outperform classical systems on narrowly defined tasks, but the larger commercial objective is quantum advantage: the ability to solve meaningful real-world problems more effectively than conventional computing methods. Reaching that point will require continued advances in both system performance and practical problem design.

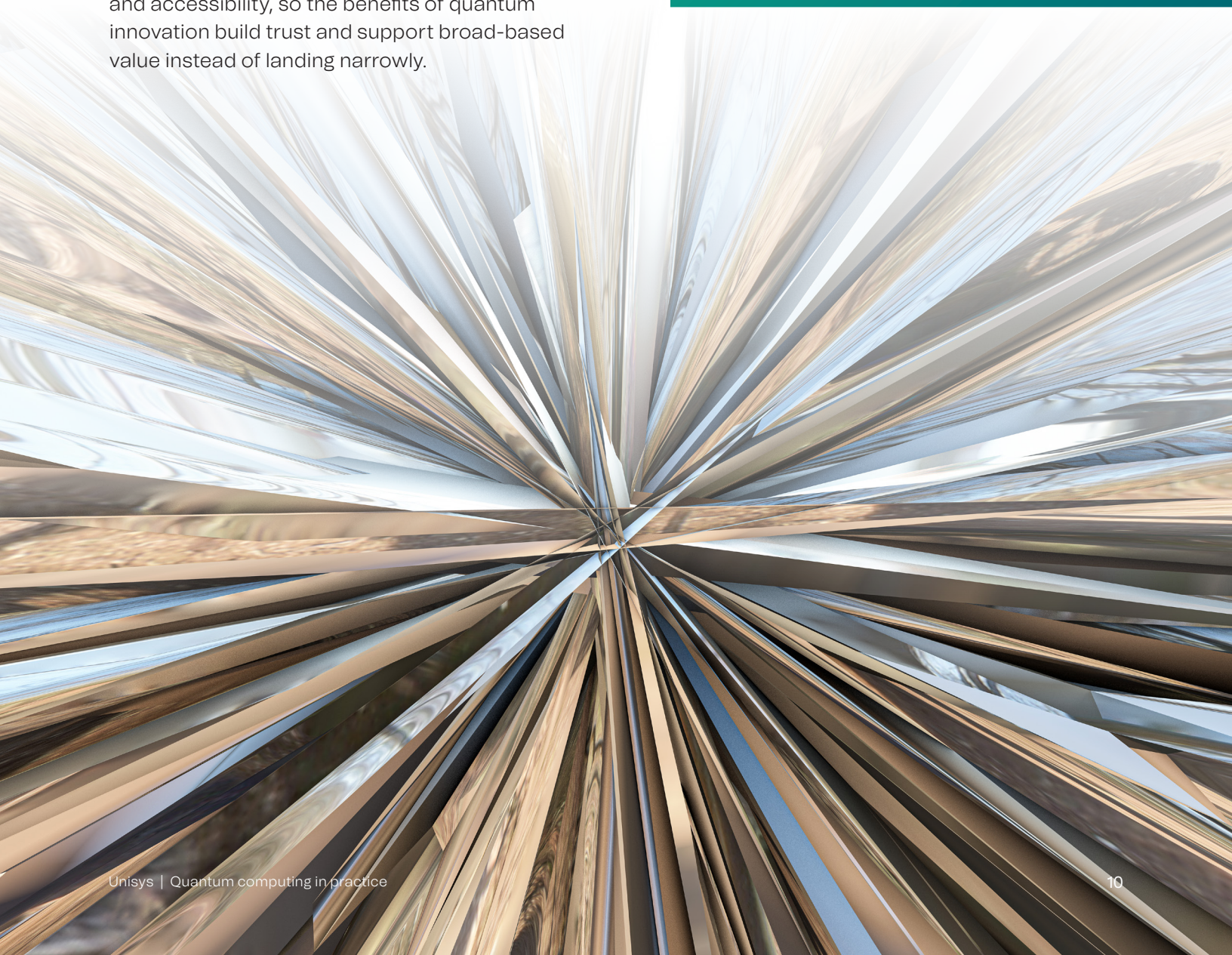
More broadly, the field is still working through a range of open problems as it moves from scientific promise toward dependable implementation. Progress in hardware engineering, software development, and quantum algorithms continues to bring the technology closer to practical relevance, though real obstacles remain before adoption becomes widespread.

Ethical considerations and responsible development

As quantum technologies advance, they raise governance questions that matter as much as the technical ones. Responsible adoption means thinking beyond performance to how quantum capabilities are introduced, governed, and applied. That takes collaboration among businesses, policymakers, researchers, and technologists to keep innovation accountable, secure, and mindful of long-term societal impact.

The implications reach beyond the lab. Quantum advances could disrupt current security frameworks, shift competitive dynamics across industries, and create economic advantages that land unevenly if access stays limited. Responsible development should address fairness, resilience, and accessibility, so the benefits of quantum innovation build trust and support broad-based value instead of landing narrowly.

For most organizations, this means quantum should still be treated as an emerging capability with real long-term potential, but with clear technical limits that shape what's realistic today.



Financial services

Portfolio optimization, option pricing, fraud detection

Executive summary

Financial services face increasingly complex decision spaces: fraud patterns adapt, portfolios must respond to volatile markets, and regulations raise the bar for explainability and governance. Quantum computing, especially hybrid quantum optimization and quantum-inspired algorithms, can improve decision quality for select high-complexity problems.

