Engineering the Quantum Future

January Edition

QUANASTRA

Quantum & Photonics Innovation

IN FOCUS: Practical and useful uantum computing – Role of logical qubits

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Issue 01

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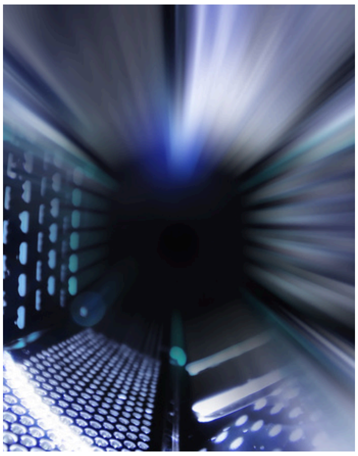
Jan, 2026

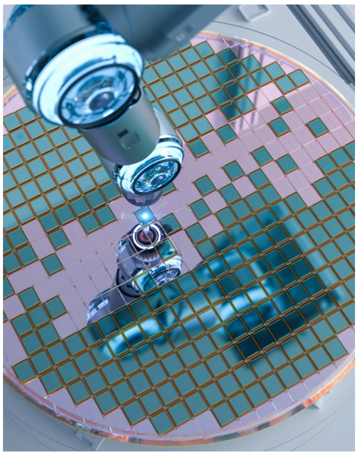
FOUNDER'S MESSAGE

From my college days, I have always been in awe of Bell Labs—a place that defined the semiconductor revolution and in many ways played a vital role in shaping the technological world we live in today. Many of its inventions became so fundamental that they disappeared into everyday life, used across industries without us even realizing their origins. What fascinated me most was not just the scale of innovation, but the culture behind it. Even most of early stage work by Peter Shor in theoretical quantum algorithm was done at Bell Labs.

When I started Quanastra, it was with a similar long-term belief: that meaningful inventions should go on to redefine the quantum era—not only in India, but globally. Technology revolutions do not happen overnight. They are built through years of focused research, deep engineering, and an environment that allows scientists and engineers to think freely and document their work honestly.

One of the defining features of Bell Labs was the Bell Labs Journal. It was more than a company publication—it was a record of ideas, failures, breakthroughs, and deep scientific thinking. Some of the research published there has changed human life and continues to remain relevant even today. That culture of documenting and sharing serious scientific work is something I feel we need to bring back, especially in India.





The Quanastra Journal is a small attempt in that direction perhaps with a lot of new flavour and charm. We are starting modestly but with a clear intent. Over the next few years, we hope this evolves into a full-fledged journal that not only captures what is happening within Quanastra, but also contributes meaningfully to the broader quantum and deep-tech ecosystem.

Along with updates from our work, we are introducing sections that look beyond the company. A dedicated "In Focus" section that will cover important quantum concepts and developments happening across the global quantum landscape. Another section focuses on explaining complex quantum terminology in simple, intuitive terms—so that these ideas can be understood, discussed, and communicated more effectively, even outside narrow expert circles.

This journal reflects how we think at Quanastra: slow, rigorous, curious, and long-term. If it helps spark thought, conversation, or deeper understanding—even for a small group of readers—it will have achieved its purpose.

I hope you enjoy reading it as much as we enjoyed putting it together.

Milestone Moments

“At Quanastra - Vision meets Execution”

VMC machine

Quanastra is pleased to welcome a new addition to its advanced manufacturing ecosystem – the 4-axis vertical machining center (VMC), Shrike AL320-S. This powerful, compact and high – precision CNC system significantly enhances our in-house prototyping capabilities and is fully equipped to manufacture critical components for advanced scientific instruments and systems.

The Shrike AL320-S enables high – accuracy micromachining, supporting applications ranging from automotive component development to ultra-high-vacuum (UHV) hardware fabrication. Its integration strengthens Quanastra’s ability to rapidly transition designs from concept to prototype while maintaining stringent quality and performance standards.

This capability marks an important step in expanding indigenous manufacturing capacity for precision components, reinforcing Quanastra’s commitment to the vision of “Atmanirbhar Bharat”.

