Section 7 ICT Technology Policy Trends

1. Summary

(1) Initiatives so far

MIC is promoting technology policy in the information and communications field, focusing on initiatives aimed at Beyond 5G (6G), which is expected to serve as the foundation for all industries and social activities as the next generation of basic information and communications infrastructure to be utilized across national borders.

Specifically, MIC formulated the "Beyond 5G Promotion Strategy" in June 2020, and has been conducting research and development to establish the elemental technologies necessary for the realization of Beyond 5G (6 G). Recognizing the importance of strengthening international competitiveness and ensuring economic security for Beyond 5G (6G), the Information and Communications Council has since then been deliberating while sharing the efforts and knowledge of relevant organizations and key stakeholders in Japan, and has been making progress in such initiatives as compiling an interim report on the "Information and Communications Technology Strategy for Beyond 5G" in June 2022.

In the "Sixth Science, Technology and Innovation Basic Plan" approved by the Cabinet in March 2021, relevant ministries and agencies are cooperating to promote research and development in advanced fields such as quantum, AI, and space, with the aim of realizing a sustainable and resilient society that ensures the safety and security of citizens.

The National Institute of Information and Communications Technology (NICT) is also promoting basic and fundamental research and development in five priority fields (advanced electromagnetic technology, innovative networks, cybersecurity, universal communication, and frontier science) during the period covering the fifth medium-to-long term plan period (April 2021 to March 2026).

(2) Future challenges and directions

With regard to Beyond 5G (6G), Japan's ICT industry has not always been able to achieve significant business and business results even though it has established internationally excellent technologies. In addition, from the perspective of ensuring Japan's economic security, demonstrating competitiveness in global markets is an issue that must be addressed. Therefore, efforts must be made to ensure R&D results are utilized globally from a global perspective (so-called "global first").

As for R&D in cutting-edge fields such as quantum, AI, and space, early social implementation in society is facing various issues such as establishing ultra-reliable quantum communication technology, realizing simultaneous interpretation in anticipation of the Expo 2025 held in Osaka, and developing advanced space network technology.

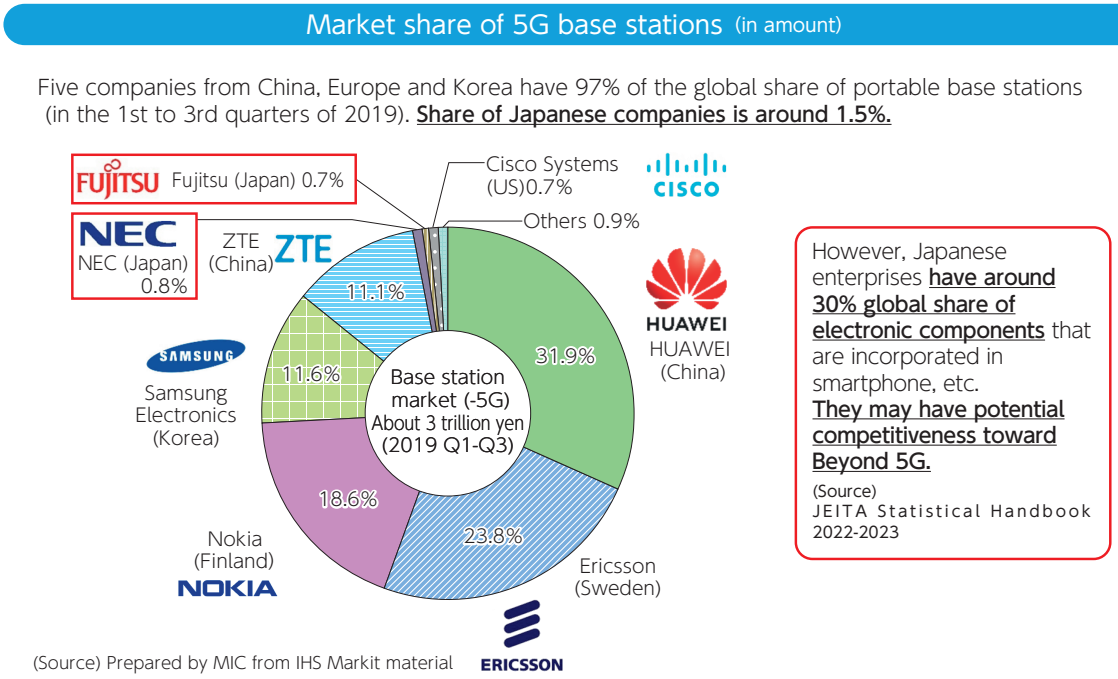
2. Beyond 5G(6G)

