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Understanding China's Quest for Quantum Advancement

By Hideki Tomoshige and Phillip Singerman

In the rapidly evolving landscape of quantum technology, every nation and major player has opportunities to lead in distinct areas and secure a share of the immense benefits expected over the next decade. Such opportunities would present major benefits for the economies and national security of the dozens of countries currently investing strategically in quantum information science and technology (QIST) research and development (R&D). The coming years will determine not just who leads in the quantum field but also who shapes the standards, markets, and security architectures of the QIST era.

In this technological race, theoretical breakthroughs and advances in research will be just as crucial as practical, applied technical knowledge for countries and companies. A comprehensive quantum ecosystem that balances deep scientific discoveries with the accumulation of practical technical know-how is required.

In these efforts, the People's Republic of China (PRC) stands out for its government-led approach to quantum development, marked by substantial public investment and long-term strategic planning. By aligning resources and coordinating efforts across sectors, China is not only advancing its theoretical expertise in quantum science, but is also building active networks among scientists and engineers. These networks are enabling China's quantum ecosystem to accrue technical knowledge and master the skills required to build and use quantum technologies to solve problems in real-world settings.

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There are **five primary areas** of QIST: (1) quantum computing and quantum-centric supercomputing, (2) quantum communication, (3) quantum sensing, (4) quantum materials, and (5) quantum artificial intelligence (AI) and quantum data centers. These technologies are at various stages of development, each progressing at a different pace due to their unique respective technical challenges. This paper examines China's historical and strategic approach to QIST development and evaluate the country's progress in these five QIST areas.

Recent Developments in China's Quantum Innovation Policy Framework and Initiatives

In a June 2024 speech, President Xi Jinping **reaffirmed** China's goal to become a science and technology powerhouse by 2035. Xi **described** the following five foundational elements of a national strategy:

> "**First**, strong capabilities for basic research and original innovation, be able to continuously make significant original and disruptive scientific achievements; **second**, robust capability to achieve breakthroughs in core technologies in key fields, effectively supporting high-quality development and high-level security; **third**, strong international influence and leadership, becoming a key global scientific center and innovation hub; **fourth**, strong capability to cultivate and attract high-level scientific and technological talent, continuously expanding the team of top international scientific talents and national strategic strength in science and technology, and the last but not the least, a robust science and technology governance system and governance capability, creating a world-class innovation ecosystem and research environment."[1]

These foundational elements will further boost China's efforts to lead in quantum technology. Already, the "Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035," published in 2021, **identified** quantum communications and quantum computing, quantum simulators, and quantum precision measurement technology as areas for formulating and implementing strategic scientific plans and projects, with plans to annually increase R&D spending by **more than 7 percent** to advance related sectors. The "Recommendations of the Central Committee of the Communist Party of China for Formulating the 15th Five-Year Plan for National Economic and Social Development" (2026-2030) explicitly **mentions** quantum technology alongside six other emerging technologies as "new drivers of economic growth." This strategic blueprint also **emphasizes** "achieving greater self-reliance and strength in science and technology and steering the development of new quality productive forces." These developments signal that the 15th Five-Year Plan, scheduled for approval in March 2026, will likely provide further institutional support for quantum technology development.

Additionally, at a press conference on economic affairs of the third session of the 14th National People's Congress in March 2025, National Development and Reform Commission Director Zheng Jiejie **mentioned** establishment of a National Venture Guidance Fund. Quantum technology is one of the focuses of the fund.

This fund **is financed** through ultra-long-term special government bonds and structured in three tiers: national fund, regional fund, and sub-fund. This structure aims to leverage central government

1 Bolding added for emphasis.

capital as a catalyst to attract investments from local governments, financial institutions, and private capital. The total scale **will approach** 1 trillion yuan ($138 billion).

The National Venture Guidance Fund **operates** under the principles of "investing early, investing small, investing long-term, and investing in hard technology." A minimum of **70 percent** of the fund will go toward seed-stage and early-stage companies. More than just providing capital, the fund aims to deepen the venture capital ecosystem by committing long-term capital to technological innovation and fostering collaboration with other regional government-guided funds. This supports China's strategic goal of building self-reliance and strengthening in science and technology.

Remarkably, as a result of the National Venture Guidance Fund, three regional funds have already been established in the Beijing-Tianjin-Hebei region, the Yangtze River Delta region, and the Guangdong-Hong Kong-Macao Greater Bay Area with **29.646 billion yuan** ($4.26 billion), **47.1 billion yuan** ($6.77 billion), and **45.05 billion yuan** ($6.47 billion), respectively. The three funds aim to reach a total of 50 billion yuan in investments each.