In financial services, the real challenge is the growing complexity of decision-making, not a lack of data. Fraud patterns adapt more quickly than static rule sets can be updated, which makes detection harder in dynamic environments. More sophisticated fraud schemes also require institutions to understand networks of related entities and transactions, beyond isolated events. At the same time, risk management depends heavily on repeated simulation across large numbers of market scenarios, while compliance expectations continue to raise the bar for explainability, governance, and audit readiness. Together, these pressures create a landscape where conventional approaches often face rising computational and operational strain.

Against that backdrop, the most promising quantum-relevant opportunities in financial services tend to cluster around a few high-value use cases. In Unisys experimentation, the biggest near-term value has come from improving fraud detection through graph-based learning and quantum-classical hybrid solvers.

Financial fraud keeps growing in scale and sophistication, which makes it harder to detect and creates real business consequences: rising financial losses, operational inefficiencies, and eroding customer trust. Traditional fraud detection systems, though effective for years, are now struggling to keep pace with real-time processing demands and the growing complexity of fraud.

That pressure is pushing the industry toward a smarter approach to detecting fraud.

Quantum computing strengthens that approach by solving complex optimization problems that are otherwise computationally expensive, enabling faster, more accurate detection of fraudulent activity. That efficiency helps organizations surface fraud patterns hidden deeper in the data while reducing false positives.



Unisys application: fraud detection

In collaboration with the National Quantum Computing Centre and a leading global payments technology company that processes billions in transactions annually across digital wallets, online payment processing, prepaid solutions, and embedded financial services.

Unisys proposed a hybrid quantum-classical architecture that uses:

Classical systems for data ingestion, feature engineering, and preprocessing	Quantum processors for optimization on quantum-encoded problems	Classical layers to interpret results and integrate with existing fraud systems

Based on results observed in pilot and benchmark studies, this approach helped improve transaction acceptance rates by up to approximately **10%** and fraud detection effectiveness by up to approximately **15%**, while reducing false positives by up to approximately **20%**.



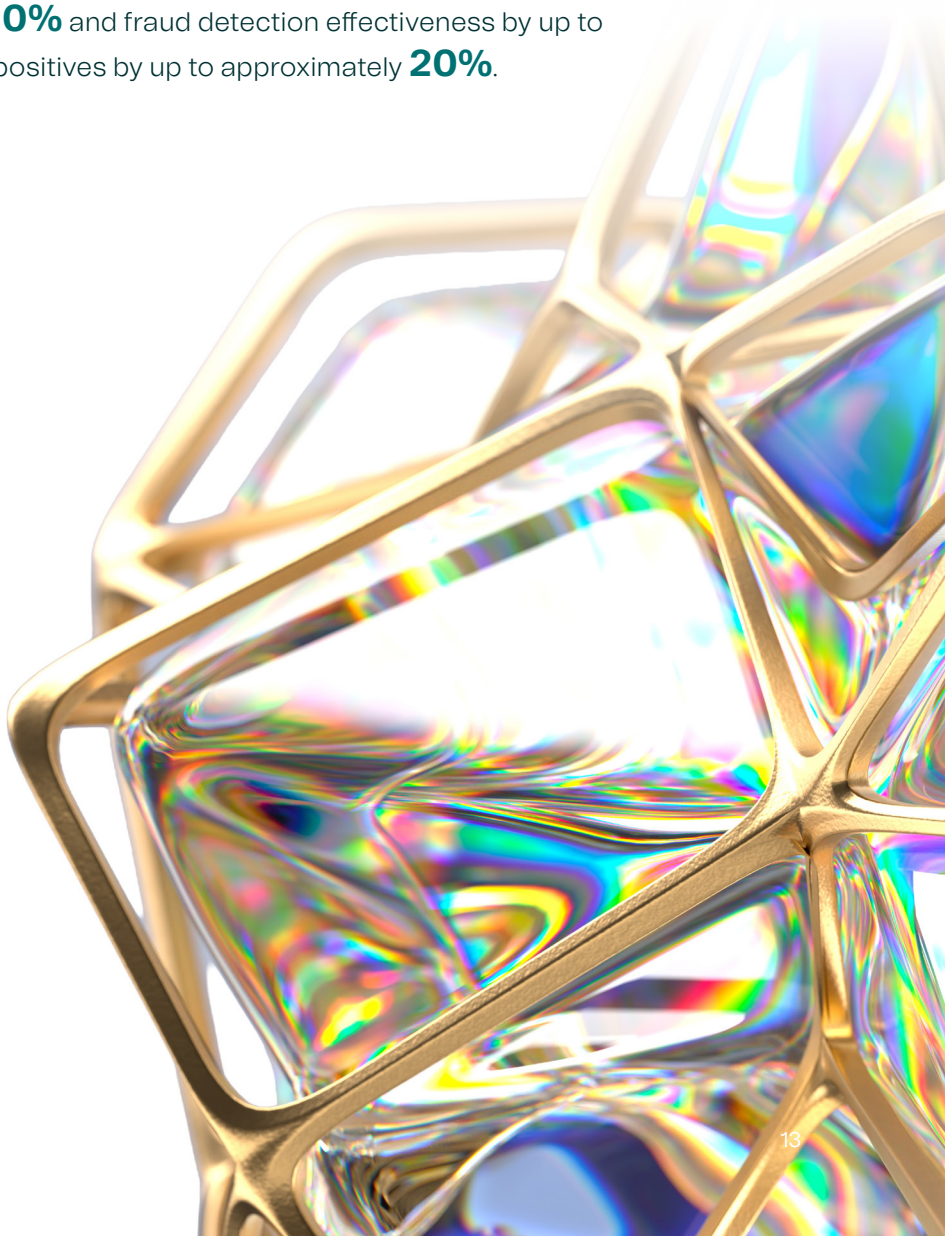
Transaction acceptance rates



Fraud detection



False positives



Why fraud detection is hard

Financial fraud detection has grown more complex as digital transactions increase in scale and speed. Financial systems can process millions of transactions per second, which calls for real-time analysis of large volumes of continuously streaming data. At the same time, fraudsters keep improving their techniques, using automation, distributed identities, and increasingly sophisticated attack patterns.