(1) Domestic and international trends surrounding Beyond 5G (6G)

Major overseas companies now account for a high proportion of the international market share of 5G base stations, and the international competitiveness of Japanese companies is relatively low.

On the other hand, Japanese companies account for about 30% of the global market share and have competitive potential in the market for electronic components that are also integrated into base stations and smartphones (**Figure 5-7-2-1**).

Figure 5-7-2-1 International competitiveness in the communications infrastructure market



Large-scale government research and development investments and research and development plans have been announced in countries outside of Japan, and global development competition is intensifying in order to secure technological superiority in Beyond 5G (6G).

For example, in the U.S., the "CHIPS and Science Act of 2022," enacted in August 2022, stipulates that a budget of 20 billion dollars (approximately three trillion yen) will be allocated over the next five years for the development of advanced technologies including Beyond 5G (6G), AI, and quantum computers. In Europe, the EU plans to spend 900 million euros (approximately 120 billion yen) over seven years from 2021 to 2027 for research and development projects related to Beyond 5G (6G). Countries are making progress in various initiatives, and are expected to actively promote research and development of Beyond 5G (6G) in the future (**Figure 5-7-2-2**).

Figure 5-7-2-2 Beyond 5G (6G) R&D by the governments of other countries

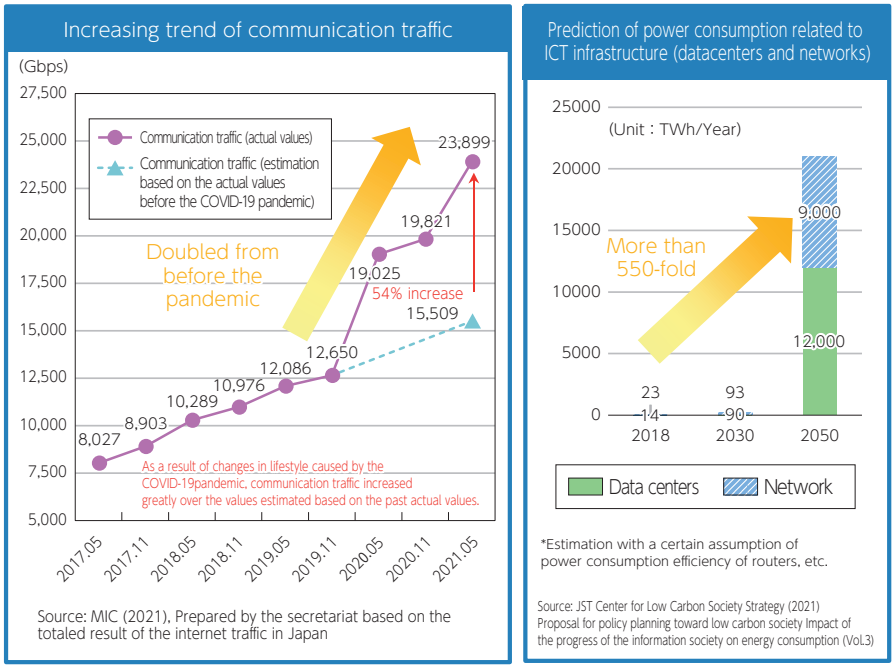
The United States	●The "CHIPS and Science Act of 2022," which provides $52.7 billion (about 7 trillion yen) in support for the production and research and development of semiconductors and **$20 billion (about 3 trillion yen) in support for the development of AI, quantum computers, and advanced technologies such as next-generation communication standards (6G)**, was enacted (August 2022)
Europe	**EU, Germany and Finland governments invest 1.85 billion Euro (about 240 billion yen) in total in 6G R&D** (as of March 2022)
EU	●EU decided 900 million Euro investment in 6G R&D in the next R&D program Horizon Europe (2021-2027) (March 2021) ●SNS JU secured 2 billion euros (about 260 billion yen) in total from the public and private sectors, including the above 900 million euros (March 2022)
Germany	●Decided to invest 700 million Euro in total in 6G technology R&D (2021 to 2025) (April 2021).
Finland	●Started 6Genesis Flagship Program and budgeted 250 million Euro (about 33 billion yen) in eight years from 2019 to 2026 (May 2018)
Russia	●The Skolkovo Foundation announced a project to develop Russian 6G communications devices at the Skolkovo Institute of Science and Technology (Skoltech) and the Radio Research and Development Institute (NIIR), with an investment of **30 billion rubles (approximately 64.4 billion yen) from 2023 to 2025** (July 2022)
China	●Released **a digital economy plan to enhance 6G R&D as part of the 14 th five-year plan** (January 2022)
Korea	●Ministry of Science and ICT (MSIT) **announced a 6G R&D action plan**, including **220 billion won (about 21 billion yen) investment by 2025** (June 2021).

