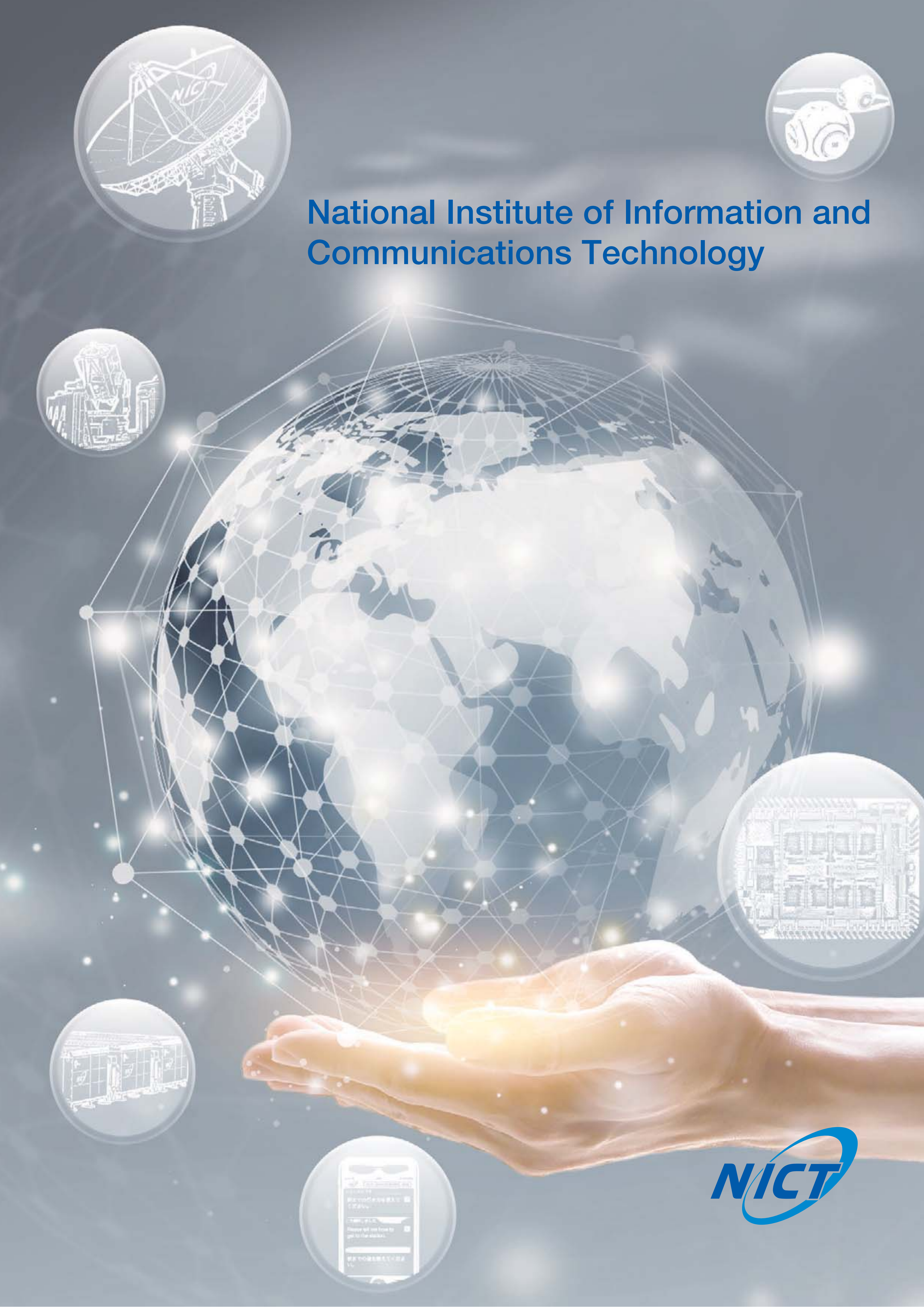
National Institute of Information and Communications Technology



As Japan's only national research and development agency specializing in the field of information and communications technology (ICT), the National Institute of Information and Communications Technology (NICT) promotes ICT R&D from an integrated perspective, from the basic to the applied, while collaborating with universities, industry, local governments, and domestic and overseas research institutions and aiming to generate innovation by giving back to society with the results of our R&D.

In order to respond flexibly to global social issues such as natural disasters, global warming, pandemics, and adapting to the “new normal” of the post-corona age, and to transform Japan into a sustainable and resilient society, it will be essential to accelerate digital transformation (DX) and realize Society 5.0 - a human-centered society - through a system that integrates cyberspace and physical space.

To the early realization of that end, under the fifth mid-to-long-term plan, which launched in April 2021, in addition to our main mission of promoting R&D and open innovation in five priority areas (Advanced electromagnetic technology, Innovative networks, Cybersecurity, Universal communication, and Frontier science) based on a new ICT technology strategy, we will actively promote R&D in the four strategic research fields of Beyond 5G, AI, Quantum ICT, and Cybersecurity. In addition, NICT will accelerate the spread of its R&D results throughout society by promoting activities to utilize the advanced technologies developed by NICT for businesses and other organizations, and creating a testbed environment for the open use of research-result data.

NICT will maximize the results of these initiatives, with the entire organization working together for the development of information and communications technology, the most important social infrastructure. We appreciate your support and cooperation.

National Institute of Information and Communications Technology

President TOKUDA Hideyuki

NICT 5th Mid-To-Long-Term Plan

Japan's “Sixth Science, Technology and Innovation Basic Plan” (*1) calls for the realization of Society 5.0 as the society of the future we should aim for. In addition, the fourth interim report on “New Information and Communications Technology Strategy” (*2) emphasizes the promotion of R&D for, and implementation in society of, information and communications technology (ICT), which is the foundation of all industrial and social activity.

Based on the government's policy, NICT's fifth mid-to-long-term plan (April 2021 to March 2026) inherits the “five priority R&D areas” of the fourth mid-to-long-term plan, and promotes open innovation by widely disseminating our R&D results within society.

The “five priority R&D areas” are the areas of Advanced electromagnetic technology, Innovative networks, Cybersecurity, Universal communication, and Frontier science. We are working on advanced, basic, and foundational themes in each area from a medium-to-long-term perspective. In addition, we will promote cross-sectional and strategic R&D in four research fields that should be pursued strategically (the “four strategic fields”).