Balancing detection accuracy with customer experience is another core challenge. Conventional machine learning techniques tend to produce more false positives, creating friction for legitimate customers. Fraudulent transactions are also rarely isolated events. They typically connect to other accounts, devices, locations, and identities, and understanding those relationships is computationally expensive.

As transaction networks grow, conventional algorithms run into combinatorial explosion when working with large-scale graphs. Ensuring the resulting detection system stays explainable and compliant with regulatory requirements adds another layer of difficulty.

Together, these challenges point to the need for more advanced, scalable, and intelligent fraud detection techniques.

Fraud detection with quantum machine learning

Quantum Machine Learning (QML) combines quantum computing with advanced machine learning techniques to work through the complexity of fraud detection in large-scale financial systems. This is one of the clearest examples of quantum computing strengthening AI, not standing apart from it. Instead of replacing the machine learning models that financial institutions already rely on, quantum processing extends what those models can represent and learn from. Fraud detection inherently involves high-dimensional data, non-linear relationships, and sparse but critical signals hidden inside massive transaction streams.

QML addresses this by using quantum state representations and probabilistic learning: classical financial data is encoded into quantum states through methods such as amplitude or angle encoding, which represents data in exponentially large feature spaces and helps models capture relationships that are difficult to learn with classical approaches alone. Models such as Variational Quantum Circuits (VQC), Quantum Support Vector Machines (QSVM), and Quantum Restricted Boltzmann Machines (QRBM) are particularly relevant for classification and anomaly detection tasks in fraud detection.

Quantum Boltzmann Machines (QBM) extend classical probabilistic graphical models by using quantum energy states to model complex distributions. They're well-suited to fraud detection because fraudulent transactions often sit in low-probability, high-energy regions, and quantum tunneling makes it possible to explore those regions more efficiently than classical sampling. A QBM learns a probability distribution over financial behavior patterns and flags anomalies as low-probability states. Compared with classical Boltzmann Machines, QBMs sample from richer distributions thanks to quantum superposition, which improves detection of subtle fraudulent structure.

The goals for the QRBM model were to:



Detect fraudulent transactions with competitive accuracy.



Demonstrate practical advantages over classical machine learning models, including better performance with limited data and improved handling of high-dimensional correlations.



Deliver measurable, transparent, and reproducible results on a real-world e-commerce fraud dataset (IEEE-CIS Data, provided by Vesta Corporation).



Evaluate the model's ability to reduce false positives and improve customer acceptance.



Track acceptance rate as a key metric, aiming to maximize the proportion of legitimate transactions approved by the system.

To train the QRBM, Unisys used a hybrid approach: classical computation handled gradient updates, while quantum annealing sampled efficiently from the model's energy distribution.

Hybrid workflow

The solution orchestrates:

- Classical preprocessing and parameter updates (weights and biases)
- Quantum annealing to draw samples from the model's energy landscape

This combination of classical gradient learning and quantum sampling trains the model efficiently. Its ability to sample thousands of high-quality values in seconds supports dynamic model recalibration, which strengthens robustness against data drift in fast-changing, high-stakes environments.

To evaluate the fraud detection pipeline, the dataset was split into training and testing sets using a stratified split, which preserves the original distribution of fraudulent and non-fraudulent transactions. This matters in highly imbalanced datasets, where legitimate transactions vastly outnumber fraudulent ones. Stratification addresses rare fraud cases, so theyare proportionally represented in both sets, which decreases evaluation bias and improves generalization.

Impact and next steps

The QRBM approach shows that Quantum Machine Learning can meaningfully strengthen fraud detection in financial systems, giving Unisys a foundation for future work on more complex fraud detection challenges.

The bigger contribution is showing that fraud detection models can scale beyond current classical limitations while remaining adaptable within today's hardware constraints. It also points to specific areas for improvement as quantum technology matures.

The work also underscores how much transparency matters in complex models. That factor will only grow in importance for financial institutions balancing performance against explainability requirements.

This research is a meaningful step toward bridging quantum computing theory and its practical use in financial services. The QRBM approach is a strong candidate for future fraud detection work. This study provides a working foundation for more advanced systems and a realistic picture of the challenges involved in bringing hybrid quantum-classical approaches into production. As quantum hardware develops, these results will likely improve further, alongside deeper integration with the compliance and explainability standards financial institutions require.

Conclusion and future opportunities

Taken together, this work marks a meaningful milestone toward putting Quantum Machine Learning to practical use in fraud detection, and it lays a foundation for more advanced systems as quantum hardware continues to mature.

Moving forward, continued advances in quantum hardware and hybrid system design will be essential to strengthening the QRBM approach and extending it to more complex, higher-stakes fraud detection challenges across financial services.

Logistics and manufacturing

Vehicle routing, supply-chain optimization, scheduling

Executive summary

Logistics and manufacturing operate in environments defined by persistent operational constraints, including lead-time pressure, volatile demand, supplier disruption, finite capacity, and strict service expectations. These conditions create large and highly interconnected optimization challenges across areas such as routing, production scheduling, inventory positioning, and manufacturing planning. In this context, quantum and quantum-inspired approaches are gaining attention for their potential to improve decision quality in complex systems where conventional methods can struggle to balance speed, scale, and competing objectives.

