Quantum Report (2)

Japan's R&D Capabilities in Advancing Quantum Technology (Part1): Building Technological Foundations and Development for the Future

Countries including Japan are strengthening efforts to advance quantum technology. In Japan, multiple "domestically produced quantum computers" have been developed and manufactured since 2023, and the pursuit of further technological advancement toward industrialization continues. Behind this are the tireless and steady efforts of companies and research institutions. This article (Part 1) focuses on trends in the development of quantum computers and related technologies in Japan, as well as Japan's technological capabilities. Part 2 will cover the initiatives of major research institutions that play a fundamental role in quantum technology research and development.

■Quantum Technology Under Development

Among quantum technologies, the development of quantum computers is being pursued alongside quantum communication, measurement, and sensing. Modern conventional computers use "bits" as the smallest unit of information, representing one bit as either "0" or "1" for calculations. On the other hand, the information unit of quantum computers is the "quantum bit (qubit)," and high-speed processing is possible because one qubit can represent both states simultaneously to perform parallel calculations. However, quantum computing is still in its early stages, and many challenges, such as errors, remain.

There are multiple approaches to quantum computing. Based on differences in computational methods, they are broadly classified into two types: the "annealing method" specialized for optimization problems and the general-purpose "gate method." The world's first commercial quantum computer was an annealing-based system released in 2011 by D-Wave Quantum (formerly D-Wave Systems), a company originally founded in Canada and now headquartered in the United States. For the gate method, research and development are progressing across multiple approaches, including the "superconducting" method pursued by major U.S. companies such as IBM and Google, as well as "ion trap," "neutral atom," "photonic," and "semiconductor (silicon)" methods (Note 1). Some are already in operation at demonstration sites and are also being utilized for business applications. At present, there is no clear outlook on which method will become dominant, and numerous companies and research institutions have been working on developing their respective hardware and software.

■Japan's Technological Development Capabilities Demonstrated to the World

Japanese researchers have also made significant contributions to the development of quantum technology to date. For example, Professor Hidetoshi Nishimori of the Graduate School of Science and Engineering at Tokyo Institute of Technology (currently a specially appointed professor at Institute of Science Tokyo) and his colleagues first published the theory of quantum annealing in 1998. The annealing-type quantum computer that D-Wave Quantum successfully commercialized is also based on Professor Nishimori's theory. Additionally, Senior Researcher Yasunobu Nakamura of NEC Fundamental Research Laboratories [currently the Director of RIKEN Center for Quantum Computing] and his colleagues developed the world's first "superconducting qubits made with solid-state devices" in 1999 and successfully demonstrated its operation. This research achievement contributed to the progress of quantum computer research and development worldwide.

Currently, various Japanese companies and research institutions are collaborating to advance the development of physical quantum computers. To date, the launch and operation of multiple "domestically produced quantum computers" have been announced. In terms of approaches, the development of superconducting quantum computers has taken the lead, with the number of qubits increasing from 64 to 256 over a period of approximately two years (see Table below).

<u>Operational Evolution of Domestically Produced Quantum Computers</u>

(As of September 2025, Note 1)

Announcement Date	**Name/Model**	**Method**	**Number of Qubits**	**Main Participating Organizations/Companies**	**Installation Site**
March 2023	First Domestically Produced Quantum Computer ("Ei")	Superconducting	64 (Note 3)	RIKEN, The National Institute of Advanced Industrial Science and Technology (AIST), The National Institute of Information and Communications Technology (NICT), The University of Osaka, Fujitsu, NTT	RIKEN (Saitama Prefecture)

October 2023	Second Domestically Produced Quantum Computer	Superconducting	64	Fujitsu, RIKEN	RIKEN (Saitama Prefecture) (RIKEN RQC-Fujitsu Collaboration Center)
December 2023	Third Domestically Produced Quantum Computer	Superconducting	64	The University of Osaka, RIKEN, AIST, NICT, Amazon Web Services Japan, e-trees.Japan, Fujitsu, NTT, QuEL, QunaSys, SEC	The University of Osaka (Osaka Prefecture)
November 2024	General-Purpose Photonic Quantum Platform (Note 2)	Photonic	Not specified	RIKEN, The University of Tokyo, Japan Science and Technology Agency (JST), NTT, Fixstars Amplify	RIKEN (Saitama Prefecture)
April 2025	256-Qubit Quantum Computer	Superconducting	256	Fujitsu, RIKEN	RIKEN (Saitama Prefecture) (RIKEN RQC-Fujitsu Collaboration Center)
July 2025	Fully Domestically Developed Quantum Computer	Superconducting	144 (Note 4)	The University of Osaka, RIKEN, Fujitsu, ULVAC, QuEL, QunaSys, TIS, SEC, e-trees.Japan	The University of Osaka (Osaka Prefecture)

Note 1: The information presented here is not exhaustive, as various companies and research institutions are continuing to develop physical quantum computers.

Note 2: A "continuous-variable (analog) quantum computer" that performs operations on continuous variables (analog) rather than qubit-based quantum computers and is accessible via a cloud-based system over the internet.

