

QUANTUM LEAP

As quantum technologies and AI reshape the foundations of industry, security and society, we probe the vast promise—and the grave risks—of this transformational wave



This page: Quantum technologies are shifting from niche research to commercial reality—quantum sensing is already in use, while computing and communication are maturing toward practical products

Opposite: Quantum technologies are finding cross-sector applications—biotechnology, for example, is exploring quantum computing and generative AI to accelerate mRNA research and vaccine design



“Today, humanity is at the tip of the iceberg of a new duo: quantum plus AI. The intersection of these technologies will create a symbiotic relationship in which each will propel the other forward.”

Not since the digital revolution of the late 20th century, which introduced personal computers, the internet and smartphones, have we taken such a leap in how society communicates and accesses information. The current shift to advanced digital technologies, often described as the “Fourth Industrial Revolution” or the “Intelligence Age,” undoubtedly presents an unprecedented opportunity to address some of the most complex global challenges we face today, such as climate change and the energy transition. It therefore becomes increasingly important for organizations to invest now to harness this game-changing technology effectively.

As a 2024 report by the World Economic Forum (WEF), “Quantum for Society: Meeting the Ambition of the SDGs,” puts it: “Quantum’s tremendous power opens the door to solutions unimaginable today to the challenges faced by humanity. It could help to decarbonize the world at scale, design new solar cells for globally expanding the use of clean energies or even monitor groundwater reserves, an issue critical to the survival of all species on Earth.

Complex problems require quantum solutions that can scale globally, creating meaningful and measurable impact for society and the planet, all of which cannot happen without a strong collaborative network of key stakeholders.”

Once a niche topic of research, quantum technologies are rapidly moving toward commercial application. The U.S. Data Science Institute predicts quantum will shift from “potential technology” to “practical products” by 2026. While quantum sensing is already in commercial use, quantum computing and communication are maturing quickly and attracting increasing attention from industry, academia and governments.

Addressing global challenges

Quantum technologies offer promising deployment opportunities across sectors. In biotechnology, for example, Moderna is exploring quantum computing and generative AI to accelerate mRNA research and vaccine design. In medical diagnostics, SandboxAQ has advanced magnetocardiography (MCG) using quantum sensors to map the heart’s magnetic fields with higher resolution, improving detection of myocardial ischemia, arrhythmias and inflammatory cardiomyopathy.

Urban planners are also testing quantum tools to optimize logistics and traffic management, which can reduce travel times and improve air quality. The port of Rotterdam, for instance, is experimenting with a quantum communication infrastructure to enhance its logistics chain. In space, Earth observation satellites (EOS) that

collect data for weather forecasting, disaster response, agriculture, mining and fishing are being optimized by quantum-enabled platforms. Planck, developed by Artificial Brain, is an example: a quantum-powered platform for hyperspectral auto-labeling, EOS scheduling and space debris management.

A symbiotic relationship

The convergence of quantum technologies and AI amplifies their potential. As WEF notes, “Today, humanity is at the tip of the iceberg of a new duo: quantum plus AI. The intersection of these technologies will create a symbiotic relationship in which each will propel the other forward. Moreover, the revolution caused by generative AI (GenAI) will only add to the equation.”

AI can accelerate quantum development by speeding quantum code programming, aiding algorithm design, optimizing system architecture, and accelerating translation from lab prototypes to deployable systems. Any simplification in quantum algorithms, for instance, could materially shorten the timeline to quantum advantage—the point at which a quantum machine outperforms classical computation on a real-world problem.

Barriers to progress

Despite the promise, significant barriers remain. Major technology companies and deep-pocketed investors—Amazon, Google, IBM and Microsoft, together with late-stage startups such as PsiQuantum and Quantinuum—lead funding trends. Yet quantum remains a niche sector within venture capital, accounting for less than 1% of total VC funding; most investment has favored hardware, while quantum software has seen proportionally little funding. The lack of broad, demonstrable real-world gains from software solutions has constrained investor confidence.

