FEATURE Beyond 5G: The Journey to Create the Next Connection

DIALOG It Takes More Than Technology to Shape the Future
Human Connections Will Drive Innovation in the Beyond 5G / 6G Era

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Beyond 5G: The Journey to Create the Next Connection

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Cover illustration:
Exactly five years ago, a volunteer team at NICT was deep in discussions about the first Beyond 5G / 6G White Paper.
Their aim was to envision society after 2030 and identify the key technologies needed to make that future possible. The cover illustration depicts a portion of that envisioned future: humans and robots working side by side in agriculture on the ground, while communication base stations and vehicles traverse the sky above. After five years of research and development, how close have we come to that future?

Message from the President

President of the National Institute of Information
and Communications Technology
Dr. TOKUDA Hideyuki

As we welcome the New Year of 2026, I would like to extend my sincere greetings to all of you.

I also wish to express my heartfelt appreciation for your continued understanding and support of the National Institute of Information and Communications Technology (NICT).

At the end of March this year, NICT's Fifth Medium-to-Long-Term Plan, which has spanned five years, will come to a close. During this period, we have steadily accumulated research achievements of significant scientific and societal value, which is core to NICT's mission, while also reporting numerous cases in which our research results have been successfully implemented in society.

In the networking field, notable progress includes the introduction of two-core fiber into submarine optical cables based on multicore optical fiber technology, as well as the commercial deployment of AI-based network failure detection systems. With respect to Beyond 5G (B5G), we have advanced research and development in areas where NICT has particular strengths, including Terahertz technologies, Space-time synchronization, and the integration of terrestrial and non-terrestrial networks (TN/NTN). We have also made active contributions to international standardization efforts. In March of last year, NICT participated for the first time with an independent exhibit at Mobile World Congress (MWC) 2025 in Barcelona, helping to elevate Japan's presence on the global stage. In addition, at the Osaka–Kansai Expo in May, we showcased our work at the Beyond 5G Ready Showcase. In August, we held a pre-opening of the Beyond 5G Innovation Bridge, a new hub designed to accelerate open innovation in B5G research and development.

In the AI field, NICT's simultaneous interpretation and consecutive translation systems were widely deployed at the Osaka–Kansai Expo. We also regard the development of NICT's own large language model as a critical initiative, both for building safe and high-performance domestic AI models grounded in high-quality Japanese-language training data that reflect Japan's culture and institutional context, and for establishing reliable evaluation frameworks for such models. At the GPAI Tokyo Expert Support Center, which promotes international partnerships on AI, we have been conducting case studies on agentic AI, advancing projects on multilingual and multicultural AI, and supporting student community initiatives.

In the quantum information and communications field, the Tokyo QKD Network, which has been under development for many years, has undergone operational trials involving numerous corporate partners. These trials have validated applications such as 4K video-encrypted web conferencing and interoperability testing with RIKEN's quantum computer. We have also demonstrated efforts to extend QKD networking across continents via the International Space Station (ISS), and enhanced the quantum-secure cloud platform to ensure the safe handling of data requiring ultra-long-term confidentiality.

In the cybersecurity field, the CYNEX Alliance, NICT's industry–academia–government collaboration initiative, has grown to include more than 100 member companies and is actively engaged in threat analysis, workforce development, and security product evaluation. In addition, the CREATE Center, launched last February to advance research in AI for Security and Security for AI, has initiated collaborative research with U.S. research institutions and universities.

In the advanced electromagnetic technology field, remote sensing, space environment technologies, electromagnetic environment engineering, time–space standards, and digital optical platform technologies form a foundational layer for a safe and secure Society 5.0, as well as for B5G / 6G. The Cloud Profiling Radar (CPR) aboard the EarthCARE satellite, launched in May of the year before last in collaboration with ESA and JAXA, has been delivering stable observation data that contribute to understanding how clouds influence climate change. Our space-time synchronization technology is also being applied to verify high-precision clock synchronization among servers inside Meta's data centers.

In frontier science, we are developing advanced core technologies that can lead to fundamental breakthroughs for the next generation. For deep-ultraviolet LEDs, we conducted virus inactivation trials using actual railway vehicles. In the 300 GHz terahertz transmission and reception domain, we achieved date rates of 40 Gbps using a CMOS chip. CiNET has also begun exploring the application of its brain models in various design domains. By continuing to strengthen cross-disciplinary collaboration, we expect these efforts to open up new ICT fields one after another.