Problem landscape

The core challenge in logistics and manufacturing is making high-stakes decisions across tightly linked, constantly changing systems. Demand can shift unexpectedly, suppliers may become unreliable, transportation networks face disruption, and production capacity is always finite. At the same time, organizations must meet delivery commitments, control costs, maintain inventory availability, and respond quickly to operational variability. This combination creates decision environments in which even small inefficiencies can cascade across the broader supply chain and production system.

High-value use cases

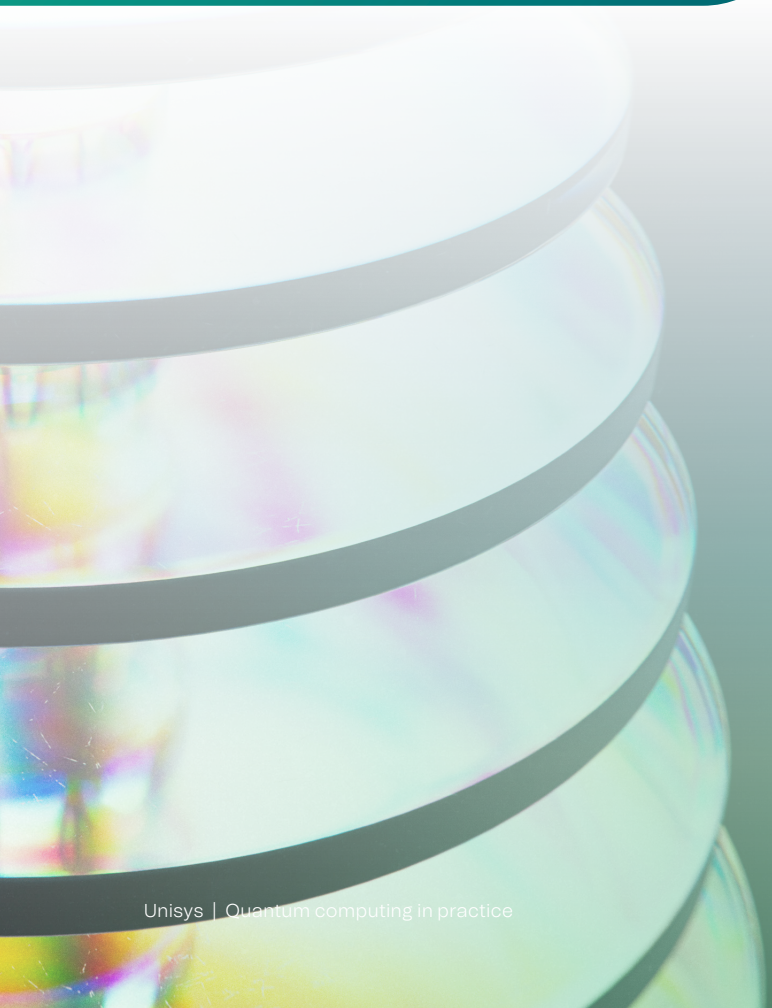
The most promising opportunities tend to appear in decisions that involve many variables, strict constraints, and measurable commercial consequences. These include vehicle routing, network design, dynamic scheduling, inventory placement, warehouse flow, production sequencing, and workforce or machine allocation. Quantum and quantum-inspired methods are particularly relevant where organizations must balance cost, service, resilience, and speed at the same time, and where conventional optimization techniques become difficult to scale or slow to adapt as conditions change.

Why logistics and manufacturing are well-suited for quantum

Logistics and manufacturing are strong candidates for quantum exploration because they frequently involve combinatorial complexity, competing objectives, and real-world constraints that are difficult to optimize simultaneously. The number of possible solutions expands rapidly as product lines, routes, suppliers, facilities, and capacity rules are added, making exhaustive search impractical. These are also environments where the cost of a poor decision can be significant, whether through delays, excess inventory, lost throughput, or reduced service performance. In such settings, the goal is often not merely to compute faster, but to reach materially better decisions under pressure.

AI and machine learning already do much of the forecasting in this space: predicting demand, flagging likely disruptions, and estimating maintenance needs. The harder problem is turning those predictions into a workable plan once dozens of constraints start competing.

That's where quantum and quantum-inspired optimization can pick up where AI forecasting leaves off, converting predictive insight into a routing, scheduling, or inventory decision faster and at greater scale than classical solvers alone.



Business impact and adoption outlook

For enterprises, the value proposition in this domain is likely to come from better operational decisions than from quantum as a stand-alone technology story. Improvements in routing, scheduling, inventory, and production planning can translate into lower cost, stronger service levels, improved asset utilization, and greater resilience against disruption. In the near term, adoption is most likely to progress through hybrid models that combine classical optimization, quantum-inspired methods, and emerging quantum capabilities. As a result, organizations in logistics and manufacturing should view this area as an opportunity to build readiness around targeted use cases with clear business value and realistic implementation pathways.

Challenges of air cargo loading

Load planning in air cargo has traditionally been a manual, labor-intensive task, with experienced planners working from pen and paper or spreadsheets. That process drives up labor costs and often produces suboptimal loading configurations, given the time pressure and the number of variables involved, including weight distribution, center of gravity, and fuel efficiency.

This challenge, known as the Air Cargo Load Planning and Balancing Problem, means optimizing cargo loading onto aircraft while meeting many constraints and regulations at once. Getting it right matters economically, since it directly affects operational costs, and for safety, since imbalanced or improperly distributed cargo can threaten flight stability and airworthiness.

The problem encompasses various facets, including:

- weight and balance distribution
- space utilization
- load capacity
- compliance with safety regulations.

Addressing these demands requires a combination of mathematical optimization, heuristics, and sometimes machine learning. These methods aim to provide an optimal cargo configuration that maximizes space utilization, minimizes operational costs, and increases aircraft safety and stability.