The strategic fields are:

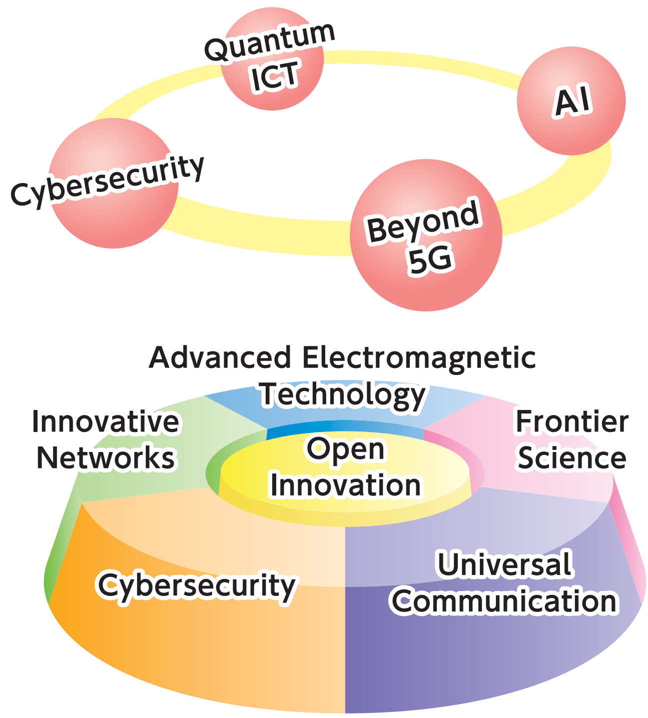
- Beyond 5G
- AI
- Quantum ICT
- Cybersecurity

NICT's Beyond 5G R&D aims to establish elemental technologies and architectures for the next generation of 5th generation mobile communications systems (5G) and their implementation in society. In AI, we will work to establish simultaneous interpretation technology at the practical level to realize the human-centered society that Society 5.0 is aiming to create. In the field of Quantum ICT, we will establish technologies for the realization of an integrated satellite/terrestrial quantum network, including unbreakable quantum cryptography and quantum-node technology. In the field of Cybersecurity, we aim to establish technology to deal with cyberattacks by aggregating and analyzing relevant information, and technology to ensure safety even in an age of quantum computers.

Collaboration across fields is also important for building a total system that links elemental technologies in addition to advancing them. Through these activities, NICT is promoting open innovation in order to contribute to solving social and regional issues, digital transformation, and value creation in social systems for the new era, and achieving SDGs, including diversity and sustainability.

(*1) Cabinet decision dated March 26, 2021

(*2) Information and Communication Council MIC Interim Report dated August 5, 2020



Four strategic fields, five priority R&D areas, and open innovation in the Fifth Mid-To-Long-Term Plan

Advanced Electromagnetic Technology Area

Remote Sensing Technology

Space Environment Technology

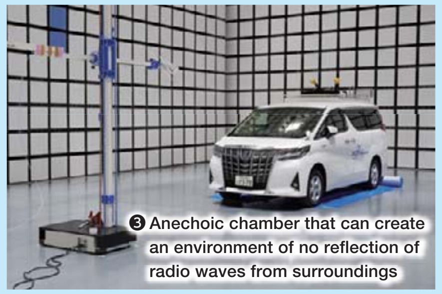
Electromagnetic Compatibility Technology

Space-Time Standards Technology

Digital-Optics Technology

❶ Parabolic antenna that captures information from satellites that observe solar activity


❷ Weather observation equipment that utilizes laser beams


❸ Anechoic chamber that can create an environment of no reflection of radio waves from surroundings


❹ Radio wave transmitting station for the standard frequency and Japan Standard Time

Radio Research Institute

Make our future safer and richer using electromagnetic waves

To realize the smart life of the future

Radio Research Institute engages in R&D of various technologies related to "electromagnetic waves," such as radio waves and light, and promotes activities related to utilizing those technologies in society. Currently, human societies are trying to integrate cyberspace (virtual space) and physical space (real world) to balance both economic development and solutions for societal problems.

Radio Research Institute is conducting a variety of research to realize the functions of: "sensing (measurement/observation)" - aggregating information from the physical space into cyberspace using various sensors; "processing (information processing)" - creating "future visions" in cyberspace by analyzing various kinds of data; and "actuation (operation/action)" - creating action effecting physical spaces by utilizing data in cyberspace. The results obtained from our research will make it possible to identify changes promptly and precisely in climate and space environments, and correctly assess social conditions, including disaster situations. We will also be able to make highly accurate predictions of the future to realize a smart life in the real world.

Cutting-edge technologies utilizing the properties of electromagnetic waves

Remote sensing technology involves R&D on technologies to observe desired targets from the ground, aircraft, or satellites and technologies for advanced analysis of the obtained data, which contributes to disaster prevention and mitigation, monitoring of global climate change, improvement of prediction accuracy in weather forecasts, etc., and elucidation of the mechanisms of global warming and water circulation (photos 2 and 6).

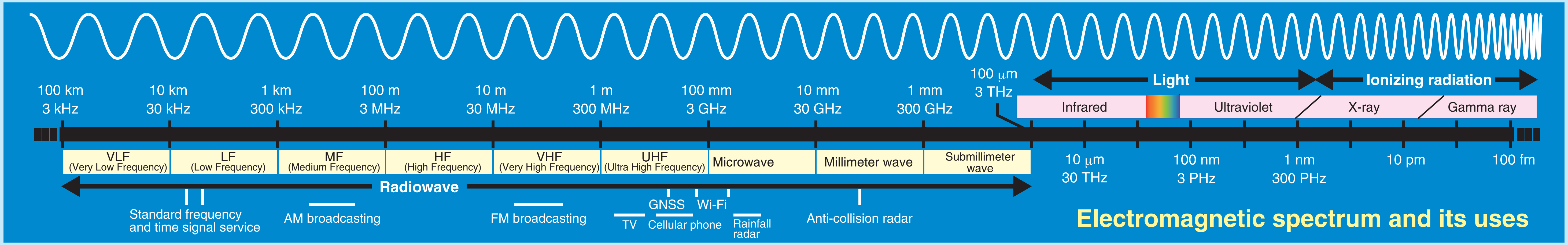
Space environment technology involves R&D for technologies to improve the monitoring (photos 1 and 7) and forecasting concerning the space environment, which is affected by solar activity, leading to stable use of radio waves and maintenance and management of societal infrastructure. NICT also provides space weather forecasts (https://swc.nict.go.jp) continuously, 24 hours a day, seven days a week.

Electromagnetic compatibility technology involves R&D to ensure electromagnetic compatibility (EMC), which is essential for smooth interoperability of communication devices and electric/electronic devices and for secure and safe use of new radio wave systems (photo 3). NICT also provides calibration services to inspect the performance of radio equipment indispensable for socioeconomic activity.

