Quantum roadmap

The future of computing is quantum-centric.

	2023	2024	2025	2027	2029	2030+
Quantum journey	Introduce parallelization of quantum computations.	S Expand the utility of quantum computing.	Demonstrate quantum- centric supercomputing.	Scale quantum computing.	Deliver a fully error- corrected system.	Deliver quantum-centric supercomputers with 1,000's of logical qubits.
Strategy overview	2023 is all about pushing speed in quantum workflows by introducing parallelization in the Qiskit Primitives.	We will improve the quality and speed of quantum circuits to allow running 5,000 gates with parametric circuits.	In 2025, we will enhance the quality of quantum circuits to allow running 7,500 gates and bring together modular processors, middleware, and quantum communication to demonstrate the first quantum- centric supercomputer.	We will scale qubits, electronics, infrastructure, and software to reduce footprint, cost, and energy usage. The quality of quantum circuits will improve to allow running 10,000 gates.	We will bring users a quantum system with 200 qubits capable of running 100 milion gates.	Beyond 2033, quantum-centric supercomputers will include thousands of qubits capable of running 1 billion gates, unlocking the full power of quantum computing.
Why this matters to our clients and the world	Today, our systems are capacity limited and user jobs can take multiple days. Efficient parallelization between QPUs and parallelization of quantum and classical resources will enable efficient near-term algorithms.	Qiskit Primitives with error mitigation will provide the foundation platform where algorithm and application developers can focus on the workflows and get the best quality out of the quantum hardware.	Abstraction will move from quantum circuits to quantum functions leveraging the Qiskit patterns. This will make quantum computing more usable and will be the start of domain libraries.	Scaled quantum systems will allow users to run larger computations. Multiple computing resources will be seamlessly combined to optimally handle workflows and extend the computational reach of quantum systems.	Users will be able to run large- scale problems using high-rate quantum error correction.	Quantum computers running algorithms using thousands of logical qubits are expected to enable general applications in security, chemistry, machine learning, and optimization.
The technology or innovations that will make this possible	 Middleware will automatically distribute tasks. Serverless tools will allow users to focus on code and not the infrastructure. Expanded classical resources in Qiskit Runtime will speed up compilation and maximize the utilization of the QPUs. 	 Built-in error mitigation will automatically determine the best method to reduce the effect of noise. Transpiler services will optimally rewrite circuits for hardware, taking advantage of AI. Watson Code Assistant will help users write Qiskit code to program quantum systems. 	A quantum node will be part of a network incorporating classical and quantum communication. Resource management will handle quantum and classical workflows. Qiskit will provide libraries of quantum functions and higher- level APIs for faster algorithm and application development.	Intelligent orchestration will analyze workflows to identify the optimal resource allocation (QPUs, communication, and classical resources) for the task. Qiskit will orchestrate approaches to handle errors to provide noise-free outputs to the users.	A novel and efficient error correction code will extend the computational reach of quantum resources. The system will have low-level dedicated classical hardware and a compiler for quantum-centric supercomputing.	Efficient logical decoding will enable 2,000 qubits working in a distributed 100,000-qubit machine. The middleware will include distributed software tools to manage noise-free quantum computations working seamlessly with classical computations. Qiskit will include general purpose quantum computing libraries to simplify the work of developers.
How these advancements will be delivered to IBM clients and partners	Multiple 100+ qubit Eagle processors will be connected using classical communication. Ahead-of-time compilation will increase utilization of the QPUs.	Multiple higher-quality 100+ qubit Heron processors will be connected using classical communication.	Pre-built Qiskit functions and optimized libraries will be avail- able. A 1,000+ qubit Flamingo system will be demonstrated, made from multiple processors, with each processor made from multiple chips.	The performance of our Flamingo systems will improve to allow users to run circuits with up to 10,000 gates and 1,000+ qubits.	The Starling system will be available to clients. It will be a modular, error- corrected quantum-centric supercomputer with 200 qubits capable of running a total of 100 million gates.	Our 100,000-qubit Blue Jay system will define 2,000 qubits capable of running a total of 1 billion gates. The middleware will integrate this system into ever more powerful quantum-centric supercomputers.