Tentative Translation

Vision of Quantum Future Society

Future Society to be Realized through Quantum Technology and Strategies for Its Realization

Outline

April, 2022

Secretariat of Science, Technology and Innovation Policy, Cabinet Office

1. Vision of Quantum Future Society

Introduction

- ✓**Quantum technology (QT) has been rapidly advancing and its influence on society has been increasing.**
- ✓QT is becoming extremely **important for economic security**.
- ✓In order to realize the transformation of society as a whole to **create growth opportunities** for Japanese industry, and to **solve social issues** such as carbon neutrality, **vision of future society through QT and strategies to realize this vision** were discussed.

Quantum Technology and Innovation Strategy (January 2020)
(R&D of QT)

→ **Vision of Quantum Future Society (April 2022)**
(Social application of QT)

→ **Socioeconomic Transformation**

Background

- ✓Global Competition in the Quantum Industry
- ✓Progress in Basic Technologies for Quantum Computer
- ✓Rapid Development of DX under the COVID-19 Outbreak
- ✓Value on Carbon-Neutral Society
- ✓Growing Importance of QT for Economic Security

Global Competition

Google Quantum Computer

Google (U.S.) (Released in May 2021)
1,000 logical quantum bits in 2029

IonQ (U.S.) (Released in December 2020)
1,024 logical quantum bits in 2028

Japan (Moonshot) (Released in January 2020)
Tens to 100 logical quantum bits in 2030
(To be accelerated)

2. Three Basic Concepts

Basic Concept 1

Create opportunities for industry to grow and solve social challenges by incorporating QT into the overall socioeconomic system and integrating it with conventional (classical) technology systems (hybrids)

Quantum Technology

■ Quantum technologies

- Quantum computer, software, cryptography, communication, metrology and sensing

■ Fundamental Efforts

- Startups, quantum base reinforcement, human resource development, securing, IP and standardization, outreach, etc.

Collaboration / Integration

Utilizing QT

Socioeconomic System

■ Socioeconomic Activities in Various Fields

- Finance, energy environment, materials, health care, transportation, aviation, consumers, etc.

■ Conventional (classical) Technology System

- Conventional computing such as AI, information and communications such as Beyond 5G, measurement and sensing, semiconductors, etc.

Basic Concept 3

Creation and revitalization of industries and startups using QT

Dramatic Improvement of Performance

Transforming Society

Basic Concept 2

Promotion of the use of QT by development of testbeds, etc.

Future Society in Harmony with the Economy, Environment, and Society

3.1. Vision of Future Society (Future Society Image)

[Assumed Scenarios]

- Further development of DX, Society 5.0
- Social implementation of Beyond 5G
- Decline in the population of productive age in Japan and global population growth
- 46% reduction in greenhouse gas emissions
- Increasing importance of economic security

Dramatic Improvement in Computing, Sensing, and Communication Performance

[Future Society Image]

