IBM Technology Atlas

Quantum roadmap

The future of computing is quantum.

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✅ Realized
🔄 In progress

	2024	2025	2026	2027	2029	2033+
Quantum journey	✅ ***Expand the utility of quantum computing.***	🔄 ***Extend algorithms on quantum computing + HPC and demonstrate error correction code.***	***Demonstrate first example of scientific quantum advantage and a fault-tolerant module.***	***Diversify quantum advantage and entangle fault-tolerant modules.***	***Deliver the first fault-tolerant quantum computer.***	***Unlock the full power of quantum computing at scale.***
Strategy overview	✅ Demonstrate accurate execution of a quantum circuit at a scale beyond exact classical simulation. (5K gates on 156 qubits)	We will release Quantum + HPC tools that will leverage Nighthawk, a new higher-connectivity quantum processor able to execute more complex circuits.	We will demonstrate the first examples of quantum advantage using a quantum computer with HPC.	The scale, quality, speed of the quantum computer will improve to allow executing quantum circuits at a scale of 10K gates on a 1000+ qubits.	The first fault-tolerant quantum computer will be available to clients and allow execution of 100M gates on 200 qubits.	Scale fault-tolerant quantum computers to run circuits of 1 billion gates on up to 2000 qubits, unlocking the full power of quantum computing.
Why this matters to our clients and the world	✅ We have created a platform where algorithm and application developers can develop candidate circuits at utility scale.	We will provide tools and methods for exploring quantum advantage on a pre-fault-tolerant quantum computer working alongside HPC.	Users and partners will unlock the first example of scientific advantage on a pre-fault-tolerant quantum computer working alongside HPC.	Users will be able to run an expanded set of examples demonstrating the scientific value of pre-fault-tolerant quantum computing.	Users will be able to run the next scale of applications using the first fault-tolerant quantum computer unlocking a wider, more complex set of use cases.	Quantum computers running algorithms using billions of gates are expected to enable general applications in security, chemistry, machine learning, and optimization.
The technology or innovations that will make this possible	✅ Developed and deployed Qiskit Functions with our partners to deliver domain specific applications at utility scale. ✅ Used AI to develop advanced classical transpilation methods. ✅ Demonstrated with partners a prototype quantum-centric supercomputer operating at utility scale.	Nighthawk, a modular processor with 120 square lattice qubits will allow more complex calculations using the same circuit depth. New and improved mitigation tools will leverage classical HPC to expand the set of circuits that can be accurately run with 5000 two-qubit gates. *To prepare for the future*, we will demonstrate c-couplers and next generation packaging for fault-tolerant quantum computing with the Loon quantum processor.	Our quantum processors will improve in quality to allow running 7,500 gates on up to 360 qubits. With our partners, we will define a use case benchmarking toolkit to evaluate candidates for quantum advantage. We will deliver mapping and profiling tools for quantum + HPC workflows. *To prepare for the future*, Kookaburra will demonstrate a single module out of Starling consisting of a logical processing unit and quantum memory.	The performance of our Nighthawk processor will improve to allow circuits with up to 10,000 gates on up to 1080 qubits. The first set of computation libraries will be developed to simplify and optimize quantum + HPC workflows. A new workflow accelerator will streamline execution for a known advantage-scale workflow. *To prepare for the future*, the Cockatoo processor will demonstrate entanglement of two modules using a universal adapter.	The first fault-tolerant quantum computer will power a quantum-enhanced HPC architecture with a complete fault-tolerant quantum ISA. With a fault-tolerant architecture, the size of the circuits will increase to 100M operations, enabling the development of more sophisticated circuit libraries. *To prepare for the future*, we will continue to scale electronics, infrastructure, and software to reduce footprint, cost, and energy usage in preparation for Blue Jay.	Scaling fault-tolerant quantum computing to 1 billion gates on up to 2000 qubits with a power consumption of 2 megawatts will require a new control elections and cryogenics infrastructure. Extensions of the computation and circuit libraries will scale and diversify quantum + HPC workflows across industries. *For the future*, we will scale beyond Blue Jay with the development of distributed quantum computing, bringing together the fields of quantum communication and quantum computation.
How these advancements will be delivered to IBM clients and partners	✅ The Heron processor capable of running 5,000 gates on 133 qubits will be delivered through the IBM Quantum Platform.	The Nighthawk processor with high qubit connectivity, capable of running 5,000 gates on 120 qubits, will be delivered through the IBM Quantum Platform.	The Nighthawk processor with up to three 120-qubit modules (360 qubits) capable of running 7,500 gates will be delivered through the IBM Quantum Platform.	The Nighthawk processor with up to nine 120-qubit modules (1080 qubits) capable of running 10,000 gates will be delivered through the IBM Quantum Platform.	The Starling system will be available to clients. It will be a modular, error-corrected quantum-centric supercomputer with 200 qubits capable of running 100 million gates.	A fault-tolerant quantum computer called Blue Jay, capable of running 1 billion gates on up to 2,000 qubits will become available.