With this addition, Quanastra can achieve tighter tolerances, faster iteration cycles, and improved repeatability across complex geometries, while reducing dependence on external vendors.

SNSPD system

Quanastra’s journey from simulation to system realization marks a significant milestone in India’s deep-tech and quantum innovation landscape. The simulated design of our Superconducting Nanowire Single-Photon Detector (SNSPD) system is now translating into physical form as we advance into the manufacturing phase of its engineered components.

We are proud to share that 100% of the components manufactured to date have been produced in India, reinforcing our commitment to the Make in India initiative and to building globally competitive quantum technologies through indigenous capabilities.

The SNSPD system consists of over 70 precision-engineered components, many of which possess strong standalone commercialization potential. Individually, these components can address critical needs across semiconductor manufacturing, cryogenic systems, photonics and emerging quantum technologies, opening multiple pathways for technology transfer and market adoption.

CII PARTNERSHIP SUMMIT, VISHAKHAPATNAM (A.P.):

At the 30th CII Partnership Summit 2025, Quanastra formally signed a Memorandum of Understanding (MoU) with the Government of Andhra Pradesh, marking its participation in the Amaravati Quantum Valley initiative.

With the strong support and visionary leadership of the Andhra Pradesh Government, Quanastra aims to contribute meaningfully as a high-impact stakeholder in strengthening India's quantum technology ecosystem. This collaboration represents a significant step toward advancing quantum research, innovation, and commercialization in the country.

We extend our sincere gratitude to the Government of Andhra Pradesh, and especially to Hon'ble Chief Minister Shri Nara Chandrababu Naidu, for inviting Quanastra to be part of the Amaravati Quantum Valley. We look forward to making substantial and lasting contributions to the Andhra Pradesh Quantum Mission (AQM) and to India's growing quantum community.

GUEST FROM LUXEMBURG:

Quanastra was pleased to host Mr. Serge Borg from Luxembourg at its office for an engaging and insightful interaction. Dr. Vidur Raj and the Quanastra team greatly valued the opportunity to exchange perspectives across a wide spectrum of topics, including the evolving quantum technology ecosystems in India and Europe, advanced manufacturing opportunities in Luxembourg, and broader avenues for international collaboration.

The discussion fostered meaningful dialogue and mutual understanding, reinforcing Quanastra's commitment to global engagement and cross-border knowledge exchange in advancing cutting-edge quantum technologies.

Simulation Setup:

Quanastra has established advanced high – performance workstations dedicated to theoretical modeling, numerical simulation and design optimization. These computational platforms enable the rigorous validation of concepts and the implementation of novel, high-impact ideas across emerging technologies.

In parallel, Quanastra is fostering a collaborative innovation ecosystem by conducting specialized training programs and bringing together India's brightest young researchers, engineers, and innovators under one roof.

This initiative is aimed at building deep technical expertise and accelerating impactful advancements in quantum science and technology, strengthening India's position in the global quantum innovation landscape.

By integrating computation with hands-on experimentation, these efforts reduce development cycles, and encourage cross-disciplinary thinking.

India International Science Festival (IISF), 2025:

Quanastra marked a strong and dynamic presence at IISF this year, reflecting both our technical depth and collaborative spirit. While the event provided a platform to showcase our work, it also evolved into a valuable forum for team engagement, knowledge exchange, and shared learning.

Particularly inspiring was the enthusiasm shown by team members from non-core research backgrounds, who actively engaged with the science, explored its underlying principles and connected with the broader mission driving our innovation. Such experiences reinforce a culture of curiosity, inclusivity and purpose across the organization.

Moments like these strengthen our collective vision and reaffirm our commitment to building impactful technologies – onward toward continued learning, collaboration and innovation.

2026

FUME HOOD & SPIN COATER:

The company has successfully commissioned a state-of-the-art fume hood – an essential infrastructure component for safely handling volatile chemicals, maintaining a healthy laboratory environment, and preventing hazardous fume accumulation.