Unisys application: feasibility study in cargo loading optimization

Unisys secured funding through a UK Innovate funding call and formed a consortium with the National Quantum Computing Centre (UK) and Newcastle University to lead a quantum feasibility study.

This feasibility study examined how quantum computing could reduce the time required for unit load device (ULD) loading, assessing how quantum optimization elements could integrate into an existing air-cargo solution. It identified the strengths, weaknesses, opportunities, and threats associated with quantum optimization, along with the resources needed to offer real-time solutions to clients using quantum computing.

The project first treated the problem as a knapsack problem: loading as many ULDs as possible into the cargo bay without exceeding weight, volume, and dimensional constraints, a classic combinatorial optimization challenge that requires intelligent selection strategies to maximize payload within strict limits.

The project then added the challenge of optimizing hold loading so the aircraft's center of gravity sat as close as possible to its geometric center, which matters for flight stability, fuel efficiency, and compliance with aviation safety regulations.

The team explored several quantum computing algorithms and hybrid quantum-classical approaches. Quantum annealing showed promise for the combinatorial complexity of the knapsack problem, searching large solution spaces more efficiently than classical methods in some cases. Hybrid approaches, combining quantum solvers with classical pre- and post-processing, were also evaluated to improve solution quality and practical usability given current hardware limitations.

Early results showed quantum methods performing well on highly constrained, small- to medium-sized problem instances, where they matched or beat traditional heuristics. Several limitations also came up, including scaling, noise, and embedding complexity on current quantum devices. Classical techniques still found optimal solutions consistently, but their time scaling was poor by comparison.

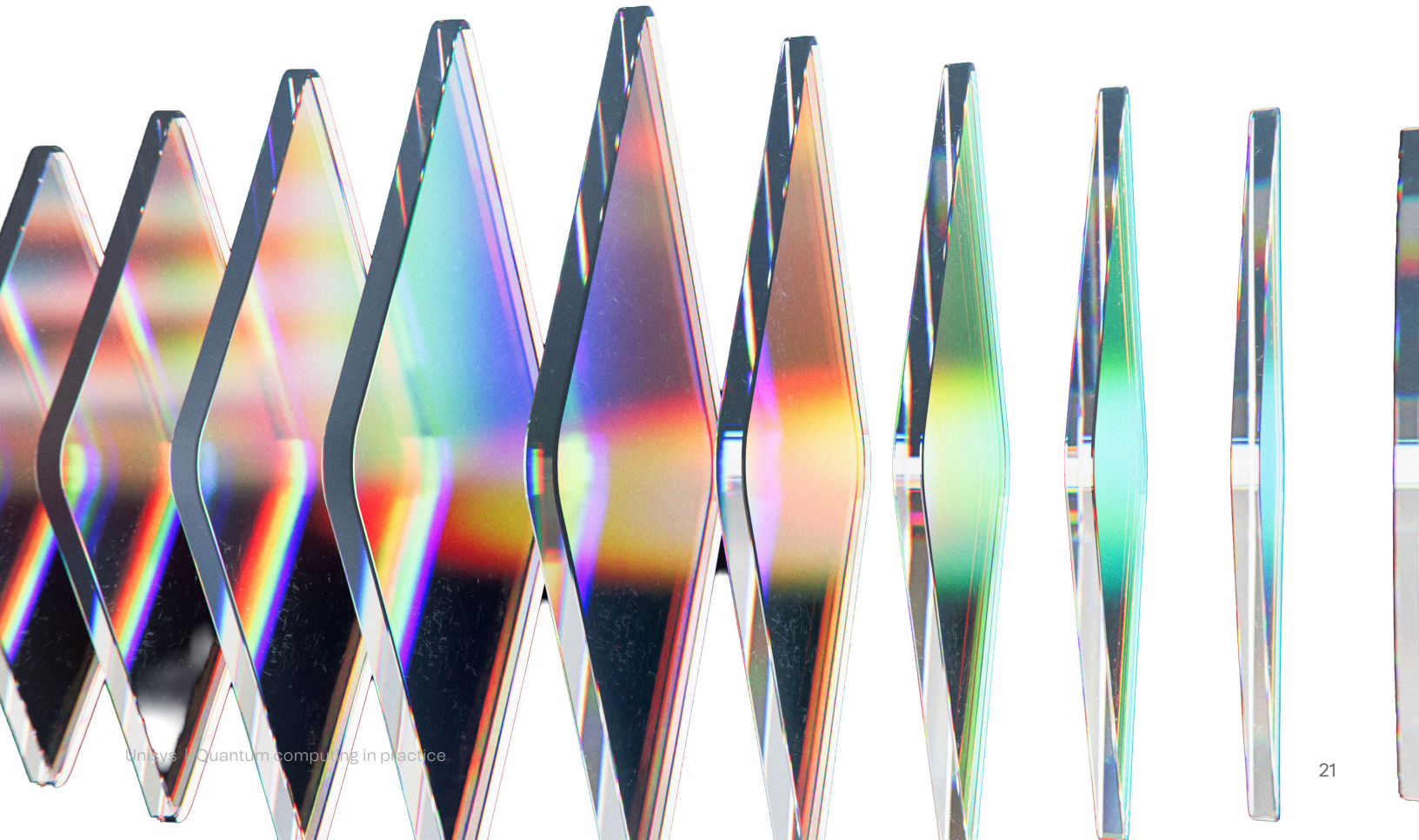
These findings suggest hybrid quantum-classical systems are the most practical near-term path for applying quantum computing to air cargo loading. Classical methods remain dominant for large-scale problems today, but quantum computing shows real promise for improving real-time operational decisions as the technology matures.