* The exchange rate at the time of publication was used for yen conversion.

Communications traffic in Japan is on the rise due to the progress of DX and other factors. There are concerns that the power consumption of information and communications networks will increase significantly unless technological innovations are made (**Figure 5-7-2-3**).

With this in mind, Japan has declared its international commitment to achieve carbon neutrality by 2050 as the need for initiatives to reduce power consumption in the information and communications field increases. For example, the government as a whole has set a policy of realizing a green and digital society and achieving carbon neutrality in the ICT industry by 2040. Therefore, in developing technologies and constructing networks for the next generation of information and communications infrastructures, it is inevitable to take drastic measures for greening, a global issue.

Figure 5-7-2-3 Trends of communications traffic and energy consumption in the ICT field



(2) Policy trends across government

The Kishida Cabinet has stated that it will accelerate bold investments in ICT and other digital fields by positioning the realization of "new capitalism" and the "Digital Garden City Nation Concept" as policy pillars.

Specifically, studies and implementation have been carried out in cooperation with relevant ministries and agencies at policy meetings such as the "Council for the Realization of New Capitalism" and the "Council for the Realization of the Digital Garden City Nation Concept," while the "Grand Design and Implementation Plan for New Capitalism 2023 Revised Edition" (approved by the Cabinet in June 2023) and the "Comprehensive Strategy for the Digital Garden City Nation Concept" (approved by the Cabinet in December 2022) have also been formulated. It has been suggested that these will aggressively promote technology strategy and research and development for Beyond 5G (6G).

As a means of promoting the "Digital Garden City Nation Concept," MIC announced in March 2022 the "Digital Garden City Nation Infrastructure Development Plan," which calls for the development of infrastructure such as optical fiber, 5G, data centers, and undersea cables, as well as accelerated efforts in research and development in order to begin operating next-generation Beyond 5G (6G) infrastructures as soon as possible. The revised "Digital Garden City Nation Infrastructure Development Plan (Revised Edition)" was released in April 2023, and the research and development of Beyond 5G (6G) aimed at social and overseas implementation will be aggressively promoted through efforts such as the Beyond 5G (6G) R&D Promotion Project.

The government's overall science, technology, and innovation policy also states that it will promote initiatives such as the fusion of cyberspace and physical space; the maintenance and development of next-generation infrastructures and technologies for Beyond 5G (6G), space systems, quantum technologies, and semiconductors; and research and development toward achieving carbon neutrality as a national strategy.