At the December 2025 launch, the three regional funds **signed** investment intent agreements for 49 sub-funds and **announced** 27 direct investment projects covering strategic fields including quantum technology. Moving forward, the National Guidance Venture Fund **plans to facilitate** the establishment of over 600 sub-funds in all three regions.

The PRC's State Council **also announced** a program in March 2024 to accelerate quantum technology startups.

Despite these recent advances, however, such strategic investments are not new: China's quantum innovation networks are built on over 20 years of persistent investments in basic science, R&D, and regional development.

China's Historical Approach to R&D in Quantum

Since the early 2000s, China has made persistent investments in quantum R&D, resulting in the establishment of key research institutions, laboratories, and regional quantum innovation ecosystems.

China's quantum R&D investment began with foundational research investments in 2001 through the **973 Program** (also known as the National Basic Research Program of China). Under the 973 Program, the Chinese Academy of Sciences (CAS) Key Laboratory of Quantum Information **was established** in Hefei that same year, becoming the first provincial-level lab in China focused exclusively on quantum research.

This foundational investment was made at a time when QIST faced skepticism in domestic academic circles. As Dr. Guo Guangcan, previously the chief scientist of China's 973 Program, **reflected**, early researchers described the field as "**unpopular**" and some critics even derided it as "pseudoscience." He **describes**, "After 20 years of being 'lonely and helpless,' the first '973 Plan' project of the Ministry of Science and Technology in 2001 brought real changes."

This initial investment yielded the foundation for China's subsequent quantum technology leadership, particularly cultivating **five distinguished scientists** of CAS (Guo Guangcan, Peng Kunchi, Sun Changpu, Jian-Wei Pan, and Du Jiangfeng). In 2003, the laboratory **was awarded** the first National Natural Science Award in the area of quantum information. Professor Jian-Wei Pan's quantum communication research team **went on to create** QuantumCTek, a key player in China's quantum communication industry, in 2009. Similarly, Professor Guo Guangcan and one of his students **founded** Origin Quantum, which developed China's first full-stack quantum computer in 2017. In 2020, QuantumCTek **achieved** the milestone of becoming the first A-share listed company in China's quantum technology sector.

Quantum technology **was first highlighted** as one of four major scientific research areas in China's "Outline of the National Medium- and Long-term Science and Technology Development" (2006-2020) in 2006. This elevated quantum research to national priority status and resulted in steady R&D funding streams. As a result of continuous government initiatives, China **has made** significant scientific progress and developed prominent research networks. Long-term, government-led national R&D efforts have led to the establishment of world-leading QIST research institutes and universities such as the University of Science and Technology of China (USTC), Tsinghua University, and CAS (including its affiliated institutes).

REGIONAL ECOSYSTEMS

China's long-term investments in quantum technology are also driving regional quantum innovation ecosystems. At the regional level, quantum innovation is concentrated in clusters across Beijing, Anhui, Jiangsu, Guangdong, Zhejiang, and Hubei.

The city of Hefei in Anhui province has emerged as a core region for quantum technology development in China. Two prominent factors contribute to Hefei's strong quantum ecosystem.

The first is the province's financial support for early-stage development of QIST. Hefei's Angel Fund and Seed Fund have set their risk tolerance levels at **40 percent and 50 percent**, respectively, to provide risk capital for industrialization. This includes a $1.4 billion Quantum Science and Technology Industry Development Fund **launched** by Anhui Province in 2017.

Hefei is also strengthening its financial support for quantum technology companies. Currently, the number of companies in the upstream and downstream segments of the quantum industry **exceeds 70**, and the number of patents related to the quantum information industry accounts for **12.1 percent of the national total**, ranking second in China after Beijing.

The second factor is Hefei's strong research infrastructure and networks, which were built over decades. Hefei has three major research institutions—the CAS Key Laboratory of Quantum Information, the CAS Center for Excellence in Quantum Information and Quantum Physics, and USTC—to commercialize research findings. QuantumCTek and Origin Quantum both spun off from USTC, in 2009 and 2017, respectively.

China's Quantum Technical Capabilities

China's long-term government R&D investment and strategic political plans are clearly reflected in the country's technological achievements. When it comes to both **shares of global research output** and **the number of patents** in quantum technologies for quantum computing, quantum communication, and quantum sensing, China's quantum innovation capability stands out over other countries. The nation's advanced research and manufacturing capabilities in five foundational areas of QIST—quantum computing and quantum-centric supercomputing, quantum communication, quantum sensing, quantum materials, and quantum AI and quantum data centers—are a testament to the significant quantum technical knowledge and the innovation network that China has built over decades. Below is an overview of where China's technical capabilities currently stand in these five key areas.