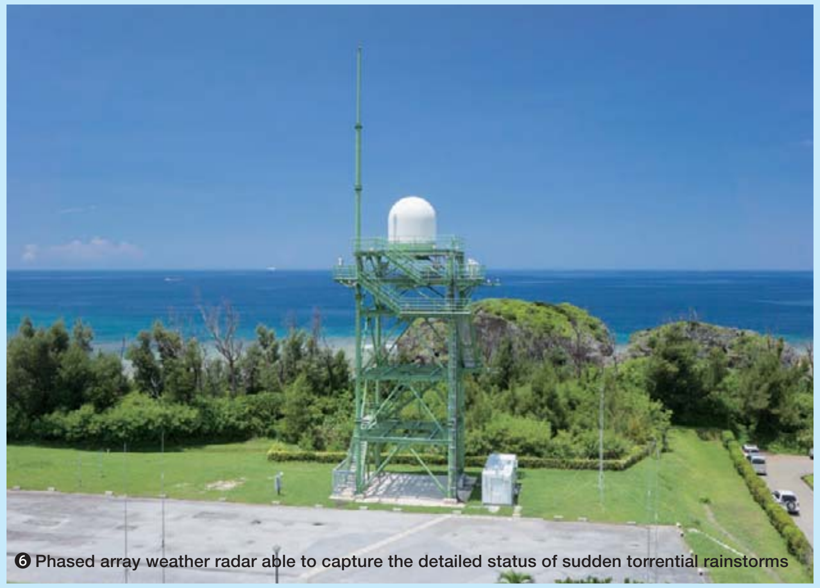
Space-time standards technology involves setting standard national frequency, transmitting standard frequency by radio waves (photo 4), disseminating stable and highly accurate Japan Standard Time (photo 5), and developing optical frequency standards and portable atomic clocks.

Digital-optics technology involves R&D on optical elements using diffraction of light, and precision optical measurement technology, as well as implementation and industrial deployment for highly efficient and inexpensive optical communication modules, head-up displays, next-generation AR systems, and next-generation advanced microscopes (photo 8).

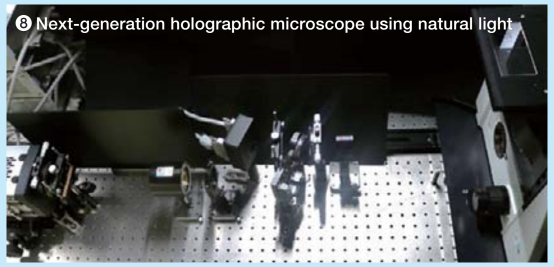

❺ Japan Standard Time generation/measurement system



Electromagnetic spectrum and its uses


❻ Phased array weather radar able to capture the detailed status of sudden torrential rainstorms

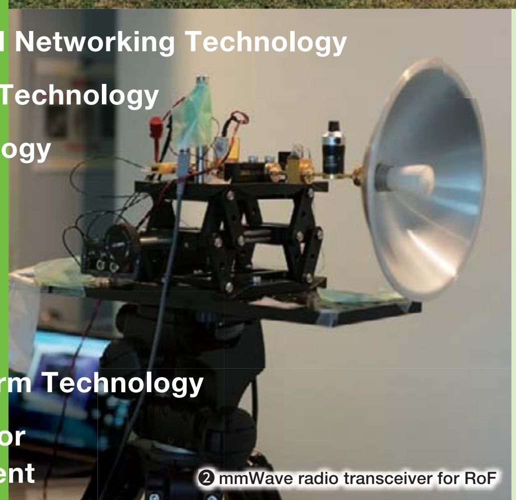

❼ Ionospheric observation at Syowa Station, Antarctica


❽ Next-generation holographic microscope using natural light

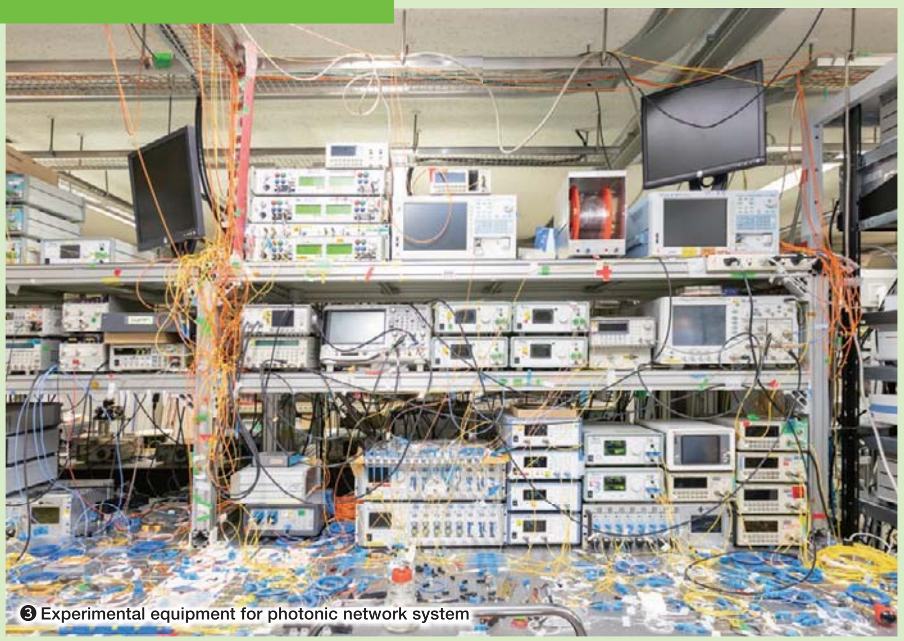
❶ Ground station for optical satellite communication

Innovative Networks Area

- Computing and AI-Enabled Networking Technology
- Next-Generation Wireless Technology
- Photonic Network Technology
- Optical and Radio Convergence Technology
- Space Communications Fundamental Technology
- Terahertz Wave ICT Platform Technology
- Resilient ICT Technology for Severe Physical Environment



❷ mmWave radio transceiver for RoF



❸ Experimental equipment for photonic network system

Network Research Institute

Driving R&D on network technologies supporting Beyond 5G and dissemination of R&D outcomes

Toward the realization of Beyond 5G

Network Research Institute conducts R&D on establishing network toward Beyond 5G to support the society in the 2030s, such as the SDGs. In particular, we conduct R&D on basic and system technologies in the area of optical, wireless (terrestrial, satellite), and networking to realize ultra-wideband, ultra-low latency, and resilient communications. The institute collaborates with companies and universities to innovate basic technologies of networks and aims to standardize and to disseminate the technologies.

Extension of three-dimensional seamless networks

For the coming Beyond 5G, it is expected to integrate terrestrial networks and non-terrestrial networks (NTN). We conduct R&D on wireless network technologies that globally extend three-dimensional seamless communication networks including the ocean and space, via a network composed of satellites, aircraft, and drones, and on technologies for optical satellite communications (photo 1).

Also, we contribute to diversification and expansion of terrestrial wireless communication systems for the Beyond 5G, through conducting R&D on wireless system assessment technologies that simplify evaluations for complex wireless systems in an actual operational environment that require a lot of human resources and time (photo 5).

❹ High-definition device processing machines in the Yellow Room

Ultimate speed for us

While information is delivered to us via an optical backbone network, it is converted into electrical, optical, and radio signals. To deliver enormous amounts of information promptly, we establish an optical network technology of tens of petabits per second class (more than 1000 times the traffic of Japan in 2020) based on multi-core optical fibers in which multiple passages are arranged in one optical fiber (photo 3).