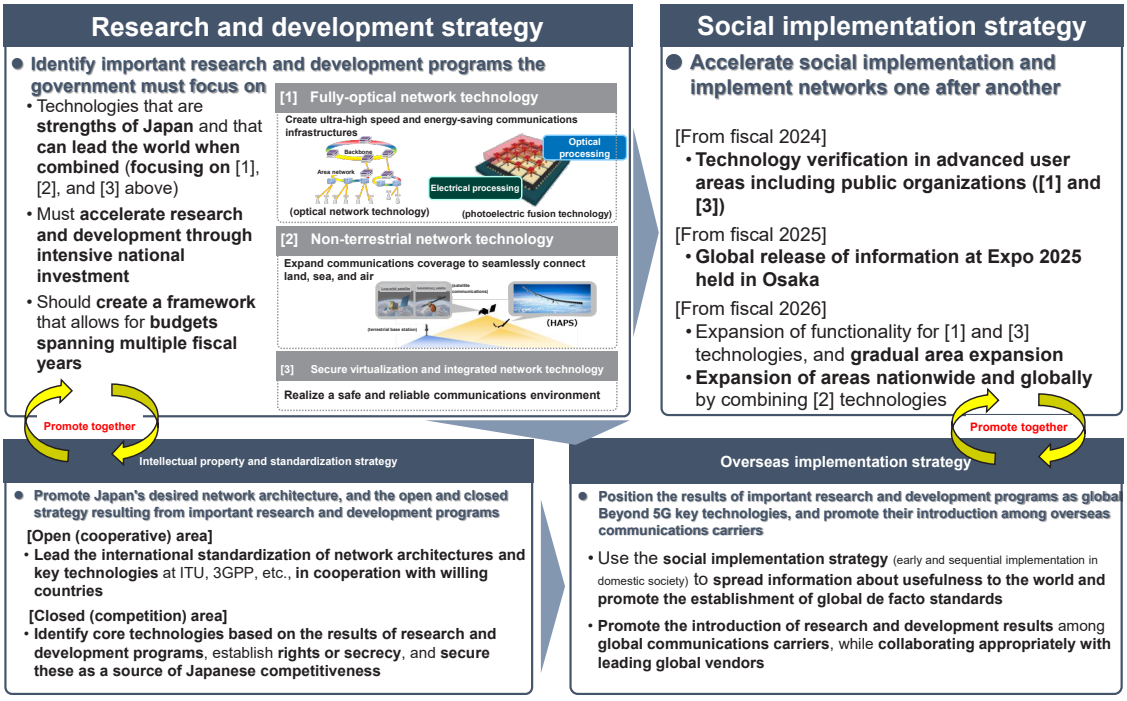
(3) Review and formulation of new information and communications technology strategies

Since the formulation of the "Beyond 5G Promotion Strategy" in June 2020, international development competition has intensified, and social issues such as strengthening international competitiveness, ensuring economic security, and the environment and energy fields have become apparent. For Beyond 5G (6G), there is a growing need for industry, academia, and government to work together in a strategic manner by implementing strategies for research and development, IP, and international standardization that Japan should pursue.

For this reason, MIC consulted with the Information and Communications Council on September 30, 2021 on the "Information and Communications Technology Strategy for Beyond 5G." The Technology Strategy Committee of the Information and Communications Technology Subcommittee deliberated on R&D, intellectual property, standardization, and other technology strategies while sharing information on the activities of industry, academia, and government (such as the "Beyond 5G Promotion Consortium") and the efforts and knowledge of various stakeholders (including major companies, universities, and national research and development agencies). An interim report was compiled on June 30, 2022.

The report significantly updates the research and development strategy for the "Beyond 5G Promotion Strategy." The strategy calls for Japan to take the lead in advanced technology development in order to become a game changer in the global communications infrastructure market, and to make strategic efforts to survive. It is necessary to consider our strengths, technological difficulties, autonomy assurance, national strategic positioning, and the need for acceleration based on prior investment, and must identify priority technology areas for Beyond 5G (6G) to focus on. Beginning in 2025, it is necessary to set a research and development strategy to work together to establish a framework that allows us to accelerate research and development and set budgets spanning multiple fiscal years, a social implementation strategy to take the results of important research and development projects and implement them into domestic networks and invest in the market, an intellectual property and standardization strategy focused on an open and closed strategy, and an overseas implementation strategy to set global de facto standards as quickly as possible **(Figure 5-7-2-4)**.