Complementing this installation is a high-precision spin coater (spinner), a critical tool for chemical synthesis and uniform thin-film coating processes required in MEMS device fabrication.

The addition of these advanced instruments significantly strengthens Quanastra's in – house fabrication capabilities and marks an important step toward developing and prototyping core components of its next – generation semiconductor chips.

CRYOCOOLER:

Cryocoolers are central to what we are doing here at Quanastra. Our detectors require ultra-cold environment to work, and these cryocooler are the way to reach at such cold temperatures.

Our newly installed cryocooler has been manufactured by Pride Cryogenics and can go to temperatures as low as 2.5K. This capability enables controlled testing, and long-duration operation, and system-level integration of superconducting devices.

IN FOCUS

Practical and useful quantum computing – Role of logical qubits

In the mid-1990s, mathematician Peter Shor published a groundbreaking paper showing that a quantum computer could factor large numbers exponentially faster than any known classical algorithm. This result was revolutionary because it demonstrated that quantum computers could, in principle, outperform classical ones at tasks considered practically impossible.

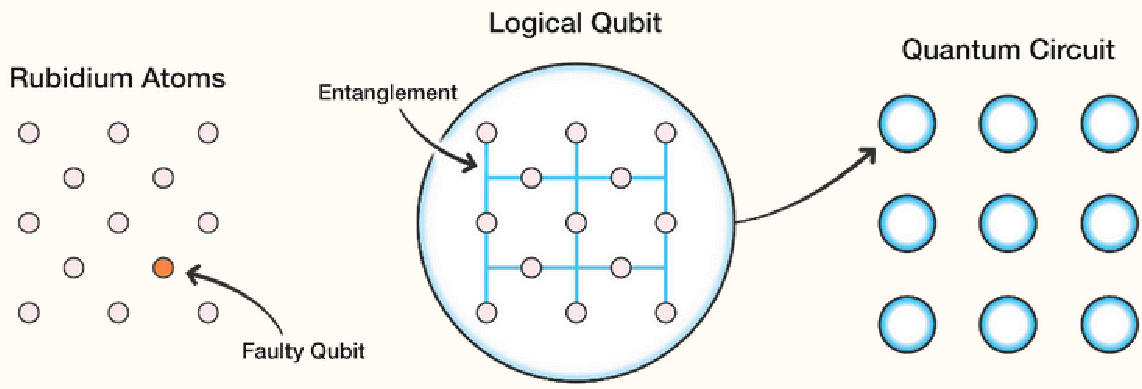
However, almost immediately, researchers realized a major problem: Shor's algorithm would only work if qubits could be kept stable long enough to perform many operations—which seemed unrealistic given how easily qubits lose their quantum nature. Early experimental efforts quickly confirmed this concern, revealing coherence times far shorter than algorithmic requirements.

More precisely, researchers observed that noise accumulated rapidly with each operation, causing errors to cascade. These findings underscored that raw quantum advantage alone was insufficient without mechanisms to actively protect quantum information during computation over extended durations.

Even tiny disturbances from the surrounding environment—such as heat, electromagnetic noise, or vibrations—can disrupt the quantum state of qubit through a process known as ***decoherence***, effectively destroying the information stored in it and making the reliable computation very difficult.

As a result, Shor and others soon turned their attention to a second, equally important question: how can we protect qubits from decoherence? The answer came in the form of ***quantum error correction***, a concept that may sound surprising at first. In classical computers, error correction is straightforward—you simply copy information and compare it. In quantum systems, copying is forbidden by the laws of physics, which makes quantum error correction a lot more difficult. Instead, researchers discovered that quantum information could be protected by spreading it across many physical qubits, linked together through a uniquely quantum connection called entanglement. The key idea was that instead of storing information in a single physical qubit, the information is encoded into a collective state of multiple qubits.