Millimeter-waves and terahertz-waves, which are expected to be used in access networks, have a shorter reach than radio waves used in 4G and 5G, so a large number of radio stations are required. It is necessary to reduce the power consumption and the cost of the system. We contribute to solving the problem with technologies that simplify network systems by harmonizing optical signals and radio signals, and ICT hardware technologies for optical signal circuits (photo 2).

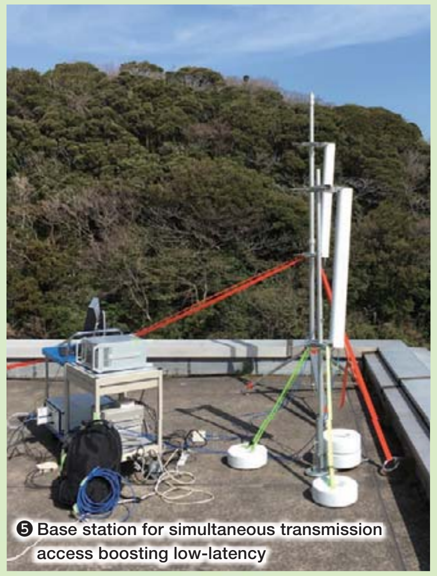
In addition, we run Advanced ICT Device Laboratory, which is an open hub for creating innovative ICT hardware devices by consolidating device technologies (photo 4). We collaborate with **Terahertz Technology Research Center** at **Beyond 5G Research and Development Promotion Unit**, to drive on research on communication by using terahertz waves.

Resilient ICTs for SDGs around the world

We have conducted on R&Ds and activities that contribute to reducing network failures after natural disasters and shortening the period until recovery. Based on our achievements, we make them evolved as supple and tough "Resilient ICTs" toward Beyond 5G. In particular, we have begun to conduct R&D on information and communication technologies in environments where wireless communication is difficult to be used, technologies that adapt when a network is disconnected, and technologies that detect, visualize, and distribute sudden changes in natural phenomena to people and systems (Photo 6).

Keyword is Flexibility

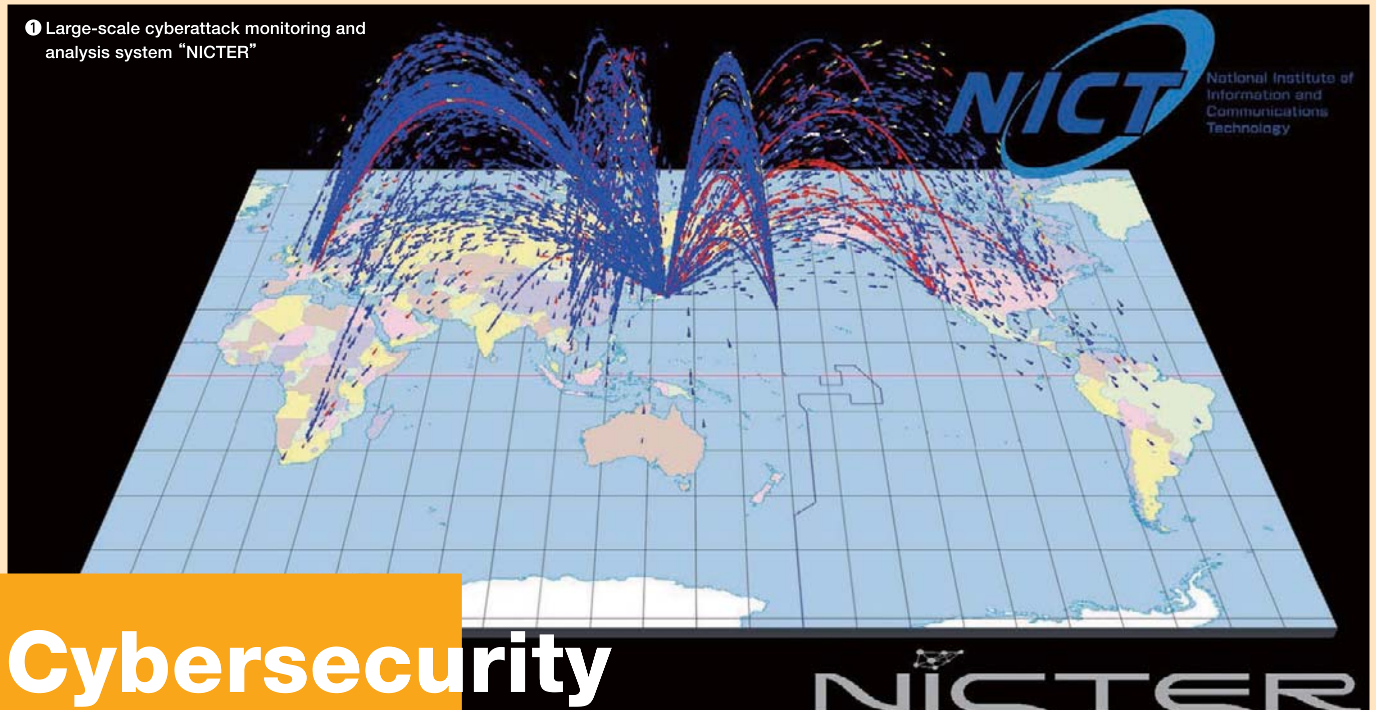
In the field of networking, we conduct R&D on distributing highly reliable information with low latency by utilizing finite communication and computing resources and measurement data effectively with AI technologies and programmable networks (photo 7). We aim to establish technologies for coexistence of various ICT services, by extending three-dimensional seamless communication networks, by increasing the capacity of the network, and by utilizing resources flexibly.



❺ Base station for simultaneous transmission access boosting low-latency

❻ Remote monitoring of natural phenomena

❼ Remote monitoring for online lecture



❶ Large-scale cyberattack monitoring and analysis system "NICTER"

Cybersecurity Area

- Cybersecurity Technologies
- Cryptographic Technologies
- Cybersecurity Trainings
- Development of a Government-Industry-Academia Cybersecurity Base
- Surveys of IoT Devices with Improper Setting of Passwords, etc.


❷ IPv6 compatible analysis platform "NIRVANA KAI"

Cybersecurity Research Institute

Engaging in a wide range of R&D and human resources development in cybersecurity, aiming to become a global center and nexus for government, industry, and academia

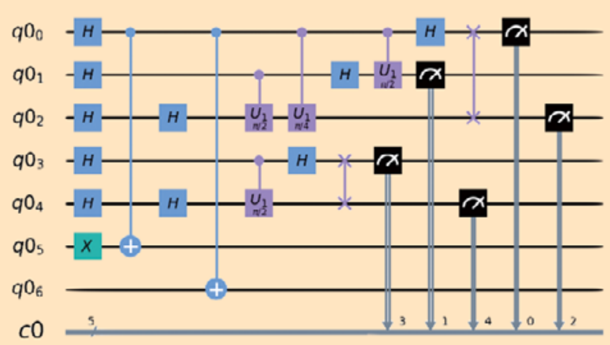
Protecting society from increasingly complex and sophisticated cyber attacks

In order to enhance Japan's ability to innovate to create unprecedented value and transform social systems, it is essential to, as part of the national capacity to protect society (life, property, and information), enhance the sophistication of technologies in the area of cybersecurity in order to protect society from rapidly increasing numbers of cyberattacks. This is an urgent challenge for the nation as a whole, and the demands from society on NICT in this area continue to increase.