Results

The project delivered benefits in environmental sustainability, operational efficiency, regulatory compliance, and the advancement of quantum technologies more broadly. Optimizing aircraft center of gravity could yield measurable fuel savings, potentially around **4,000** kg over a **10,000**-mile journey, contributing to broader efforts to reduce aviation carbon emissions.

These outcomes were based on modeling and proof-of-concept work, but they align with the ambitions of the UK's Sixth Carbon Budget and long-term net-zero targets. The project also addressed operational challenges facing the aviation industry, including disruptions from the COVID-19 pandemic and geopolitical instability, and showed potential to improve supply chain resilience, operational efficiency, and fuel consumption over time, though further development is needed for full real-world application.

By drawing on high-performance computing and quantum annealing together, the project offered a clear view of when and how quantum solvers could improve the ULD loading process. This helped identify both the strengths and current limitations of quantum computing and informing recommendations for reducing processing times and improving load factors. The work also contributed to early-stage progress in the UK's quantum computing ecosystem, supporting practical use cases and informing the future direction of quantum adoption in critical industries.



Unisys application: capacitated vehicle routing optimization

Part of a research activity and early feasibility analysis.

Unisys assessed the quality of solutions to several capacitated vehicle routing problems (CVRP) using a commercial quantum annealing platform, comparing results against known optimal solutions. The study drew on more than 30 hours of access to commercial quantum annealing platforms to investigate how problem size and complexity affect solution accuracy and solve time. Results showed the absolute error between known-optimal and quantum annealer results ranging between 0.12 and 0.55, with quantum processor unit time between 30 and 46 microseconds. As constraint density increased, solution quality degraded, suggesting that model complexity, more than problem size, plays the critical role, and that practical applications should favor formulations that minimize constraint density.

Why vehicle routing is hard

The vehicle routing problem is a variant of the traveling salesperson problem: given a set of locations, what's the most efficient route to visit them all? It's an NP-hard problem, meaning no known polynomial algorithm can solve it, and its time complexity is exponential or factorial depending on the algorithm used. That makes brute-force exact solutions unrealistic. A 10-node problem might take seconds to solve; a 20-node problem could take years.

Unisys tested three example problems from the CVRPLIB website, with 32 nodes and five trucks, 60 nodes and nine trucks, and 80 nodes and 10 trucks, respectively.

CVRPLIB is an online library documenting hundreds of CVRP problems ranging from 32 nodes and five trucks (n32-k5) to 30,000 nodes and 200 trucks (n30000-k200), with published optimal solutions available for comparison.



The goal was to assess the real-world effectiveness of adiabatic quantum computing as a solver for combinatorial optimization problems, guided by four questions:

- What is the Quantum Annealer's (QA) accuracy for the CVRP problem over benchmark data sets?
- How does the size (number of nodes and routes) impact the QA solver's accuracy?
- How does the constraint density impact the accuracy?
- How does the problem complexity impact the time the quantum processor unit uses?

Unisys used mean absolute percentage error (MAPE) to measure the quantum annealer's accuracy against known-optimal solutions for each of the three CVRPLIB problems.

Each problem was run over 100 anneals on the quantum annealer. Full details are available in the published paper.

Quantum annealing is emerging as a promising general approach for tackling complex, NP-hard optimization problems, and recent advances have made this technology commercially available. This study is an important step toward understanding how to put quantum annealing to practical use in solving real-world optimization problems.

Taken together, these results reinforce that constraint density, not problem size alone, is the key driver of solution quality on quantum annealing hardware.

Conclusion and opportunities

Quantum in logistics and manufacturing should be viewed as a strategic optimization opportunity, not a short-term replacement for existing systems. The strongest near-term potential lies in focused use cases where operational complexity, constraint intensity, and the cost of suboptimal decisions are already well understood. Over time, as quantum hardware, algorithms, and hybrid workflows continue to mature, organizations may be able to address larger and more dynamic planning problems with greater precision and adaptability. The practical path forward is to build capability through targeted pilots, quantum-inspired methods, and business-led experimentation, while preparing for a future in which quantum becomes a more meaningful part of enterprise decision-making.



Healthcare and life sciences

Carefully selected use cases, benefits, and realistic limitations

Executive summary

This section outlines thoughtfully evaluated use cases where quantum computing can add value in healthcare and life sciences. It is intended as innovation and strategy material to support discussions, workshops, and early exploration with industry and public-sector partners. The focus is deliberately pragmatic: each use case highlights both the potential benefits of quantum approaches and the limitations or dependencies that must be acknowledged.

Drug discovery and molecular design

Since molecular interactions are governed by quantum mechanics, quantum computers can work alongside classical methods to estimate molecular energy states and interactions with more precision. That helps researchers narrow chemical searches faster than traditional approaches allow, which can mean fewer late-stage failures and shorter research and development cycles. Pairing quantum-derived molecular data with AI-based candidate screening is where this compounds: quantum computing improves the precision of the underlying molecular data, and AI turns that improved data into faster prioritization across large candidate libraries.

Clinical trial design and operations

Quantum optimization can help organizations balance the competing demands of cost, location, patient availability, and regulatory requirements in clinical trial design, streamlining logistics, shortening timelines, and improving participant recruitment. That supports a higher chance of successful trials and faster regulatory approval.

Traditional trial planning often runs into difficult trade-offs and limited resources. Quantum optimization is well-suited to navigating these constrained, complex decision spaces, helping teams explore more effective trial setups that boost operational efficiency, lower costs, and add flexibility to trial design.