Figure 5-7-2-4 Strategy to accelerate research and development and social implementation of Beyond 5G (6G)



(4) Establishment of new funds to strengthen Beyond 5G (6G) research and development

In order to establish the elemental technologies necessary for the realization of Beyond 5G (6G), MIC has been providing research and development support to companies, universities, and other organizations through a time-limited Research and Development Fund (third supplementary budget of fiscal 2020) established at NICT based on the "Act Partially Amending the Act on the National Institute of Information and Communications Technology" in February 2021, and has been working to develop common facilities and equipment such as test beds.

Taking into account the further intensification of international development competition for Beyond 5G (6G), the progress of Beyond 5G research and development promotion projects, and the interim report of the Information and Communications Council in June 2022, the "Act Partially Amending the Act on the National Institute of Information and Communications Technology and Radio Act" (Act No. 93 of 2022) was enacted during the extraordinary Diet session in the fall of 2022 and came into effect on December 19 of the same year, enabling NICT to establish a permanent fund (the ICT Research and Development Fund) and to allocate radio wave usage fee resources to the fund **(Figure 5-7-2-5)**.

Figure 5-7-2-5 Act Partially Amending the Act on the National Institute of Information and Communications Technology and Radio Act

Act Partially Amending the Act on the National Institute of Information and Communications Technology and Radio Act (Act No. 93 of 2022)

[Related to supplementary budget, enacted on December 2, 2022]

- In order to promote the creation of innovative information and communications technologies that will serve as the foundation for Japan's economic and social development in the future, NICT will establish a research and development fund.

*NICT: National Institute of Information and Communications Technology

1. Summary of revisions

(1) Revision to the Act on the National Institute of Information and Communications Technology

Stipulates that NICT establish a fund (ICT Research and Development Fund) to be allocated to cover costs required for research and development through public recruitment for the creation of innovative information and communications technologies.

* Major revisions: Establishment of fund, separate accounting of fund operations, report to the Diet each fiscal year, abolition of the current time-limited fund

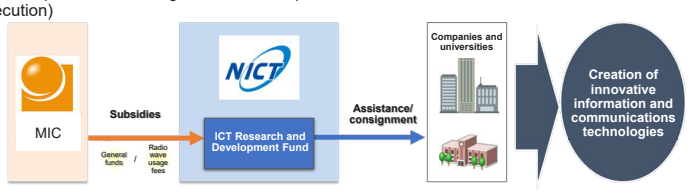
(2) Revision to the Radio Act

Clarifies that subsidies for research and development that contribute to the effective use of radio waves financed by radio wave usage fees may be allocated to the fund, and stipulates that the remaining amount of the fund and other usage of the fund be studied and publicized each fiscal year.

2. Effective date

The date specified by Cabinet Order (December 19, 2022) within a period not exceeding one month from the date of official announcement (December 9, 2022).
Provided, however, that the revision pertaining to the abolition of the current time-limited fund shall be made on the date specified by Cabinet Order within a period not exceeding six months from April 1, 2024.

(Execution)



(5) Implementation of the Beyond 5G R&D Promotion Project

Through the Innovative Information and Communications Technology (Beyond 5G (6G)) Fund project to be newly implemented by the above mentioned fund, R&D with the aim of social implementation and overseas expansion will be strongly promoted mainly in the following key technology fields based on the above mentioned interim report of the Information and Communications Council, and the development results will be gradually implemented in society from 2025 onward.

(1) Fully-optical network technology to bring ultra-high speed, ultra-low delay, and ultra-low power consumption to communications infrastructures
(2) Non-terrestrial network (NTN) technologies such as satellites and HAPS to expand communications coverage in a way that seamlessly connects land, sea, and air
(3) Secure virtualization and integrated network technology to ensure secure and reliable communications environments for users

In implementing the above funding project, MIC will focus on strategic research and development projects with a strong focus on social implementation and overseas implementation by making drastic development investments (including self-investment by companies), while keeping in mind the goal of technologies being utilized throughout the world ("global first") instead of the conventional idea of research and development itself being the main purpose or activities being centered on the domestic market.