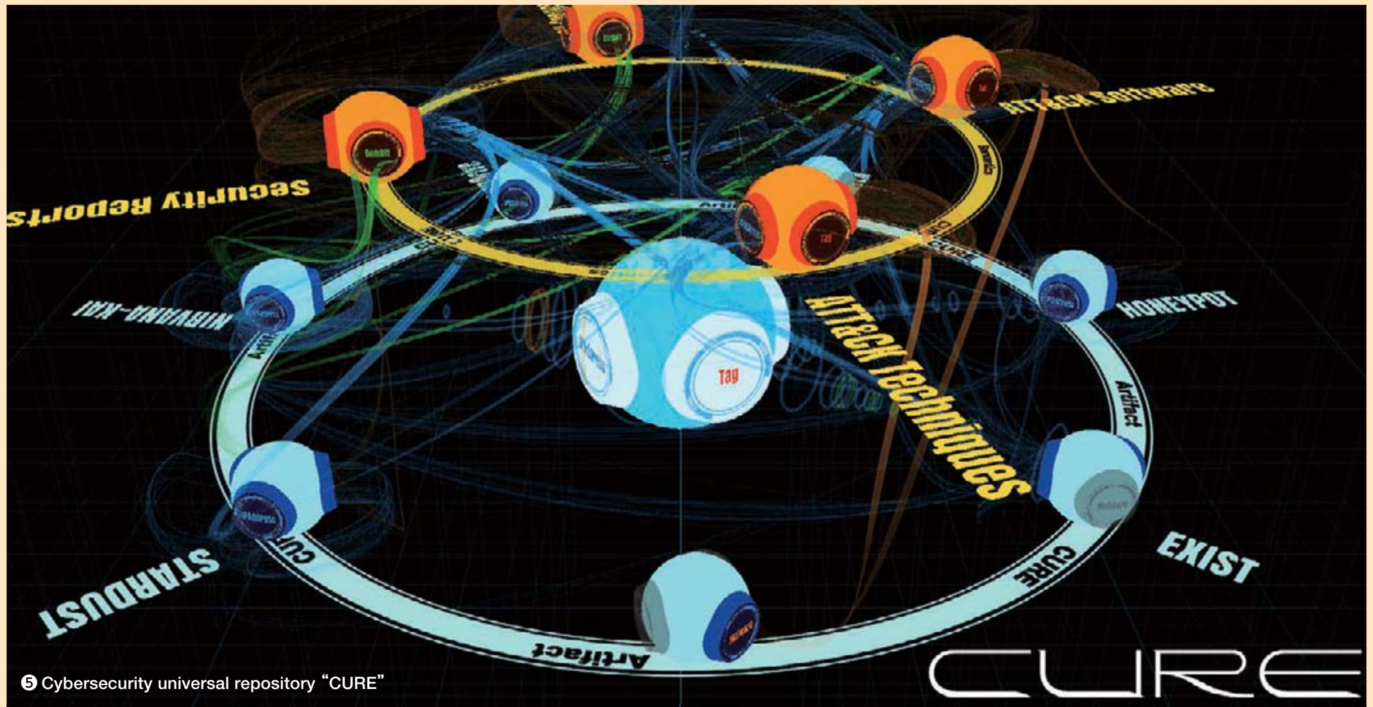
As one of the top research institutes in the area in Japan, Cybersecurity Research Institute aims to enhance the national capacity to deal with cyberattacks and promote secure data utilization, and conducts a wide range of activities from basic research to practical technology development based on strong societal demand, as well as implementation of relevant results within society. In accordance with national government policy, the Institute also conducts cybersecurity training, is developing a government-industry-academia cybersecurity base, and carries out surveys of IoT devices with inadequate password settings, etc.

Cybersecurity Laboratory conducts R&D on automatic analysis and visualization technologies that support situational understanding of cyberattacks by observing them from multiple angles (photos 1, 2, 5, 6), while **Security Fundamentals Laboratory** endeavors to carry out R&D aimed at the establishment of cryptographic infrastructure for the quantum computing era, as well as work on technologies for secure data utilization that contribute to solutions for societal challenges such as working from home (photo 3).

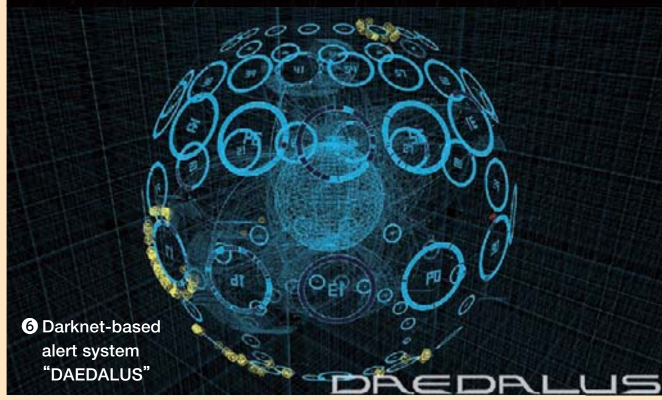
National Cyber Training Center runs cyber training for security operators from government and the private sector, as well as SecHack365, a program to foster young security innovators for those aged 25 or younger (photos 4 and 7), while **National Cyber Observation Center** surveys IoT devices with inadequate password settings and provides the information to internet service providers.


❸ Solving the discrete logarithm problem on superconducting quantum processors


❹ SecHack365 program to foster young security innovators

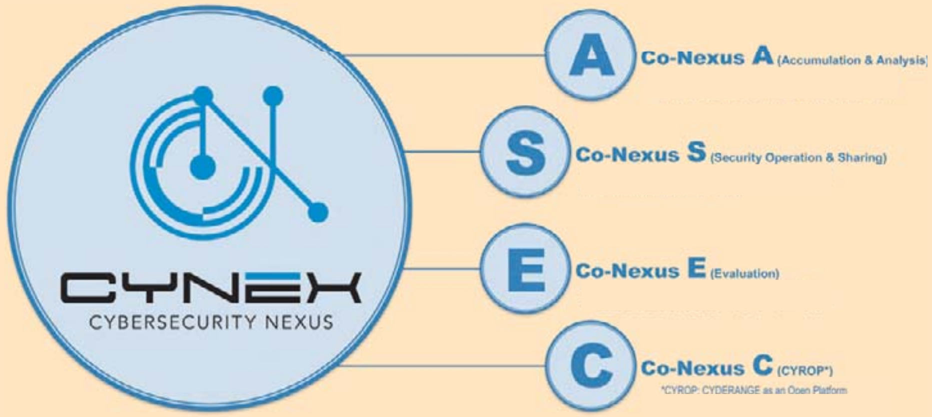


❺ Cybersecurity universal repository "CURE"



❻ Darknet-based alert system "DAEDALUS"


❼ Data center for cybersecurity training at Hokuriku StarBED Technology Center



❽ Development of government-industry-academia Cybersecurity Nexus

Improving society's cybersecurity capacity through collaboration between government, industry, and academia

Although large-scale collection and storage of actual data related to cyberattacks is essential for R&D in the cybersecurity area, many organizations in Japan are unable to collect a sufficient amount of data, which leaves R&D stagnating and cybersecurity self-sufficiency lagging.