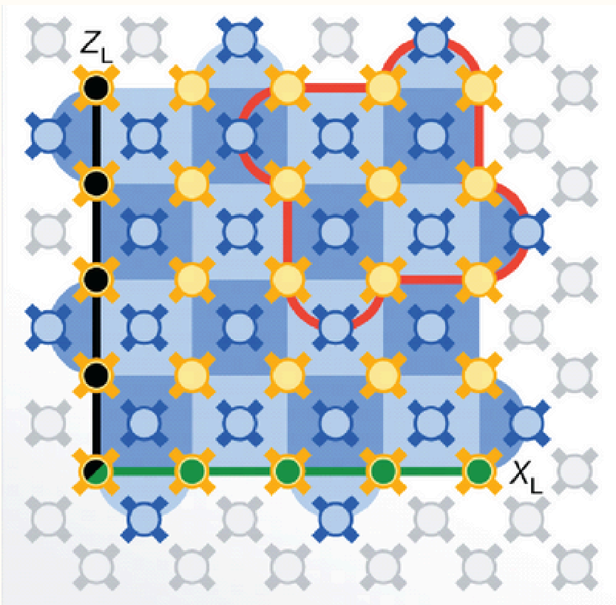
These qubits are carefully entangled so that no single qubit carries the full information on its own. If one of them is disturbed, the overall quantum state can still be reconstructed using information from the others. In this way, the harmful effects of decoherence are greatly reduced, even though individual qubits remain fragile. In practice, this means that a single, reliable unit of quantum information—called a logical qubit—is built from many underlying physical qubits. Some of these qubits store the information, while others act as supporting qubits that continuously monitor for errors without directly measuring the quantum state itself. When an error is detected, it can be corrected before it spreads and destroys the computation.