In order to promote this funding project in an effective manner, the "Innovative ICT Project Working Group" composed mainly of outside experts specializing in management and business was newly established under the Information and Communications Council (Information and Communications Technology Subcommittee, Technology Strategy Committee) to examine how to appropriately evaluate and monitor research and development projects from a business perspective, and compiled "Recommendations on Conducting Appropriate Business Evaluations for the Beyond 5G R&D Promotion Project" on March 10, 2023.

MIC plans to establish related technologies over the next five years while monitoring progress appropriately, based on this report. MIC will also strive to improve the environment supporting Japanese companies competing in the global market by promoting international standardization and creating international consensus and rules, in order to more easily implement research and development results overseas.

(6) Promotion of the acquisition of IP and international standardization for Beyond 5G (6G)

The "Beyond 5G New Business Strategy Center" was established in December 2020 to strategically promote international standardization and the acquisition of intellectual property by industry, academia, and government. The center promotes the dissemination of information through conducting seminars on new business strategies and the development of human resources through workshops for young management candidates within companies. Efforts are also being made to establish an information infrastructure for future standardization, such as building an IP landscape to analyze the status of IP acquisition. MIC will engage in further analysis to promote IP and international standardization of Beyond 5G (6G) by utilizing the IP landscape announced in the interim report (June 30, 2022).

In order to promote international standardization ac-

tivities from the early stages of research and development, international joint research is now being conducted with national and regional research institutions that are strategic partners that can be expected to provide synergy. Specifically, MIC began offering research and development funding for joint research with U.S. research institutes in fiscal 2016, and with German research institutes in fiscal 2019. In fiscal 2023, a total of three international joint research projects are now under way to develop and demonstrate technologies that will lead to the creation of use cases for more advanced use of 5G. Joint research projects on wireless link technology and 3D spatial data compression technology are being conducted between Japan and the U.S., while a joint research project on wireless communication technology in the manufacturing field is being conducted between Japan and Germany.

Furthermore, the "Beyond 5G Promotion Consortium" (established in December 2020 to aggressively and actively promote Beyond 5G [6G] in cooperation with industry, academia, and government) produced the "Beyond 5G White Paper" in March 2022, summarizing usage methods and performance targets for Beyond 5G, and then conducted additional interviews with various industries in March 2023 and published an updated 2.0 edition. Based on the results of the study on future technological trends and prospects of IMT summarized in the white paper, MIC has been promoting international standardization activities since the 38th meeting of ITU-R SG5 WP5D, such as continuing to submit contributing documents. The "Open RAN Promotion Subcommittee" was also established in March 2022 to discuss various issues related to Open RAN, with the goal of spreading and promoting Open RAN in Japan and helping domestic companies to expand overseas. The "Beyond 5G International Conference" was also held in October 2022 to strengthen cooperation between domestic and international stakeholders, and a memorandum of cooperation was signed[1] with three new organizations in fiscal 2022.

3. Quantum technology

(1) Quantum security network policy trends

Quantum technology is an innovative technology that will dramatically and discontinuously develop future societies and economies. It is also crucially important for economic security. Other countries, especially the U.S., European countries, and China are significantly increasing research and development investments in this technology and making strategic efforts including development of research and development sites and human resources.

Based on the "Quantum Technology Innovation Strategy" (decided by the Integrated Innovation Strategy Promotion Council in January 2020), the "Vision for the Quantum Future Society (a future society vision to realize through quantum technology, and strategies to realize this)" (decided by the Integrated Innovation Strategy Promotion Council in April 2022), and the "Quantum Future Industry Creation Strategy" (decided by the Integrated Innovation Strategy Promotion Council in April 2023), the government as a whole will support activities to strengthen research and development and commercialization in each technology area (such as quantum computers, quantum software, quantum security/networks, quantum measurement/sensing, and quantum materials), and will promote fundamental initiatives to create innovation (such as the formation of bases where industry, academia, and government work in unison from basic research to technology demonstration and human resource development).