In order to overcome this situation, a new organization - **Cybersecurity Nexus** - was established in April 2021 with the aim of creating an advanced platform that will serve as a nexus for government, industry, and academia (Photo 8). Specifically, it aims to improve Japan's cybersecurity capability by collecting, storing, analyzing, and providing cybersecurity information domestically, as well as by sharing a common platform for fostering cybersecurity experts throughout society as a whole.

❶ Prototype simultaneous interpretation system

Universal Communication Area

- Multilingual Communication Technology
- Data-Driven Intelligent Communication Technology
- Smart Data Analytics Technology

❷ Speech translation app "VoiceTra"

❸ Predicting mobility risks by cross-data analysis

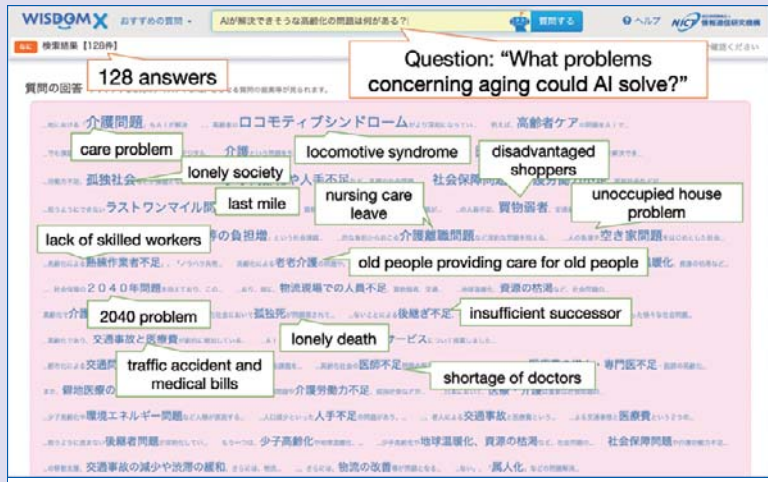
Universal Communication Research Institute

Realizing universal communication for mutual understanding

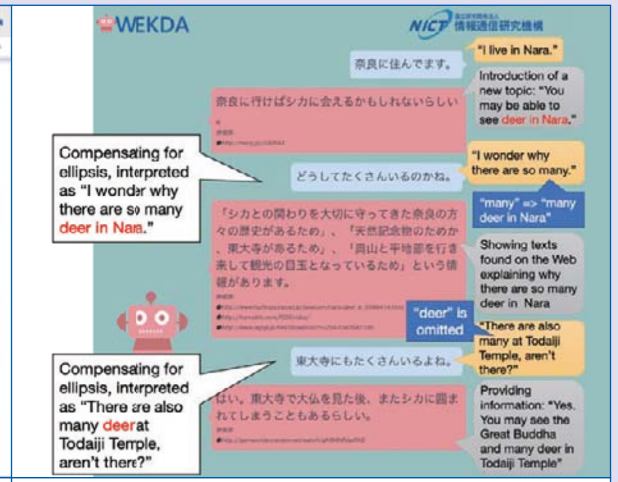
Creating an AI research platform and utilizing it for R&D

Universal Communication Research Institute (UCRI) is one of Japan's leading R&D centers in the area of AI, and aims to achieve universal communication and to establish mutual understanding among people. In addition to its large-scale computational resources, UCRI is developing an AI R&D platform (photo 7) using a high-quality, large-scale database especially focused on the Japanese language, and is promoting R&D of the three core technologies that leverage the platform.

❹ MICSUS: Multimodal spoken dialog system for elderly care (Introductory video ▶https://www.youtube.com/watch?v=gCUrC3f9-Go)
(Jointly developing with KDDI, NEC Solution Innovator and Japan Research Institute under the second period of Cross-ministerial Strategic Innovation Promotion Program (SIP))



❺ Deep-learning version of WISDOM X https://www.wisdom-nict.jp/



❻ WEb-based Knowledge Disseminating dialog Agent WEKDA

The three core technologies are: **Multi-lingual communication technology**, which enables low-latency AI simultaneous interpretation that can be used in business situations (photos 1 and 2); **Data-driven intelligent communication technology**, which enables spoken dialog systems to use virtual personalities to converse with users based on their interests and backgrounds (photos 4, 5, 6); and **Smart data analytics technology**, which enables real-world analyses and predictions by connecting all kinds of public and private sensing data from various fields (photo 3).

Contributing to solving social issues and creating new values through R&D and its dissemination

In terms of R&D, UCRI will create unique, top-class core technologies unbound by precedent and hone them into universal technologies with broad scope for use. We will then develop and expand demonstration and commercialization systems utilizing those technologies in an industry-government-academia collaboration that will lead to their implementation in society, and feed the issues and knowledge created by society back into our R&D activities. We aim to create this kind of positive spiral to develop and disseminate our core technologies throughout society.

❼ Computer facilities

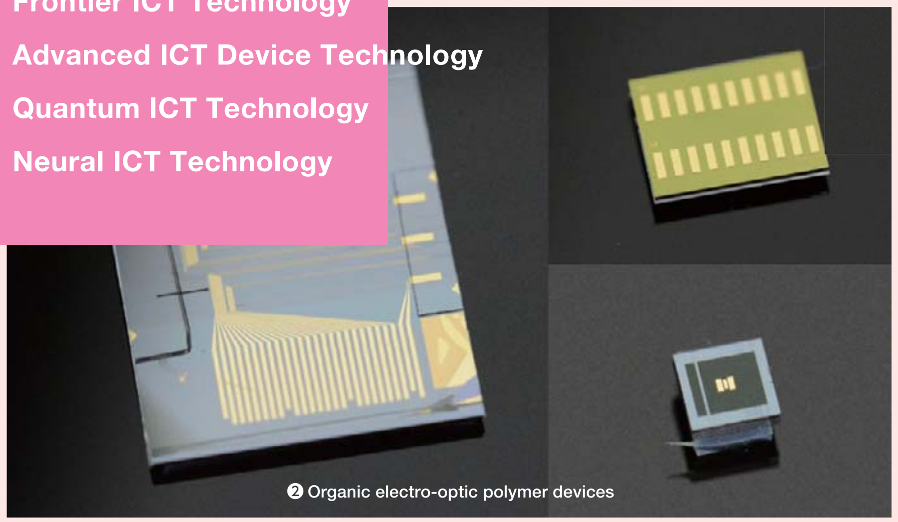
UCRI has some of the largest data and computing resources held by any public research institute researching the relevant area in Japan and plans to further increase them in the future. We will accelerate the positive spiral by enhancing these activities through collaboration with overseas and domestic institutions to become the leading R&D institute in Japan with an AI research platform.