QUANTUM COMPUTING

China's superconducting, photonic, trapped-ion, and neutral-atom quantum computing are all moving or moved from laboratory prototypes toward commercial use. China is pursuing a deliberate strategy to scale hardware, localize supply chains, and provide broad cloud access.

Superconducting Quantum Computing

China has steadily advanced its superconducting quantum computing capabilities through research, prototyping, manufacturing, deployment, and commercialization. Three independent superconducting quantum computing developments, including (1) the transition from **Zuchongzhi (2021, 62 qubits)** to **Zuchongzhi 3.0 (2024, 105 qubits)** and **Zuchongzhi 3.2 (2025,107 qubits)** (2) the transition from **Origin Benyuan Wuyuan (2020, 6 qubits)** to **Origin Wukong (2024, 72 qubits)**, and (3) the introduction of **Tianyan-504 (2024, 504 qubits)**, are a sign of China's technological capability in scaling up superconducting-based quantum computing.

These three superconducting-based quantum computers—Zuchongzhi 3.0, Origin Wukong, and Tianyan-504—have been built through collaboration between a group of research universities, research centers, and companies, including:

- USTC;
- Shanghai Quantum Science Research Center;
- Center for Excellence in Quantum Physics;
- Anhui Quantum Computing Engineering Research Center;
- China Telecom Quantum Group (CTQG);
- Origin Quantum Computing Technology; and
- QuantumCTek Co.

The Tianyan-504 and Zuchongzhi 3.0 quantum computers are reported to rival international competitors like **IBM's quantum system** and **Google's Willow** in key performance metrics, though verification from a third party has not been done.

The three computers are available through cloud platforms such as **Zuchongzhi Cloud**, **Tianyan Quantum Cloud**, and **Origin Quantum Cloud**, granting users access to cloud quantum computing. The Tianyan-504 became available recently, in addition to 24 qubits computer and two 176 qubits machines, on China Telecom's "Tianyan" quantum cloud platform, which has already been accessed by more than **12 million visits by users from over 50 countries**. China Telecom Quantum Group has emerged as a strategic player in quantum computing in addition to quantum communication, after **becoming** the controlling shareholder of QuantumCTek in January 2025. China is now positioning itself not only as a technology developer but also as a quantum computing service provider.

China has also built indigenous supply capabilities in the strategically important area of quantum computing manufacturing. For example, China's Anhui Quantum Computing Engineering Research

Center **had developed** the capacity to assemble eight quantum computers simultaneously, up from five previously. This demonstrates China's rapidly growing capabilities in manufacturing quantum computers.

Also, Professor Guo Guoping, cofounder of Origin Quantum Co. and deputy director of the CAS Key Laboratory of Quantum Information, **has noted** that Chinese suppliers developed 80 percent of Origin Wukong's hardware, chips, operating systems, and application software.

As another example of developing its indigenous supply chain, China has long relied on imports for dilution refrigerators, which are essential for superconducting quantum computers, but the Anhui Quantum Computing Engineering Research Center and QuantumCTek last year jointly **announced** that they will mass produce dilution refrigeration. China **has also published** a study that theoretically demonstrates the possibility of attaining extremely low temperatures without relying on helium. These technological indigenization efforts in quantum computing could boost China's speed of innovation and adaptation, and might also create future potential vulnerabilities for the United States and allied national security and technological leadership.

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Photonic and Trapped-Ion Quantum Computing

Researchers and industry **have been using** various approaches to create high-quality qubits, each with its own strengths and challenges. Photonic and trapped-ion quantum computers are two of the best possible approaches for developing utility-scale quantum computing and its commercialization. One important Chinese development in this regard is Tsinghua University's successful **demonstration** of the largest trapped-ion quantum simulator using 300 qubits. Likewise, CAS's innovation from **Jiuzhang 2.0 (2021)** to **Jiuzhang 3.0 (2024)** highlights China's advances in trapped-ion quantum computing.