(2) Research and development on quantum cryptographic communications technologies

There are concerns that modern encryption methods will be rendered useless in the age of quantum computers. Therefore, it is necessary to establish quantum cryptography that generally cannot be deciphered by any computer. MIC in collaboration with NICT is promoting research and development on quantum cryptographic communications technologies (quantum key distribution technologies), while at the same time establishing a "Quantum Security Hub" for the quantum security and network technology area at NICT based on the Quantum Technology Innovation Strategy in fiscal 2021 and tackling a broad range of activities including social implementation through construction and use of test beds and human resource development.

a Research and development on distance extension and networking of quantum cryptographic communications

One major issue with realizing the social implementation of quantum cryptographic communications is extending communications distances. With the aim of tackling the challenge of extending distances and developing global quantum cryptographic communications network, MIC has been engaged in research and development projects on linking and relaying terrestrial quantum encryption communications over long distances, since fiscal 2020. Since fiscal 2018, MIC has been engaged in research and development on using quantum cryptographic communications in microsatellites, with the aim of building secure satellite communications networks. Furthermore, in fiscal 2021, research and development for the construction of a global-scale quantum cryptographic communications network integrating terrestrial and satellite-based networks began.

[1] Signed with the 6G Smart Networks and Services Industry Association (Europe) and Next G Alliance (U.S.) in May 2022, and Northeastern University (U.S.) in November of the same year.

b Development of test beds for quantum cryptographic communications and promotion of social implementation

In Japan, NICT has been engaged in research and development of elemental technologies for quantum cryptographic communications since early on. In order to verify the principles of quantum cryptographic communications, NICT constructed a quantum cryptographic communications test bed called "Tokyo QKD Network" in 2010 and has been operating it since then. The basic specifications of quantum encryption communications devices developed based on the long-term operation of Tokyo QKD Network were adopted as international standards (ITU-T Y.3800 series) in 2020, which shows its high international competitiveness.

Because quantum cryptographic communications are expected to be used in financial, medical, and other commercial services in addition to use in public organizations handling confidential information, there are strong demands for its early practical application. With the aim of accelerating social implementation through verification of use in actual environments, MIC began working to develop broad-area test beds for quantum cryptographic communications in fiscal 2021, which are capable of demonstrating network architectures including routing control with architecture connecting multiple sites.

c Research and development for realizing the quantum Internet

The quantum Internet is the ultimate form of a quantum network that allows for communications in a quantum state. It is expected to become the communications technology that underlies the utilization of various quantum technologies such as secure communications, increases in computing power and distributed quantum computer enabled through increasing the number of qubits by connecting multiple quantum computers, and network connections of quantum sensors. In fiscal 2023, MIC began research and development efforts on elemental technologies to maintain the quantum state and realize stable long-distance quantum communications, in order to realize the quantum Internet.

Figure (related data) Global quantum cryptographic communications network
URL: https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2023/data_collection.html#f00387
(Data collection)

4. AI technologies

Beginning with the advent of deep learning in 2006, the third AI boom has led to dramatic technological innovations in areas such as image recognition and natural language processing. In 2022, generative AI, which can automatically generate images and sentences based on learning data,[2] began to be put to actual use and is now showing signs of revolutionizing a wide range of industries.

Based on "AI Strategy 2022" (decided by the Integrated Innovation Strategy Promotion Council in April 2022), MIC is now working extensively on research and development projects and the social implementation of natural language processing technology, multilingual translation and speech processing technology, distributed federated machine learning technology, and brain cognitive model construction in cooperation with NICT, a core AI-related center.

For example, MIC is working with NICT on the research and development of multilingual translation technology to eliminate language barriers and realize the free exchange of information on a global basis. By utilizing NICT's multilingual translation technology incorporating the latest AI technology, practical level translation accuracy has been achieved in 17 languages for use in dealing with foreign visitors, foreign residents, and diplomatic situations. MIC and NICT are also promoting social implementation of multilingual translation technology. NICT provides "VoiceTra" as a research application targeting independent travelers. More than 30 private-sector services have been developed[3] through technology transfers and are now being used in a variety of fields including disaster management, transportation, and medical care in addition to government offices.