Quantum methods support the operational and design side of trial management, working alongside established statistical and clinical approaches. Realizing measurable benefit depends on integrating quantum computing with existing trial management systems and focusing on meaningful performance measures.

Personalized treatment and care pathway optimization

Quantum-enabled optimization can help providers design care pathways tailored to each patient by weighing multiple treatment options and constraints at once, supporting more precise, cost-effective therapies. This is especially useful when clinical teams need to balance factors such as patient safety, desired outcomes, and individual circumstances.

Personalized care is fundamentally a multi-objective problem, since clinical results, safety, cost, and patient-specific requirements all need consideration at once. Quantum computing is well-suited to exploring large numbers of potential care configurations and identifying those that best serve both patients and providers, working as a decision-support tool that complements clinical expertise and predictive AI without replacing either: AI models can predict likely outcomes across patient populations, while quantum optimization works through the constraint-heavy job of turning those predictions into a specific, workable care plan.

Its success still depends on data quality, system integration, and ongoing clinical validation. Quantum computing should be viewed as an enabler that works alongside existing systems.

Healthcare operations and capacity planning

Quantum and quantum-inspired solvers can help hospitals and care networks manage staff, beds, and equipment more effectively, adapting quickly to real-time demands and competing priorities in ways that outpace manual planning or static rules.

Done well, this can reduce patient waiting times, lower operational costs, and improve staff satisfaction by balancing workloads and ensuring more timely care. The results depend on high-quality operational data and effective change management.

The greatest impact comes when these approaches are integrated into existing decision-support tools, not deployed in isolation.

Pharmaceutical supply chain and manufacturing optimization

Pharmaceutical supply chains carry significant complexity, coordinating sourcing, production, inventory, and distribution, often for regulated, temperature-sensitive products. Quantum optimization techniques are well suited to these large-scale challenges, helping organizations work through the trade-offs that often limit supply reliability and operational efficiency.

Integrated with existing enterprise systems, this approach can improve supply reliability, reduce waste, and build resilience against disruption. At this stage, the improvements are incremental, more than dramatic, but the strategic impact can still be significant, particularly in balancing resource constraints, regulatory requirements, and shifting demand to deliver more consistent product availability.

Realizing this value depends on thoughtful adoption and close collaboration between technology and business teams.

Post-quantum security and secure healthcare data collaboration

As healthcare organizations increasingly share and store sensitive patient information over long timeframes, protecting that data against future threats matters more than ever. Quantum computing brings new capabilities, but it also introduces new risk to existing security systems, which makes preparing for quantum-safe security a priority for healthcare leaders looking to protect confidential records and maintain trust with patients, providers, and research partners.

Post-quantum cryptography helps secure data with long-term value, including research and patient records, as technology evolves. This is especially important when collaborating with multiple partners, where robust quantum-safe security supports both compliance and shared research.

Preparing now for quantum-safe security means healthcare organizations can keep collaborating confidently with partners and patients as the technology landscape evolves.

The road ahead

Including NISQ, fault-tolerant systems, and societal impact

Impact of quantum computing

Quantum technologies are beginning to influence the real world by expanding computational capability, changing security assumptions, and accelerating scientific discovery. Early use cases are already underway in materials science, drug discovery, optimization, and quantum-safe cybersecurity planning, with larger breakthroughs expected as hardware scales.

Future business opportunities and strategic direction

Quantum computing is moving from a research-driven discipline to a strategic business opportunity, with the potential to reshape industries and create new sources of competitive advantage. As quantum capabilities mature, organizations are exploring how the technology can accelerate complex simulations, optimize large-scale operations, strengthen financial modeling, and support faster decision-making across enterprise environments.

Business leaders increasingly view quantum computing as a long-term innovation platform with high-impact applications across financial services, pharmaceuticals, healthcare, logistics, manufacturing, energy, and agriculture. Early use cases are expected in areas where classical computing struggles most with optimization and predictive analysis, including portfolio optimization, supply chain efficiency, drug discovery, materials science, and risk management.

As quantum advantage moves closer to commercial reality, enterprises have an opportunity to build early capabilities, form strategic partnerships, and identify the business problems most likely to benefit from quantum-enabled solutions. Investing early in experimentation, workforce readiness, and ecosystem collaboration positions organizations to capture future opportunities.

Governments, national laboratories, technology providers, and private enterprises are already increasing investment in quantum technologies, a sign of growing confidence in the sector's long-term economic potential. Industry forecasts suggest quantum computing could generate billions, and potentially trillions, of dollars in economic value over the coming decades.

The World Economic Forum, for example, estimates that quantum technologies could generate up to **$2 trillion** in value for the financial services sector alone by 2035.