With the establishment of the Takaichi Cabinet last October, becoming a "nation built on advanced technologies" has been reaffirmed as a core national policy. Expectations for national research agencies like NICT continue to grow as part of this direction. Under the sixth Medium- to Long-Term Plan beginning in April, we will build on the progress of the past five years, further strengthen our capabilities, and pursue innovations that generate new value while expanding social implementation across a wider range of fields. We respectfully request the continued support and cooperation of universities, research institutions, industry, government bodies, and the public at large.

In closing, I would like to extend my sincere wishes for your continued health and success, and above all, for a more peaceful world. I offer these words as my New Year's greeting.

ISHIZU Kentaro   DIALOG   SAKUMA Morica

It Takes More Than Technology to Shape the Future
Human Connections Will Drive Innovation in the Beyond 5G / 6G Era

ISHIZU Kentaro
Research Executive Director, Beyond 5G Research and Development Promotion Unit, Director of Beyond 5G Design Initiative

After Receiving Ph.D, Dr.ISHIZU joined NICT in 2005. He has been engaging in research of cognitive communication system, TV White space system and architecture Beyond 5G, Ph.D. (Information Science).

SAKUMA Morica
Representative director, General Incorporated Association incr / Operating Officer, and CSO, andwee Co., Ltd./Digital Data Strategy Department, SOMPO Holdings Inc./Senior Business Creator, SOMPO Light Vortex Inc.

After graduating graduate school in medicine, she started her career as an expert of investment and financing at a regional bank, then she joined SOMPO Group in April 2022. She has been engaging in new business planning and development of Healthcare area. She also participated in General Incorporated Association incr / Operating Officer, and CSO, andwee Co., Ltd. She is working on woman empowerment and innovation creation.

In March 2026, Innovation Bridge @TOKYO will open at the NICT Nihonbashi Innovation Center. This new hub is designed to accelerate innovation for the coming Beyond 5G / 6G era. Beyond 5G / 6G, which will far surpass today's 5G, represents the future of communications and will form a foundation for the societies and industries that rely on it. However, the evolution toward Beyond 5G / 6G is no longer a story about technology alone. Innovation emerges when people from across industry, academia, and the public sector come together, share insights, and fuse their expertise. In this article, we present a dialogue between ISHIZU Kentaro, Head of the Beyond 5G Design Initiative within NICT's Beyond 5G R&D Promotion Unit—the organization coordinating NICT's Beyond 5G / 6G research—and SAKUMA Morica, Representative Director of incri, whose proposals explore the business and cultural implications of these technologies.

Moderator To begin, could you each briefly introduce yourselves and share a bit about your background?

ISHIZU The Beyond 5G R&D Promotion Unit was launched five years ago in April 2021. At that time, we published the Beyond 5G / 6G White Paper, which set out not only the technologies involved but also our vision for the kind of society these networks should help create. Achieving that vision requires innovation shaped by ideas from outside NICT, so we have been building collaborations across industries and with international partners.

We have also begun discussions that bring outside experts into the process so they can better understand NICT's technologies. By combining our insights, we aim to generate new social value. One of our key activities is developing proof-of-concept systems together with NICT researchers and external collaborators to explore what is truly possible.

SAKUMA In graduate school I researched cancer. After working at a regional bank and elsewhere, I moved to the SOMPO Group, where I now focus on new healthcare-related businesses. At the same time, I run an organization called incri. It is a collective of people from many companies who share a vision of creating a "zero-gravity society," a community where hierarchy does not dictate how people relate.

Many Japanese companies place organizational hierarchy above all else, and the resulting rigid vertical structure creates barriers in society. incri attracts people who feel uncomfortable with those constraints. Through that work, I became involved in a Ministry of Internal Affairs and Communications Leaders Forum project that explored the future of communication. That is where I met Dr. Ishizu.

ISHIZU Ms. Sakuma has supported many of our initiatives, not only within the Beyond 5G R&D Promotion Unit, but also in outreach projects on Beyond 5G / 6G led by other departments of NICT.

SAKUMA I sympathize with Dr. Ishizu's commitment to cross-industry collaboration. That led me to help organize the "Beyond 5G Zero-Gravity Event," which brought together private-sector professionals and NICT researchers.

■ **International Collaboration as a Priority**

ISHIZU One of the key directions for Beyond 5G / 6G is what we call "global first." From the beginning, we design our strategies with international markets in mind. The first country we partnered with was Germany. They have an organization that coordinates the national "6G Platform Germany" project, and we began holding workshops with them.