Economic Growth - Innovation -

Next-generation high-speed computing

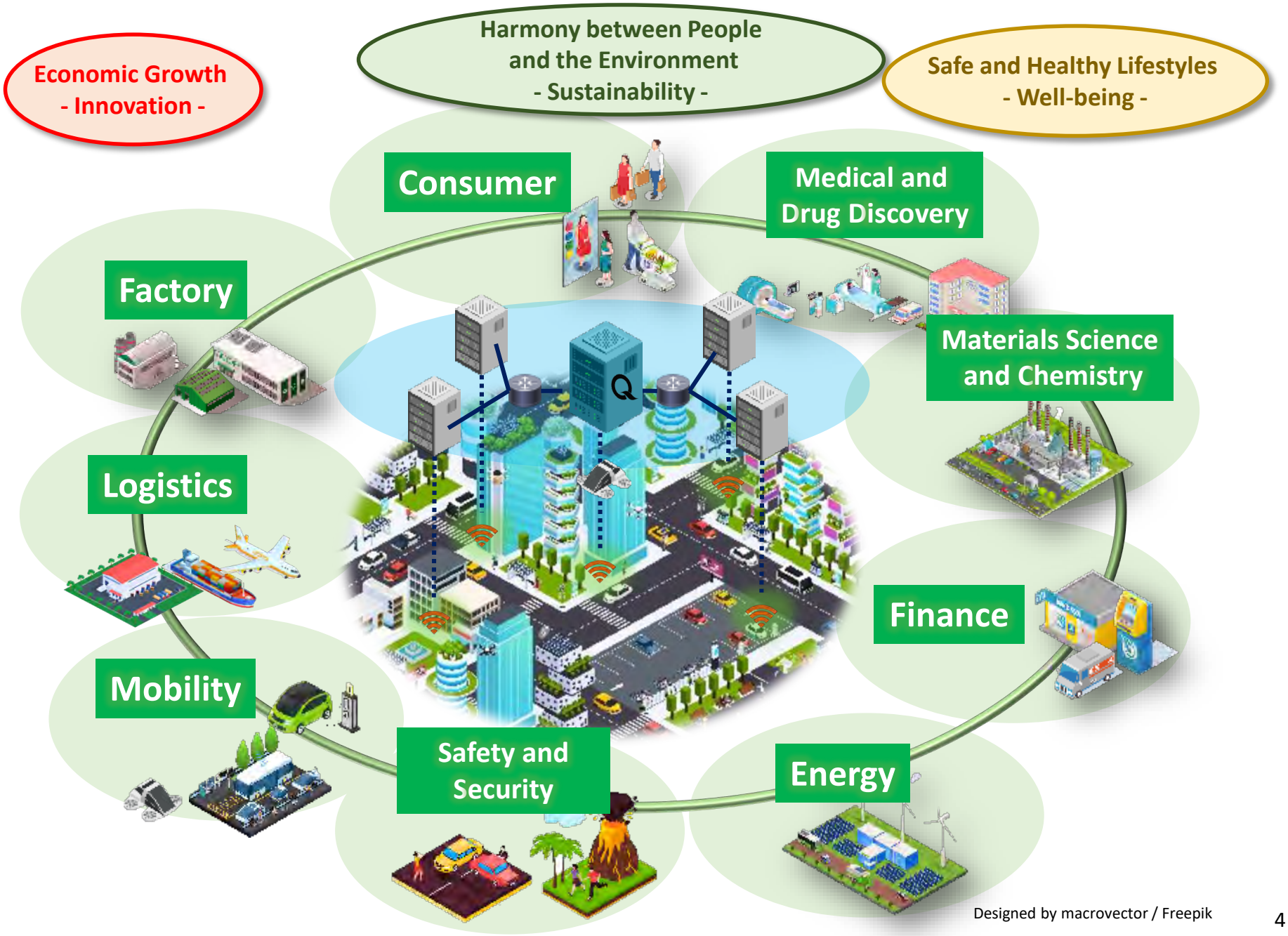
Harmony between People and the Environment - Sustainability -

Carbon neutral and sustainable economy through QT

Safe and healthy Lifestyles - Well-being -

Healthy long-lived and resilient societies powered by QT

3.2. Values created by Quantum Technology in the Future Society



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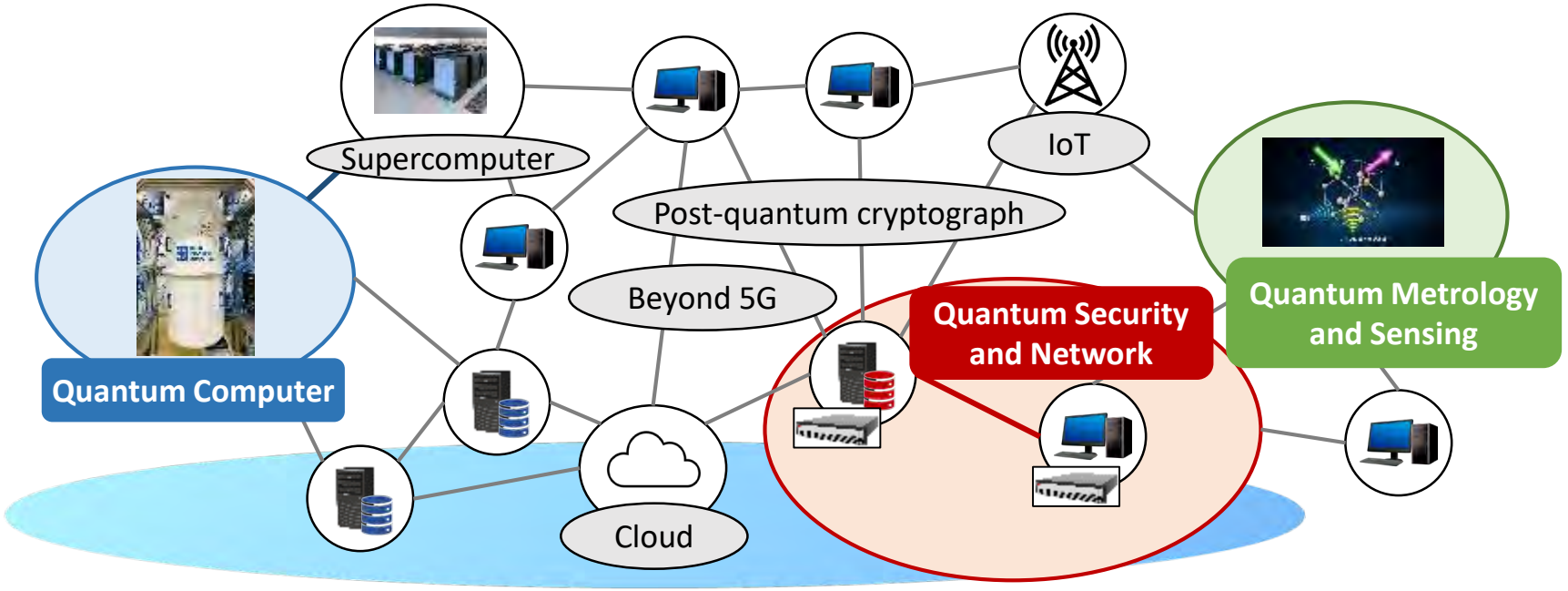
3.3. Hybridization of Quantum and Classical Technologies