Neutral Atom Quantum Computing

In October 2025, Hanyuan-1 quantum computer, a 100-qubits neutral-atom quantum computing system, **began** its first commercial deployment based on China's almost twenty years of research and engineering work. It **was developed** by CAS's Innovation Academy for Precision Measurement Science and Technology in Wuhan in collaboration with Wuhan University, Zhongke Kuyuan Technology Co., Wuhan Optics Valley Information Optoelectronic Innovation Center Co., Wuhan Institute of Quantum Technology, and Huazhong University of Science and Technology. A unit was delivered to a subsidiary of China Mobile, with an additional order placed for export to Pakistan. The sales were worth **over 40 million yuan ($5.6 million)**. This represents China's first commercial neutral-atom quantum computer and signals diversification. Optoelectronics innovation networks of research, system integration, application development, mass production, and delivery in Hubei Province, where Wuhan is located, **made** this development and commercialization possible.

A team from Wuhan University and the Wuhan Quantum Technology Research Institute has also developed an atomic quantum computing cloud platform to accelerate application development. As of 2025, more than 50 universities and companies **have accessed** it. This team also developing China's first neutral-atom quantum computing center.

Quantum High-Performance Computing Integration and Quantum Simulation

According to publicly available information, Chinese R&D with respect to the integration of quantum computing and high-performance computing (HPC) appears to be limited. When it comes to quantum simulation on HPC, both the Chinese government and private sector are researching and attempting to commercialize ways to efficiently simulate and develop quantum circuit programs and quantum algorithms on HPC. For example, the National Supercomputing Center in Wuxi, home to the Sunway TaihuLight supercomputer, **is being used** to simulate quantum computational chemistry problems. In the industrial sector, Alibaba Cloud's E-HPC platform **offers** commercial users an interface for deploying quantum-inspired algorithms.

QUANTUM COMMUNICATIONS

China's quantum communications program represents perhaps its most visible and successful quantum technology achievement to date, having successfully launched the world's first quantum satellite, **Micius**, in 2016, and completed a 2,000-plus kilometer (km) fiber-optic network in 2017. In March 2025, an international research team led by USTC and CAS institutes in collaboration with Stellenbosch University **successfully established** the world's longest intercontinental quantum satellite link, connecting Beijing and Stellenbosch, South Africa—over 12,900 km.

China has also demonstrated the ability to deploy **quantum key distribution**, a hardware-based quantum cryptography approach that uses principles of quantum mechanics on a national scale beyond technical achievements. Notably, China developed the world's first integrated quantum communications network, the **Beijing-Shanghai Backbone Network** (BSBN), which combines ground-based fiber-optic cable and ground-to-satellite links over a total distance of **4,600 km**. Through the national quantum communication network project, China Quantum Communication Network (CN-QCN), China has significantly **expanded** its coverage by constructing "145 fiber backbone nodes, 6 ground station backbone nodes, 20 metropolitan networks, and an operations and maintenance (O&M) center, extending across 17 provinces and 80 cities." CN-QCN is linked to BSBN, and together the integrated fiber network extends more than 12,000 kilometers, making it the world's largest quantum network so far.

Lu Guiqing, chairman of China Telecom Quantum Group (CTQG), a major Chinese telecommunications company, **has stated** that CTQG's quantum key distribution services have been introduced hundreds of applications in China, with more than 5.5 million users and 3,000 service providers. This includes applications in fields such as public administration, emergency response, and financial services.

Additionally, China is planning to accelerate its R&D in the field of quantum communications. Professor Jian-Wei Pan **has stated** that China's teams are developing quantum repeaters capable of supporting quantum networks over thousands of kilometers. He **expects** to launch a high-orbit satellite in 2027 for quantum communication. This timeline presents the possibility that China could gain a first-mover advantage in quantum communications by being the first country to **reach** every corner of the globe. China's practical experience and research in the areas of quantum key distribution, quantum network protocols, and system integration also potentially position the country to be a strategic leader in standard setting for the field of quantum communications. China's leadership in the next generation of quantum communication architecture and standard setting could cause significant changes in terms of geopolitical power, economic competitiveness, and information security.

Separetely, China's Institute of Commercial Cryptography Standards **launched** an independent call for post-quantum cryptographic algorithm proposals in 2025, diverging from the U.S. National Institute of Standards and Technology's post-quantum cryptography standardization effort. This development could influence international standards-setting and potentially bifurcate global cybersecurity infrastructure between U.S.-aligned and China-aligned standards.

QUANTUM SENSING

In the field of quantum sensing, China has made strides in developing highly sensitive instruments for applications ranging from navigation to resource exploration. The Chinese government **has issued** 13 national-level policy measures to support quantum precision measurement, leading to at least four major funding or investment deals in this area, with total financing estimated at **$37.5 million**. These moves reflect the growing capital mobilization capacity in China's quantum sensing sector.

Many countries are currently working to develop more advanced core subcomponents for quantum sensing, **including** single-photon detectors, photon-number-resolving (PNR) detectors, and lasers. China is a leading country globally in commercializing such components and developing self-sufficiency.