Under our AI research platform, we will contribute to solving society's challenges and creating new values by removing language, knowledge, and data-utilization barriers in global businesses, elderly care, environmental risk reduction, etc., and by achieving a perfect balance of "research" and "dissemination."

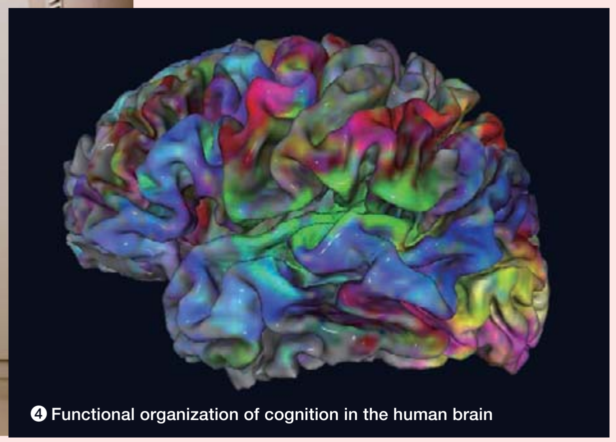
Frontier Science Area

- Frontier ICT Technology
- Advanced ICT Device Technology
- Quantum ICT Technology
- Neural ICT Technology

❶ DUV photonic manipulation and evaluation technology


❷ Organic electro-optic polymer devices

❸ 7 Tesla MRI scanner


❹ Functional organization of cognition in the human brain

Advanced ICT Research Institute

Creating and developing innovation beyond conventional concepts

Opening up new horizons in ICT

Of the five research institutes at NICT, Advanced ICT Research Institute is the one positioned to focus on conducting advanced and basic research. With the goal of "creating and developing innovation beyond conventional concepts" in ICT, our role is that of "opening up the future" by pioneering, without fear of failure, seemingly barren frontiers with science.

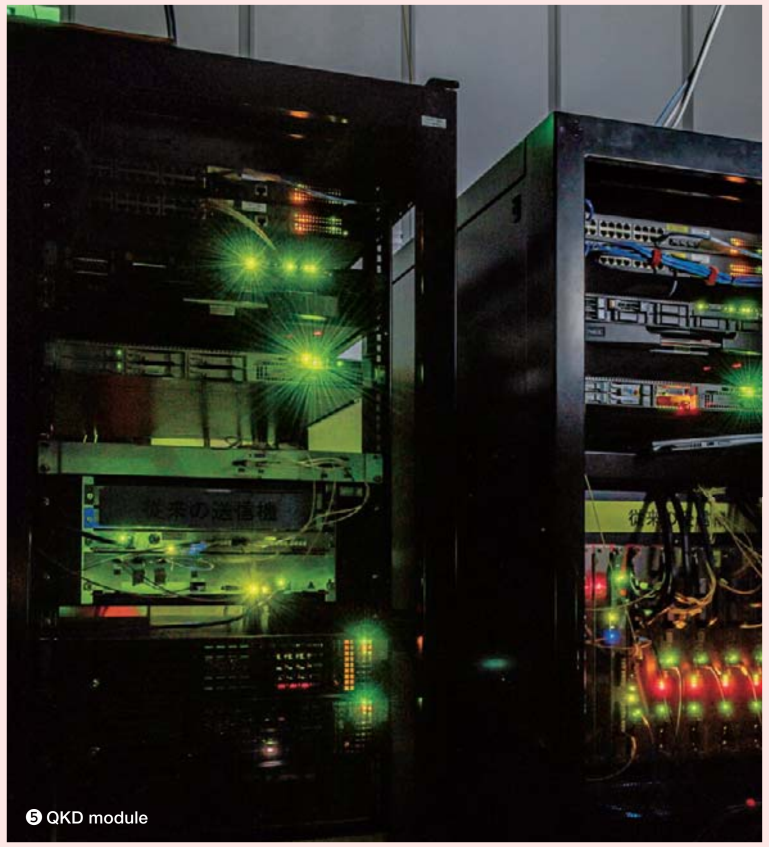
The Institute is involved in a wide range of areas, such as **Frontier ICT** (photos 2, 6, 7, 8, 9), **Advanced ICT devices** (photos 1 and 10), **Quantum ICT** (photo 5), and **Neural ICT** (photos 3 and 4), and the organization itself is the largest of the five NICT research institutes. In addition to conducting research in a variety of areas, from basic science to engineering, it is anticipated that the Institute will make effective use of its wide range of fields to achieve interdisciplinary fusion and create completely new areas of research. In fact, fusion research in the fields of devices and biotechnology has already begun. It is also an important role of the Institute to support such active interdisciplinary research.

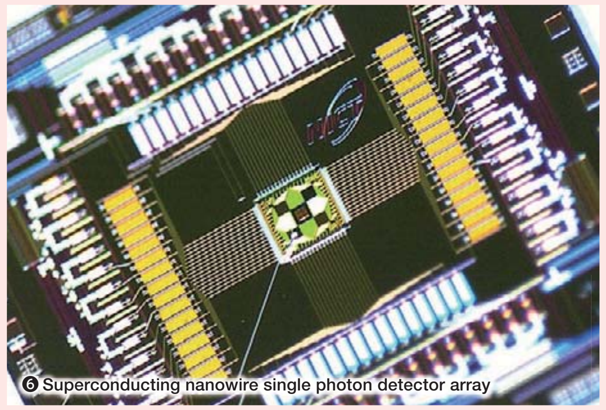
We are also living in an age where the question of how to make use of basic research for the benefit of the world is a more pressing one. Some of the research projects that the Institute is working on will take 20 to 30 years to produce results, but by releasing some of our developed technology to the world we are able to get early feedback, which we can then use again in our research. Some of these topics currently under research are expected to be implemented in society in the near future.