Computing

Conventional Technologies

Supercomputer
HPC, AI, Big Data, etc.

Quantum Technology

Quantum computer

Innovative computational services

Communication and Security

Conventional Technologies

Information security
Post-quantum cryptograph
Beyond 5G, Cloud, etc.

Quantum Technology

Quantum security
Quantum network

Secure and advanced telecommunications

Measurement and Sensing

Conventional Technologies

Various sensors
Medical diagnostic equipment (NMR, MRI, etc.), IoT, etc.

Quantum Technology

Quantum metrology and sensing

Ultra-high-precision sensing

3.4. Goals by 2030 for Vision of Future Society

10 million quantum technology users in Japan

Through quantum technology, production to 50 trillion Yen

Fostering quantum unicorn companies to create future markets

4.1. Measures in Each Technical Field

1. Quantum Computers

Gear-up R&D of domestic quantum computer and support for industrialization

- ✓ **Realization of hybrid computing systems** and **services**
- ✓ **Supporting industrialization of quantum computers** through standardization and the establishment of a new center at AIST
- ✓ **Strategic R&D** on **breakthrough technologies** for large-scale quantum computers

Domestic quantum computer (under development at RIKEN)

2. Quantum Software

Promote the use of quantum computer and reinforce software R&D

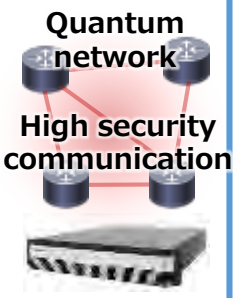
- ✓ **Testbeds** and other infrastructures for the use of quantum computers
- ✓ **Cross-sectoral and interdisciplinary partnership** between industry and academia
- ✓ **National projects on quantum software**

Quantum software market (2040/worldwide) 40 to 75 trillion yen

3. Quantum Security Networks

Expand quantum cryptography communications, realize comprehensive security, and promote quantum Internet research

- ✓ **Comprehensive security through intergradation between quantum and conventional (classical) technologies**
- ✓ **Technology assessment and certification**
- ✓ **National projects on quantum internet**

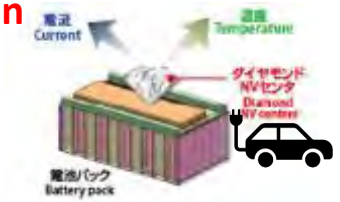


Quantum Cryptography Communication Systems (Toshiba)

4. Quantum Metrology and Sensing, Quantum Materials, etc.

Applications of quantum metrology and sensing and support for industrialization

- ✓ **Expansion of use cases**
- ✓ **Environmental arrangement of development of testbeds, etc.**
- ✓ **Assistance for industries for their discoveries of users or suppliers and industrialization**
- ✓ **R&D and supply structure for world-leading quantum materials**



EV current and temperature are measured more than 100 times more accurately with quantum sensors

Improves driving distance of EV by 10% or more (energy saving)

4.2. Fundamental Measures to Create Innovation (1)

1. Startup Creation and Revitalization

Creating and revitalizing new industries/startups using QT

- ✓ **Development and support of new businesses**, and **development** of a comprehensive **startup environment** including the use of government-affiliated funds, and idea contests and pitch contests
- ✓ **Support of quantum computer use and application R&D for startups**
- ✓ **Improvement of procurement** of products and services by SMEs, including startups

Examples of ventures in Japan

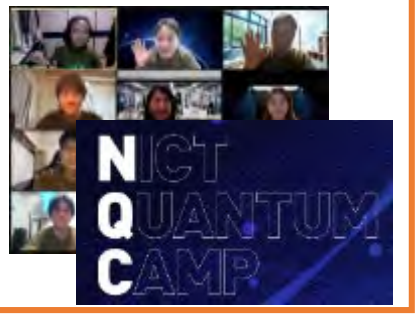
2. Strengthening Quantum Technology and Innovation Hubs