Note 3: The system is actually operating with 53 qubits.
Note 4: Normal operation of 28 qubits was confirmed at the start of operation, with plans to expand to 144 qubits in the future.
Source: Prepared by JETRO based on various news reports and press releases

The all-Japanese quantum computer announced in July 2025 is fully Japanese made, including all major components and software. The following month, at a special exhibition of the 2025 Japan World Exposition (Expo 2025 Osaka, Kansai), an event was held where visitors could experience hands-on remote operation of the system via the cloud. Professor Makoto Negoro of the Center for Quantum Information and Quantum Biology (QIQB) at The University of Osaka, who was involved in the development and manufacturing of this fully domestic quantum computer, stated, "It is highly significant that multiple Japanese companies and research institutions have worked closely together to demonstrate Japan's technological capabilities. Looking ahead, in the continued development of quantum computers, collaboration with overseas partners will also be essential to create better systems, and it is equally important to proactively promote Japanese technologies abroad" (Note 2). Japan's quantum computer development is expected to pursue new breakthroughs by strengthening domestic technological capabilities while maintaining a broad global perspective.

In terms of qubit count, the 256-qubit superconducting quantum computer developed by Fujitsu and RIKEN was the world's largest physical quantum computer available to external users at the time of its announcement in April 2025. Looking ahead, Fujitsu and RIKEN aim to bring a 1,000-qubit superconducting quantum computer into operation within fiscal year 2026. Fujitsu is constructing a new quantum research facility at Fujitsu Technology Park in Kawasaki City, where the 1,000-qubit superconducting quantum computer is scheduled to be installed. As a longer-term roadmap, the company has also announced plans to begin research toward building a superconducting quantum computer with more than 10,000 qubits in fiscal year 2030.

■Momentum Accelerating Toward Industrialization of Quantum Computers

As part of the efforts to realize a 10,000-qubit quantum computer, Fujitsu was selected for a commissioned and subsidized project titled "Acceleration of Development Toward Industrialization of Quantum Computers" under the New Energy and Industrial Technology Development Organization (NEDO)'s "Research and Development Project of the Enhanced Infrastructures for Post-5G Information and Communication Systems" (project period: FY2025–2027). Fifteen project themes and multiple implementing entities have been selected for this project [see the "List of Scheduled Implementing Entities for FY2025 Research and Development Project of the Enhanced Infrastructures for Post-5G Information and Communication Systems / Development of Post-5G Information and Communication Systems / Acceleration of Development Toward Industrialization of Quantum Computers (Commissioned, Subsidized)"], and under each project theme, system development related to superconducting, neutral atom, photonic and other methods, advanced materials, middleware development, and other activities are being carried out.

In this NEDO project, while Fujitsu will be engaged in the development of superconducting quantum computers, Yaqumo, a startup originating from Kyoto University that develops neutral atom quantum computers, will work on developing a range of functions including lasers and systems for qubit control, quantum circuit design, and error correction. Hamamatsu Photonics, a manufacturer of optical-related electronic components and equipment, aims to develop ultra-high-speed cameras, multi-pixel spatial light modulators (Note 3), and laser stabilization technologies required for scaling up neutral atom quantum computers. These technologies are also expected to be applied to photonic and ion trap quantum computers. In addition, OptQC, a startup originating from The University of Tokyo that has been developing photonic quantum computers, has expressed strong interest in initiatives such as the development of a successor to the first commercial unit currently being built at AIST. AIST's Global Research and Development Center for Business by Quantum-AI Technology (G-QuAT) is also one of the selected organizations and will collaborate with OptQC to enhance photonic detection systems as part of efforts to advance components and materials. Furthermore, G-QuAT is participating as a collaborative research institution in 10 other project themes, including those led by Yaqumo and Hamamatsu Photonics, reflecting its commitment to providing comprehensive support for technological development. With cutting-edge research and development also advancing across other project themes selected under this NEDO initiative, the industrialization of quantum computers is expected to become increasingly feasible.

In Japan, much of the development of quantum computers and related technologies is being promoted through collaboration among various companies and research institutions. While this article has focused primarily on the development capabilities accumulated domestically, international collaboration among individual companies and research institutions is also progressing. The expansion of domestic and international collaboration can lead to a virtuous cycle where Japan's technological capabilities are further enhanced, driving advances in quantum technology. In Japan, the development of quantum computers and related technologies is being pursued through a wide range of national projects, not limited to the NEDO initiative described above. The momentum toward industrialization of quantum technology is expected to increase even further.

Note 1: Each method differs in its implementation. The "superconducting" systems use electrons confined in superconducting circuits as qubits. In "ion trap" systems, ions are captured using electromagnetic fields and utilized as qubits. In "neutral atom" systems, neutral atoms captured and cooled by laser light are utilized as qubits. In "photonic" systems, the quantum states of photons are utilized. In "semiconductor (silicon)" systems, qubits are implemented using semiconductor-based technologies.

Note 2: For details on international collaboration related to quantum computers, see "Japan Showcases Its Technological Prowess with Fully Domestically Produced Quantum Computer" dated October 9, 2025.

Note 3: An optical device that electrically controls the spatial distribution of light amplitude, phase, or polarization.

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