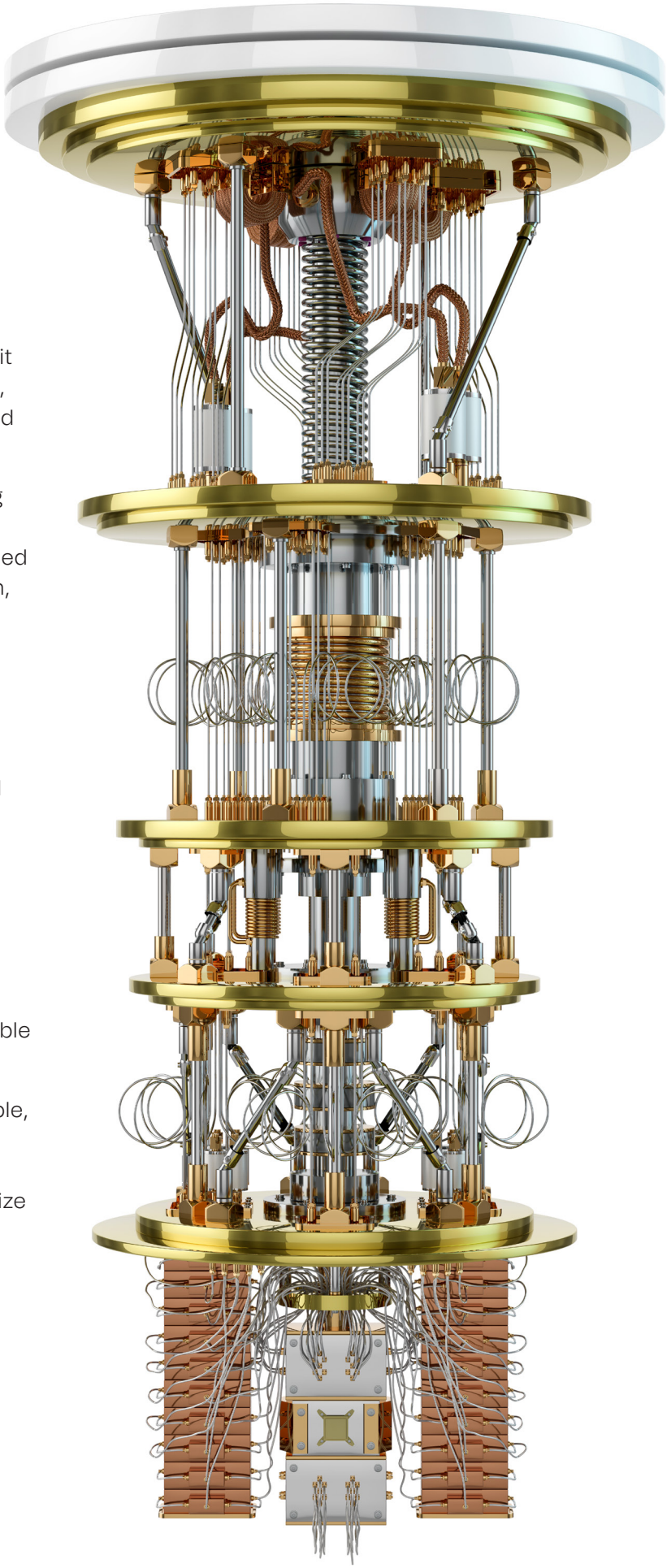
Future advancements in quantum technologies

Progress will continue to be driven by advances in hardware, algorithms, and scalable system architectures. Today's landscape includes both gate-based quantum computers and quantum annealers, each suited to different categories of computational and optimization challenges. Organizations are actively exploring multiple qubit technologies, including superconducting circuits, photonic systems, silicon-based approaches, and cold-atom architectures.

Significant technical challenges remain, including noise reduction, decoherence, system stability, energy requirements, and scalability, but continued advances in qubit fidelity, modular system design, quantum error correction, photonic processing, quantum networking, and quantum-enabled materials discovery are steadily moving the technology from experimental environments toward practical enterprise use.

For business leaders, these developments signal more than scientific progress. They represent the foundation of a future technology platform that could reshape industries through better optimization, simulation, predictive analytics, and computational modeling. Improvements in timing precision, entanglement measurement, and error-management techniques are already showing measurable progress toward more reliable quantum systems.

The critical milestone ahead is developing scalable, fault-tolerant quantum systems capable of consistently and efficiently solving commercially meaningful problems. Organizations must prioritize building quantum awareness, partnerships, and targeted experimentation.



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Alan Mott is a Research Architect in the ECS Advanced Research & Innovation team at Unisys. Since joining in 2020, he has researched and developed solutions using Quantum Computing, Neural Networks, Neurosymbolic AI and Knowledge Graphs, and he represents Unisys at UK technology forums such as the National Quantum Computing Centre (NQCC). Before Unisys, Alan spent 20 years in technical and cybersecurity roles for the British Government and IT service providers, delivering secure solutions on cloud platforms including AWS and Azure. He worked closely with CESG, now the National Cyber Security Centre, on analyzing and attributing targeted cyber-espionage attacks and Advanced Persistent Threats. Alan co-authored whitepapers on quantum technology in logistics, optimization and drug discovery, and has mentored postgraduate teams at NQCC Hackathons.

Conclusion

Quantum computing is emerging as a high-potential technology with growing strategic relevance for business and industry. Investment from technology providers, startups, governments, and enterprises continues to accelerate innovation across the ecosystem, and expanding use cases in financial services, healthcare, life sciences, cybersecurity, logistics, and manufacturing are strengthening commercial interest.

Cloud-based access models, industry partnerships, and early-stage enterprise experimentation are making quantum technologies more accessible to organizations exploring future competitive advantage. As the technology matures, quantum computing has the potential to complement classical and high-performance computing by addressing complex computational challenges that are difficult or impractical to solve with conventional methods alone.

At the same time, important challenges remain. Hardware stability, error correction, scalability, cost, and operational reliability continue to limit large-scale commercial deployment. Moving from scientific breakthroughs to dependable business outcomes will require sustained innovation, ecosystem collaboration, responsible governance, and practical implementation aligned with measurable business value.

For executives, the opportunity today is less about immediate transformation and more about strategic preparedness. Organizations that build awareness, identify high-impact use cases, form partnerships, and invest in targeted experimentation now will be better positioned to benefit as the quantum ecosystem evolves. The question is no longer whether quantum technologies will shape the future of computing, but how and when they will deliver meaningful business advantage alongside the computing capabilities organizations already rely on.

For more information about Unisys quantum computing research and capabilities, visit the Unisys quantum research page.

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