SAKUMA Did you actually travel to Germany?

ISHIZU No. For the first workshop, about twenty senior researchers leading various German research projects came to NICT headquarters in Koganei, Tokyo. That gathering became the starting point for several collaborations. By July 2025, when we held the sixth workshop, the event had grown to more than one hundred participants.

SAKUMA Do you find differences in how overseas partners and Japanese teams approach these efforts?

ISHIZU Yes. In addition to Germany, we have partnerships forming with Singapore, the United States, and several other countries, and their approaches to research vary. Some place priority on establishing foundational technologies, while others begin with the services they want to realize and work backward from there.

SAKUMA I believe that research and development in Japan has been technology-first, but from now on, especially new things will start with people-to-people connections.

ISHIZU Germany is a good example. The environment there enables not only large corporations but also small and medium-sized enterprises to thrive. Even small companies can achieve national-level results by forming many connections. Human networks matter, of course, but so do the networks between companies of all sizes.

SAKUMA I agree. I also run a small organization alongside my full-time job, and I feel every day that new value emerges when different companies and industries come together.

ISHIZU Exactly. Building relationships inside one's own organization is important, but connections formed outside the company—sometimes through side projects or independent initiatives—often lead to fresh, unexpected ideas.

■ **The Importance of Cross-industry Collaboration**

SAKUMA In my main role at the SOMPO Group, I work in areas such as insurance and eldercare. Some parts of the sector have advanced quite far with digitalization, while others remain largely untouched. But digitalization keeps moving forward, and in the end, nothing works without connectivity. For example, care facilities often have bed sensors installed and maintain digital records, so a certain level of digitalization is already in place. But when it comes to home-based care, many older adults still do not use smartphones, and blood pressure readings may still be written on paper. It can feel like a world far removed from digital tools and data.

Moderator Agriculture is another field that aligns well with digital technology.

ISHIZU Agriculture is deeply connected to weather data, logistics, retail, and numerous other types of information and stakeholders, so it is a field where cross-industry collaboration can make a difference. Timing is everything: if you miss the right moment, produce can spoil and lose all its value. But the opposite is also true; with the right actions at the right time, you can create significant new value.

That is why we recently launched an event called the "Agri-Chain Forum,"* where we bring together people involved in agriculture and discuss these issues.

SAKUMA Some banks are even forming agricultural corporations together with local farmers. Agriculture is an industry that touches many others, such as finance, insurance, and distribution, and I believe communication technologies will be essential to supporting it.

ISHIZU Exactly. This is what we mean by cross-industry orchestration." Agriculture is a perfect example. When you coordinate the many resources and actors involved, you can create social value on a scale that simply was not possible before.

■ **Collaborating with the Younger Generation**

SAKUMA It is not just agriculture; across the board, Japan simply does not have enough people.

ISHIZU Especially young people. The ones who will actually use Beyond 5G and 6G are those who will be active in society 10 or 20 years from now. In that sense, we need to understand what kind of society today's teenagers and people in their twenties want to build, and ensure we create an environment where they can thrive. Alongside cross-industry and international collaboration, working with young innovators is equally important.

Moderator How are young people responding?

ISHIZU From our conversations, many young people seem to have a clear vision of the kind of future society they hope to realize. But when it comes to the technical details of cutting-edge technologies, the discussion naturally becomes more difficult. That is why we want not only to share the potential of new technologies with them, but also to listen carefully to what they hope to achieve.

And we must think about the senior generation as well. We often hear that we are entering an era where people live to 100, and the number of older adults, ourselves included, will continue to grow. Even if someone has motivation and valuable experience, declines in physical ability can make it difficult for them to remain active. But with robotics and AI, we believe many seniors can continue contributing to society just as younger people do. The foundation that enables this is precisely Beyond 5G and 6G.

■ **Building a New Social System**

ISHIZU In the Leaders' Forum at the Ministry of Internal Affairs and Communications, which Ms. Sakuma mentioned earlier, one of the ideas that emerged from our discussions on the future shape of communications was the concept of "a society built on genuine connection and mutual support." In other words, a society sustained not only through monetary transactions, but through the exchange of gratitude and human warmth. Perhaps the time has come to return to the fundamentals of human relationships and reconsider the role of information and communications from that perspective.