- ✓ **Establishing new centers and enhancement of functions**
  - **"Global Industrial Support Center (tentative)" (AIST)** for **comprehensive support to industry**
  - **"Quantum Function Creation Center (tentative)" (QST)** for **R&D and supply of world-leading quantum materials**
  - **"Quantum Solution Center (tentative)" (Tohoku University)**, for **valuable R&D support** to industry
  - **"International Center for Education and Research Center (tentative)" (OIST)** for most advanced **international R&D and education**
- ✓ **Strengthening headquarter functions** in RIKEN

3. Developing and Securing Human Resources

Developing human resources through public-private partnerships

- ✓ **Providing education programs to a wider range of people**, including the industrial sector, through the use of private-sector businesses **(recurrent education, etc.)**
- ✓ **Human resource development** that integrates materials, finance, AI and **other fields** (e.g., "●●● × quantum" hybrid human resources with quantum as the second language)
- ✓ **Fostering researchers** and **"Quantum Natives" using science museums and video content**

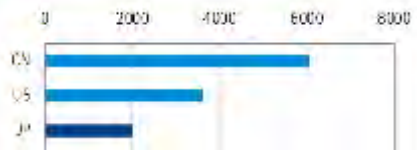


4.3. Fundamental Measures to Create Innovation (2)

4. Intellectual Property and Standardization of QT

Promoting QT intellectual property and standardization through open and close strategies

- ✓ **Formation** of a private-sector-led **patent pool** based on an open-closed strategy and establishment of a private-sector management organization
- ✓ Establishment of a system and mechanism to lead **international rule-making** and the **standardization of intellectual property** in QT
- ✓ **Sophistication and standardization of practical application technologies** through usage demonstrations of quantum cryptography communications, **the world's first intellectual property and standardization**, and **the establishment and standardization of practical technologies, including peripheral technologies**



Top three QT-related patents

5. International Collaboration/Industry-Academia-Government Collaboration

International joint research/support for overseas expansion/establishment of a system of cooperation between industry and quantum bases

- ✓ Strengthening **strategic international joint research, dispatching mainly young researchers, and attracting outstanding researchers from overseas** to **improve international exchange and mobility**
- ✓ Revitalization of **international exchange and cooperation** among industry and **support for overseas expansion** of industry
- ✓ **Establishment of a system of collaboration and cooperation among industrial associations, Quantum Technology Innovation Hubs, and related ministries**

QIH Quantum Innovation Hubs

Q-STAR

6. Promoting Outreach Activities

Exhibitions at science museums, transmission of SNS, video and other content

- ✓ **Enhancement and strengthening of public relations activities** through exhibitions at science museums, SNS, video etc.
- ✓ Strengthening the provision of information, that **provides information** on **quantum** in **an integrated manner**
- ✓ **Human resources connecting quantum and society (Evangelists and Ambassadors, etc.)** and **front-runner** personnel such as entrepreneurs and researchers.

7. Economic Security/Business Environment, etc.

Economic security, improvement of conditions for business, etc.

- ✓ Securing and strengthening economic security (acquisition of advanced critical technologies, **securing supply chains** of important **core components and materials**, and **protection of technologies** from **cyber attacks, etc.**)
- ✓ **Providing risk money** through the use of government-affiliated funds and **promotion of demand** through early adapters (**government procurement**)
- ✓ **Operational improvement of government projects**, such as **the use of a fund system** that enables long-term investment

5. Quantum Technology Innovation Hubs

Functional enhancement

https://qih.riken.jp/en/

Newly added

【Global Industrial Support Center (tentative)】
AIST
National Institute of Advanced Industrial Science and Technology

Providing comprehensive support to industry

【Quantum software】
QSRH 量子ソフトウェア研究拠点
Osaka Univ.

【Quantum sensing】
Tokyo Tech.

R&D and supply of world-leading quantum materials

【Quantum computer applications】
QII
U Tokyo & Business alliance

【Quantum computer】
RIKEN
HQ (Core location)
RIKEN

Strengthening the functions of HQ

【Quantum life science・Quantum Function Creation Center (tentative)】
QST
National Institutes for Quantum Science and Technology

【Quantum security】
NICT
National Institute of Information and Communications Technology

【Quantum material】
NIMS
National Institute for Materials Science

International R&D and education

【International Center for Education and Research Center (tentative)】
OIST
Okinawa Institute of Science and Technology Graduate University

【Quantum Solution Center (tentative)】
TOHOKU UNIVERSITY
Tohoku University

Valuable solutions R&D support to industry