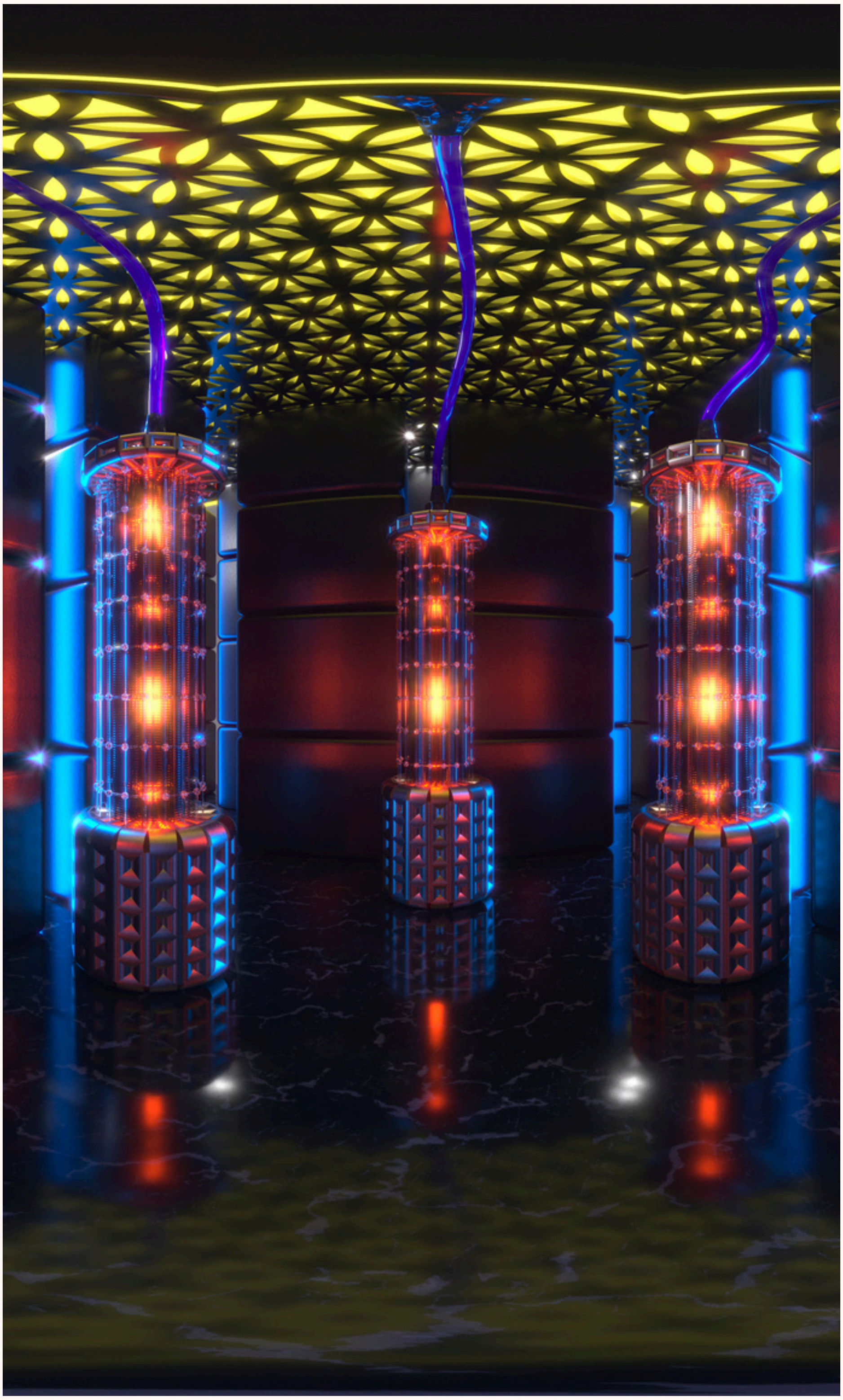


Although the exact number depends on the error-correction scheme being used, a logical qubit typically requires many physical qubits operating collectively. One such example is illustrated above. An individual rubidium atom acting as a physical qubit may undergo decoherence, leading to faulty operations. However, by entangling multiple rubidium atom qubits—arranged, for instance, in a square lattice—quantum information can be encoded into a single logical qubit. In this configuration, errors affecting individual atoms can be detected and corrected, resulting in a significantly lower overall error rate for the logical qubit compared to that of any single physical qubit.

This concept of logical qubits fundamentally changed how scientists think about quantum computers. Rather than trying to make a single qubit perfectly isolated from the world—a nearly impossible task—the strategy became to embrace imperfection but correct for it in a structured and predictable way. This approach mirrors how complex systems in nature achieve stability: not by eliminating all noise, but by organizing themselves so that noise does not dominate.

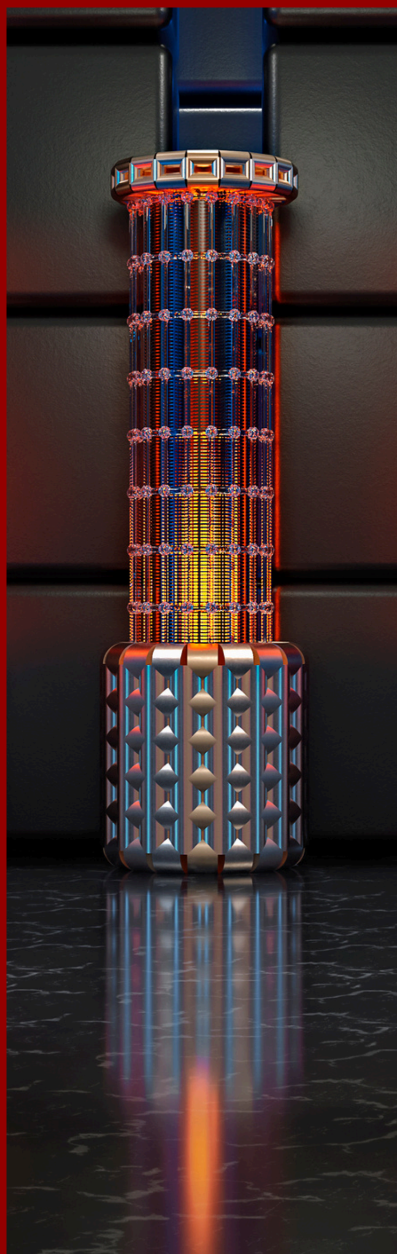
Today, the construction of large numbers of logical qubits remains one of the biggest challenges in quantum technology. Modern quantum processors may contain dozens or even hundreds of physical qubits, but only a few—or sometimes none—of these can yet function as fully error-corrected logical qubits. Nevertheless, the theoretical foundation laid by these early ideas continues to guide the field. Every major advance in quantum hardware is now judged not just by how many qubits it has, but by how well those qubits can be protected, stabilized, and combined into logical units capable of reliable computation