For example, Photon Technology, a Chinese company, **developed and commercialized** the Qumi-2000 microscope, which provides advanced bioimaging using superconducting nanowire single-photon detectors. This exemplifies one of China's successful market-ready products of quantum sensing. In addition, the Shanghai Institute of Microsystem and Information Technology **has developed** a world-class ultrafast PNR detector, which can distinguish up to 61 photons arriving simultaneously at a speed of 5 GHz. Also, in October 2025, the Quantum Information Engineering Technology Research Center in Anhui Province **announced** a mass production of an ultra-low-noise, ultra-cold-tolerant, four-channel single-photon detector. This device **is** just one-ninth the size of similar single-channel products sold internationally and can perform complex detection tasks with a single unit that previously required multiple detectors.

Some Chinese lasers are priced at **only one-third** of competitors in Germany, the United States, and Switzerland. **Shanghai Precilasers Technology** and **Beijing UniQuanta**, two Chinese companies, are commercializing lasers for high-precision measurement. Lasers from Shanghai Precilasers Technology are reported to be world-leading in some specifications and **are being exported** to other countries.

QUANTUM MATERIALS

China maintains research infrastructure to research and develop quantum materials. In 2010, Peking University **established** the International Center for Quantum Materials (ICQM), which includes 17 experimental laboratories dedicated to advancing research in quantum materials. These include facilities for taking accurate measurements of physical properties and a shared nanofabrication facility, as well as a public supporting laboratory for physical property measurement. As of 2019, scholars at ICQM **had authored** more than 900 scientific research papers, including many papers that have been published in well-respected scientific journals. In the same year, the amount of research funding received by ICQM faculty members from Chinese government agencies **reached** 350 million yuan ($48 million).

Also, in 2017, the Beijing municipal government, in collaboration with Peking University, Tsinghua University, CAS, and other institutions, established **the Beijing Academy of Quantum Information Science** (BAQIS). This institute prioritizes quantum materials as one of its key research areas and has brought together quantum materials researchers from leading universities and research institutions in China. In 2024, BAQIS **received** a significant donation of a quantum computing lab and equipment from Baidu Quantum, the quantum division of the major Chinese technology company Baidu. In 2025, scientists at BAQIS **achieved** a new world record by storing light information for 4,035 seconds, which enhances the potential of quantum memory technologies for the development of quantum computers and quantum communication networks.

QUANTUM AI

Scientists at the Quantum Computing Engineering Research Center in Anhui Province have successfully **fine-tuned** an large-scale AI model with over one billion parameters on Origin Wukong, a domestically developed third-generation superconducting quantum computer. Its architecture **enables** the generation of hundreds of parallel quantum tasks from a single set of data input.

Experimental results of a new fine-tuning method using quantum computing **have successfully** reduced the computational resources required for data fine-tuning by 76 percent while reducing learning errors by 15 percent, compared to **low-rank adaptation**, one of the widely used classical data fine-tuning methods. This research also resulted in an 8.4 percent improvement in accuracy on a specific complex psychological counseling dataset. While these research results will require further validation by third parties and need to be evaluated on more diverse tasks and larger datasets, in general-purpose environments, they represent a significant step towards demonstrating practical use cases of quantum-enhanced AI applications.

Conclusion

QIST is a fundamental driver that will help reshape the future structure of global power. Quantum technologies will enable countries to protect confidential information, solve complex economic problems, and maximize the potential of advanced AI. Whichever country or countries gain early advantages in the field of QIST will likely be significant determinants for the future global order.

Recognizing these stakes, China is carrying out a deliberate strategy to build a comprehensive quantum innovation powerhouse, leveraging its historic investments in basic science and expanding quantum research networks with strong results across fields. China is expanding sustainable competitive advantages by strengthening its indigenous supply chains, manufacturing capabilities, operational experience, and industrial efforts. China is not resting on its laurels, and the United States, mindful of the competitive and national security impacts of China's long-term vision, would be wise to implement its own quantum strategy to sustain its leadership over the long term. ■

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The CSIS Renewing American Innovation program is undertaking a review of the U.S. Quantum Opportunity, as requested by the National Institute of Standards and Technology and in cooperation with the Quantum Economic Development Consortium.

***Hideki Tomoshige** is a fellow with Renewing American Innovation at the Center for Strategic and International Studies (CSIS) in Washington, D.C. **Phillip Singerman** is a senior adviser (non-resident) with Renewing American Innovation at CSIS.*

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