Figure (related data) Multilingual translation technology
URL: https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2023/data_collection.html#f00388
(Data collection)

In order to prepare for Expo 2025 held in Osaka, MIC formulated the "Global Communication Plan 2025" in March 2020 to further advance NICT's multilingual translation technology. Based on this plan, MIC has

[2] 2022 saw the emergence of "Stable Diffusion" (an AI that can automatically generate images) and "ChatGPT" (an AI that can automatically generate sentences).
[3] Global Communication Development Promotion Council, examples of products/services of private enterprises using the multilingual translation technology of the National Institute of Information and Communications Technology (NICT): https://gcp.nict.go.jp/news/products_and_services_GCP.pdf

been developing a computer environment for NICT to conduct world-class AI research and development, and has been conducting research and development since fiscal 2020 to upgrade the technology (which used to be limited to the sequential translation of short sentences) to allow for simultaneous interpretation to be performed during business and international conference discussions.

Figure (related data) Efforts to further advance multilingual translation technology
URL: https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2023/data_collection.html#f00389
(Data collection)

In addition to research and development on multilingual simultaneous interpretation, four additional languages will be added in order to deal with foreign visitors, foreign residents, and refugees from Ukraine.

5. Remote sensing technologies

NICT is conducting research and development on remote sensing technology to observe rainfall, water vapor, wind, and ground surface conditions with high temporal and spatial resolution, with the goals of quickly identifying sudden atmospheric phenomena such as linear precipitation zones and torrential downpours, helping clarify how these develop, and quickly determining damage during disasters.

In addition to conducting research and development on developing Dual Polarization Multi-Parameter Phased Array Weather Radar (MP-PAWR), which is capable of three-dimensional observation of rain clouds at high speed and high accuracy, and on promoting the utilization of data, research and development on technologies for estimating the amount of water vapor in the atmosphere using the propagation delay of terrestrial digital broadcasting waves, wind profiler technology to observe the wind velocity in the sky, and ground-based water vapor and wind lidar technology using an eye-safe infrared pulsed laser to simultaneously observe water vapor and wind are being promoted.

Figure (related data) Development of water vapor observation network in linear precipitation zone: Efforts to improve the accuracy of short-time rainfall forecasting
URL: https://www.nict.go.jp/press/2022/06/29-1.html

6. Space ICT

According to the Basic Space Plan based on the Basic Space Act (Act No. 43 of 2008) and its schedule, MIC is promoting the following research and development efforts related to space development and use.

(1) R&D of radio-optical hybrid communications technology for small satellite constellations and wireless communications technology using unused frequencies for space networks, in order to realize ultra-wide-band satellite optical communications systems through effective use of frequency resources
(2) R&D to establish core technologies for quantum cryptography in satellite communications and realize a global quantum cryptographic communications network through satellite networks, etc.
(3) R&D of technology to explore water energy resources on the lunar surface, to contribute to the international space exploration project (Artemis Program) proposed by the U.S.
(4) R&D of satellite communications system for Engineering Test Satellite-9 and optical communications technology to enable ground-satellite optical data transmission at 10 Gbps
(5) Development of space environment monitoring sensor technology to observe and analyze ionosphere, magnetosphere, and solar activities, to be used for space weather forecasting under 24-hour, 365-day human-crewed operation and to be mounted on the successor to the Himawari geostationary meteorological satellite

The importance of space weather forecasting is growing, especially for companies responsible for the stable operation of social infrastructures such as power, communications, broadcasting, and aviation. In light of the fact that solar activity is expected to increase, MIC held the "Study Group on the Advancement of Space Weather Forecasting" (January to June 2022), and compiled a report on proposals to enhance warning systems and effectively deal with impacts on social infrastructures. Based on this report, MIC is now considering and introducing new forecast and warning standards that take social impacts into account.

Figure (related data) Impact of solar flares on the Earth
Source: MIC, Material of the Study Group on the Advancement of Space Weather Forecasting (the 1st session)
URL: https://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2023/data_collection.html#f00390
(Data collection)