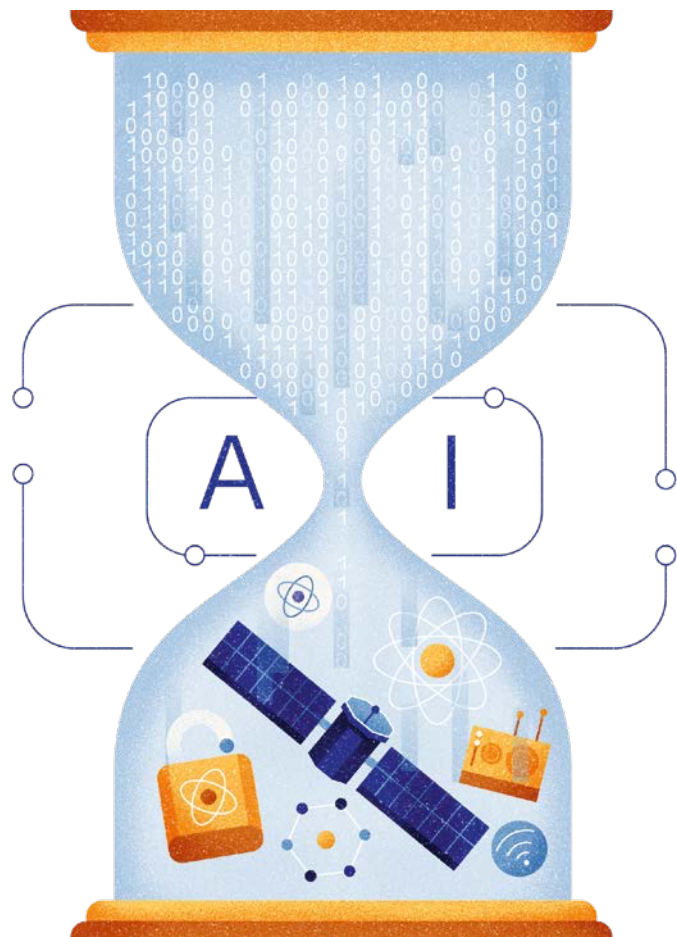
Techno-economic strategist Oliver Inderwildi highlights the practical hurdles: “Quantum computing requires a very advanced and stable technical environment, from sensors to cooling. Plus, you need a classical computing environment that helps you keep it at that place,” he explained. “And that’s where the symbiosis between AI and quantum computing comes in. Obviously, the enormous advances in AI are now helping people who develop these systems to keep it all

stable, but at the moment, there are still many technological hurdles that have to be overcome.”

Geopolitics and ethics

Quantum advances also carry geopolitical and ethical implications. Advanced quantum sensing can enable navigation without GPS, making platforms harder to detect—a development with clear strategic consequences. “The complete quantum technology sphere will have a geopolitical impact,” Inderwildi said.

In finance and national security, quantum’s threat to current encryption standards is stark. Inderwildi warns that encrypted communications and transactions—from ATM PINs to classified government files—are vulnerable to future quantum decryption. “Communications can be intercepted, but the PIN is encrypted. With a quantum computer, attackers could extract the PIN from intercepted data. Now, when you think about large-scale financial transactions, about government information, you would have the Swiss multi-tool to open up everything,” he said.





The Interviewee

Oliver Inderwildi is an unapologetic techno-optimist. His conviction is simple: Humanity’s most pressing issues—from climate change and sustainability to energy and water security—can be solved by next-level engineering supported by novel digital technologies. He operates at the intersection of science and strategy, working with startups, multinationals and governments to deploy these cutting-edge technologies. His insights and ideas aren’t just opinions, they have been put into action for a sustainable future. His books, published by Springer Nature, serve as the blueprint for putting technology to work for a better future. Many of Dr Inderwildi’s lectures, talks, interviews and podcasts are available to watch on YouTube, and his academic work is accessible via ORCID (orcid.org).

“The big philosophical question is whether we can give it an ethical and moral compass and, if so, which ethical and moral compass should it be?”

The U.S. and the European Union are prioritizing efforts to build quantum-safe digital infrastructure. In the U.S., the National Institute of Standards and Technology (NIST) leads the development of post-quantum cryptographic algorithms; in Europe, the EuroQCI (European Quantum Communication Infrastructure) aims to create a hardware-based network for secure quantum communications across all 27 European Union member states.

Harvest now, decrypt later

A pressing worry is “harvest now, decrypt later”—the practice of harvesting encrypted data today to decrypt when quantum capacity emerges. Inderwildi noted, “Obviously, private entities, intelligence services, etc., have harvested enormous amounts of information already, which they just store, and will decrypt once they have a quantum computer, so this is going to be a problem in the future.”

Despite these threats, the potential upside is considerable. WEF identifies three domains

where quantum computing could excel with major environmental and societal gains: molecular simulation and discovery in materials science and biology; optimization and risk management in complex systems; and advances in AI and machine learning.

A philosophical conundrum

The quantum transition raises fundamental ethical and philosophical questions about AI’s influence on decision-making for politics, finance and health. Inderwildi asks whether we can embed an ethical and moral compass in these systems, and if so, what form that compass should take. “The big philosophical question is whether we can give it an ethical and moral compass and, if so, which ethical and moral compass should it be?”

He rounds to a cautious optimism: “In general, I’m a techno-optimist. The thing is, this is really the one area where we could create a *deus ex machina*, meaning we’re not the number one species in the world anymore when it comes to intelligence. The question for me really is, with this quantum computing and AI symbiosis, how long will we still be in control?”

Quantum technologies present immense opportunity to address complex global issues and will be crucial to advancing industry, innovation and infrastructure goals. But as the global quantum race intensifies, delivering on that promise requires sustained technical progress, ethical frameworks and coordinated policy—and a clear commitment from public and private stakeholders to manage both the promise and the risks. ◀