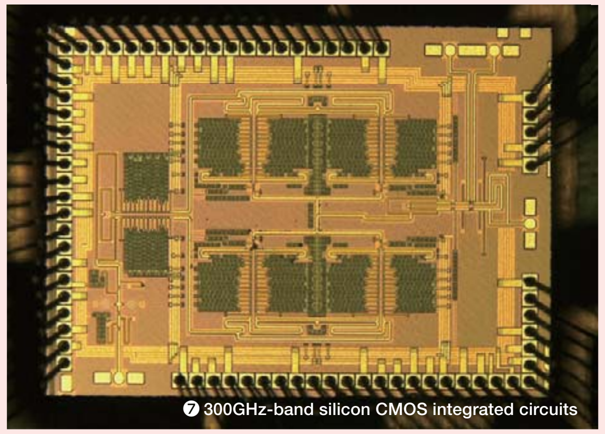
Quantum ICT for a safe and secure society

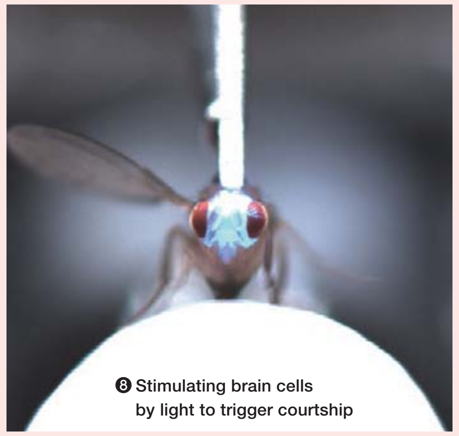
Of the four areas being strategically promoted by NICT, research into quantum ICT aims to, in cooperation with the newly established **Quantum ICT Collaboration Center**, create highly confidential networks that protect critical information in the government, medicine, infrastructure, and finance sectors over the very long term.

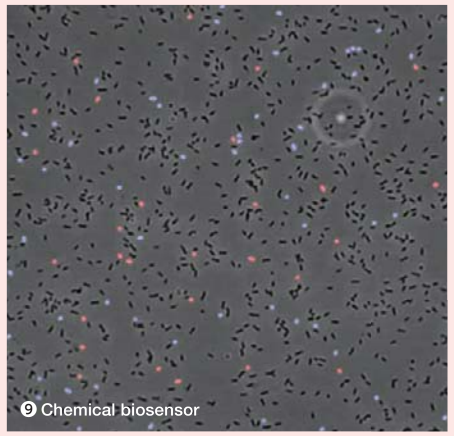
For example, there is quantum key distribution, which uses the quantum mechanical properties of light to make it possible to share a secure cryptographic key (random number) between two remote parties. This eliminates the threat of key information being decrypted, even if computing power increases significantly in the future. Its safety is guaranteed by the laws of physics. Also proceeding is research on the application of quantum technology within the nodes of an optical network - so-called "quantum network" research - with the aim of transmitting quantum states themselves over long distances, and we aim to introduce quantum technology in stages. In addition, we are also engaged in research looking decades into the future involving the development of elemental technologies for improving the performance of quantum computers.

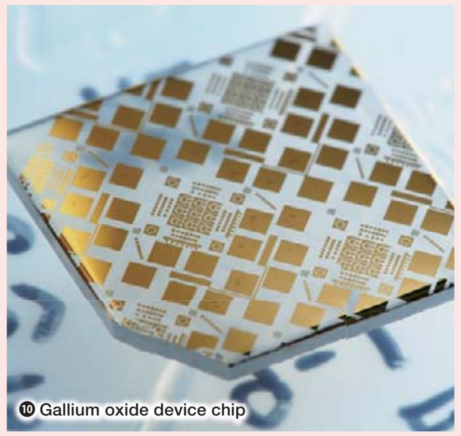

❺ QKD module


❻ Superconducting nanowire single photon detector array


❼ 300GHz-band silicon CMOS integrated circuits


❽ Stimulating brain cells by light to trigger courtship


❾ Chemical biosensor


❿ Gallium oxide device chip

Open Innovation


❶ A group of computer containers in Hokuriku


❷ A group of servers that are part of StarBED

Open Innovation Promotion Headquarters

Accelerating open innovation and taking the lead in "new-normal" social and economic reform

Promoting the creation of new value

With the goal of rapidly implementing the results of R&D in society, Open Innovation Promotion Headquarters aims to establish an ecosystem that promotes the creation of new value by accelerating open innovation through various means, such as industry-academia-government collaboration and international cooperation, including the development and operation of testbeds as environments for various organizations to evaluate technical validity and usability using state-of-the-art ICT, and the conducting of commissioned research. Amid intensifying international competition in the development of advanced technology, we will use ICT to take the lead in "new-normal" social and economic reform and clear the way to a bright future characterized by great hope and enormous potential.

Promoting the development and operation of ICT testbeds

With the aim of supporting and promoting a wide range of research activities, including R&D of advanced network technologies and experimental verification of various applications, we develop and provide a high speed R&D network testbed named "JGN," which enables verification of various technologies and services from backbone networks to applications using a real wide-area network environment; a large-scale emulation testbed named "StarBED" for developing verification platforms for the IoT era; and the DCCS (Data-Centric Cloud Service), which is a service-layer testbed to develop new applications through advanced and open utilization of various data, including research results (photos 1 and 2). These testbeds can be used by anyone who signs a joint research agreement with NICT.

Promoting R&D and publicizing its results

For the realization of Beyond 5G and the resolution of social issues, NICT conducts commissioned research utilizing the capacity of industry, academia, and government, and provides opportunities for joint research and researcher interaction with domestic and overseas companies and universities while promoting joint R&D through collaboration with NICT's own R&D (photos 4 and 7). In addition, we also engage in active standardization efforts with industry, academia and the public sector and transform R&D results into socially beneficial products by acquiring and effectively using intellectual property licenses (photo 3). Furthermore, to promote open innovation on a global scale, we facilitate joint research with overseas research organizations and universities (photos 5 and 6), promote international interaction between researchers, and collect relevant information through NICT's Overseas Centers.

Contributing to the development of the ICT field

In order to create ICT start-ups with innovative technologies and services, we support the discovery of students and promising young entrepreneurs who aspire to start their own businesses, and in addition to holding the Entrepreneur "Koshien" Tournament and Entrepreneur Expo (photo 8), we support visits by overseas researchers to research organizations in Japan by offering international exchange programs and organizing international researcher meetings. We also promote support for information-barrier-free access enabling the use of ICT by anyone, including the elderly and people with disabilities.


❸ Measurement of radio wave environment in a factory to realize coordinated control

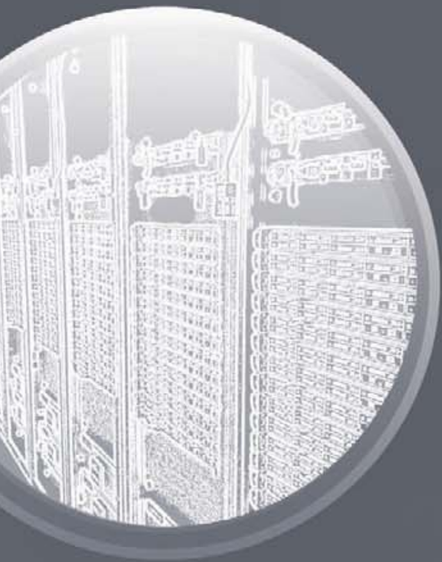

❹ Hackathon: the future of Kitakyushu cities and lifestyles empowered by IoT


❺ Nondestructive surveying of frescoes in cooperation with overseas museums


❻ ASEAN IVO Project


❼ Ideathon: the future of the Sendai metropolitan area using open data


❽ Entrepreneur Expo



National Institute of
Information and Communications Technology



Sept. 2021