In this context, Google's recent experimental results represent an important and concrete advance. Their work demonstrates a superconducting qubit platform operating below the surface-code threshold, meaning that increasing the size of the error-correcting code leads to a measurable reduction in logical error rates. This observation is significant because it moves quantum error correction from a largely theoretical requirement to an experimentally validated regime. Rather than extrapolating from small-scale demonstrations, the results show that fault-tolerant behavior can emerge in real hardware when physical qubit performance crosses the required boundary.

Crucially, the experiments also highlight that fault tolerance is not achieved by a single improvement, but by the combined optimization of gate fidelities, measurement accuracy, and qubit coherence, together with repeated rounds of error detection. The logical qubit produced in this manner remains imperfect, but its behavior follows the predicted scaling laws of quantum error correction, providing confidence that further improvements in hardware will translate directly into more reliable logical operations.



QUANASTRA'S ISRAEL QUANTUM VISIT

Quanastra participated in the official visit to Israel from 11–13 November 2025 as part of the Indian delegation representing the National Quantum Mission (NQM), Department of Science and Technology, Government of India. For Quanastra, this visit was an important opportunity to directly engage with Israel's quantum ecosystem and gain first-hand insight into how leading quantum hardware, software, and system-level technologies are being developed and translated into deployable solutions.

The engagements provided Quanastra with a clear view of Israel's strong emphasis on hardware-driven innovation. Interactions with companies working on trapped-atom systems, photonic quantum architectures highlighted the depth of engineering-led approaches being pursued.

In particular, discussions around scalable qubit architectures, photonic cluster-state generation, compact atomic clocks, and tightly coupled hardware–software systems were particularly relevant to Quanastra's own focus on quantum hardware and enabling technologies.

The second day of the visit focused on quantum communication, software abstraction layers, error mitigation, and control electronics. From Quanastra's perspective, these discussions reinforced the importance of end-to-end system co-design, where detectors, control electronics, software, and algorithms must evolve together. It also provided insights into how complementary technologies can accelerate experimental progress and system reliability.

The visit concluded with structured discussions at the Israel Innovation Authority, where national quantum strategies, funding mechanisms, and ecosystem-building models were shared by both sides.

For Quanastra, these conversations were particularly valuable in understanding pathways for international collaboration, access to specialized testbeds, and mechanisms for startup–academia–government interaction. Sector-wise discussions enabled deeper exchanges on fabrication access, system integration, talent development, and commercialization challenges.

Overall, the visit offered Quanastra a comprehensive perspective on Israel's integrated quantum ecosystem and its focus on translating research into scalable technologies.

QUANTUM MEMORY MATRIX?

1. (ACROSS) A QUANTUM PHENOMENON WHERE A SYSTEM EXISTS IN MULTIPLE STATES SIMULTANEOUSLY (SCHRODINGER'S CAT).

2. (DOWN) THE LOSS OF QUANTUM COHERENCE DUE TO INTERACTION WITH THE ENVIRONMENT.

3. (DOWN) A QUANTUM PROCESS WHERE A PARTICLE PASSES THROUGH A CLASSICALLY FORBIDDEN BARRIER.

4. (ACROSS) A PHENOMENON WHERE TWO PARTICLES REMAIN CORRELATED REGARDLESS OF DISTANCE.

5. (DOWN) WAVE-LIKE BEHAVIOUR OF PARTICLES OBSERVED IN THE DOUBLE-SLIT EXPERIMENT.

6. (ACROSS) PRINCIPLE STATING THAT CERTAIN PAIRS OF PHYSICAL PROPERTIES CANNOT BOTH BE PRECISELY KNOWN.

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						6											
4																	

Let's build the future together

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