SAKUMA Yes, it was essentially a discussion about what kind of life we want to lead.

ISHIZU What we aim for is not convenience for its own sake, but the ideal form of human life that lies beyond it. And it is human connections that allow us to envision that ideal. This is one of the conclusions we arrived at over the course of the past five years.

And taking this vision one step further is Innovation Bridge @TOKYO, which will open in March 2026. The word "Bridge" symbolizes the connections between people, while also referencing Nihonbashi, where "hashi" means "bridge" in Japanese. Nihonbashi has long been, and still remains, a starting point for new frontiers.

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* The first meeting of the Agri-Chain Forum was held on September 4, 2025. Aiming to foster collaboration between Beyond 5G and agriculture, the event targeted experts and practitioners from the agricultural sector, as well as engineers, researchers, and businesses interested in Beyond 5G technologies. Additional networking events are planned in the future.

The Five-Year Journey of the Beyond 5G Research and Development Promotion Unit: From Vision, Research and Development, and Proof of Concept to Collaborative Innovation

HOSAKO Iwao

**Executive Director,
Beyond 5G R&D Promotion Unit**

Following completion of a doctoral program, he joined NKK Co., Ltd., subsequently entering the Communications Research Laboratory (currently NICT) of the Ministry of Posts and Telecommunications in 1996. There, he worked on the development of terahertz technology (including detectors, semiconductor lasers, cameras, and wireless communication technology and standardization). Having served as Director General of the Advanced ICT Research Institute and contributed to writing and editing the Beyond 5G White Paper, he was appointed to his current position. Ph.D. (Science)

The Beyond 5G Research and Development Promotion Unit took a small step at the beginning of NICT's 5th Mid-to-Long Term Plan. On our very first day, our four original members gathered together at the Unit's base of activities, and it was there that we boarded a boat called the "NICT Beyond 5G / 6G White Paper" that was issued at the end of March of that year. With the White Paper serving as the Unit's "compass," we rowed out into an ocean filled with both anxiety and elation.

■Background

In compiling the Beyond 5G / 6G White Paper, we applied a variety of mechanisms to expand the circle of discussions within NICT. This was an activity in which a high degree of autonomy aligned with NICT's sense of purpose. About 150 people in total participated in separate themes under independent leadership. The White Paper published as a result of these discussions would become the core of our activities.

■Formulation of Beyond 5G / 6G Vision and Presentation of Global Guidelines

The Unit was the first in the world to present Beyond 5G / 6G architectural concepts. The purpose of our activities is not limited to formulating a technical vision. It also promotes Proof of Concept (PoC) demonstrations, international cooperation, standardization, and public awareness in an integrated manner and aims to establish international leadership in the field of information and communication technology.

The White Paper serving as the core of our activities presents the results of studies at NICT conducted by a group of experts on achieving a Beyond 5G / 6G world. It drew up a vision of future society after 2030 and beyond, proposed Beyond 5G architecture for orchestrating all kind of systems and producing new value, extracted fundamental technologies for which research and development must be strengthened, and clarified the role of architecture for making Society 5.0 a reality.

The White Paper is widely recognized. With more than 12,000 copies downloaded from Japan and other countries, it has been established as global guidelines.

■PoC Demonstrations Based on R&D Strategy

Together with extracting three important features essential to Beyond 5G architecture, we set up a PoC environment for verifying services. We collaborated with organizations inside and outside NICT to build PoCs jointly. The specific PoCs that we built are summarized below.

PoC 1: Terahertz Wireless Communication × Time and Space Synchronization

Drones guided by digital twins obtain high-definition video captured by cars from the sky through spot communications using terahertz waves. The video obtained from multiple cameras can be merged by high-precision time synchronization to obtain three-dimensional environmental information.

PoC 2: CPS × NTN × AI

Performs optimal switching between the Terrestrial Network (TN) and Non-Terrestrial Network (NTN) based on the AI analysis of collected data on pedestrian flow and manages base-station power to save energy. Verifies the effectiveness of a Cyber Physical System (CPS) in the Open Radio Access Network (O-RAN), one of the architectural forms for realizing Beyond 5G.

PoC 3: Digital Twin Orchestration

Defines a Digital Twin Orchestrator consisting of five functional modules and verifies whether multiple digital twins can cooperate with each other.

We shortened the lead time from the start of research and development to external deployment and accelerated research and development itself. In FY2025, we used this PoC environment to perform field tests involving cross-industry stakeholders.
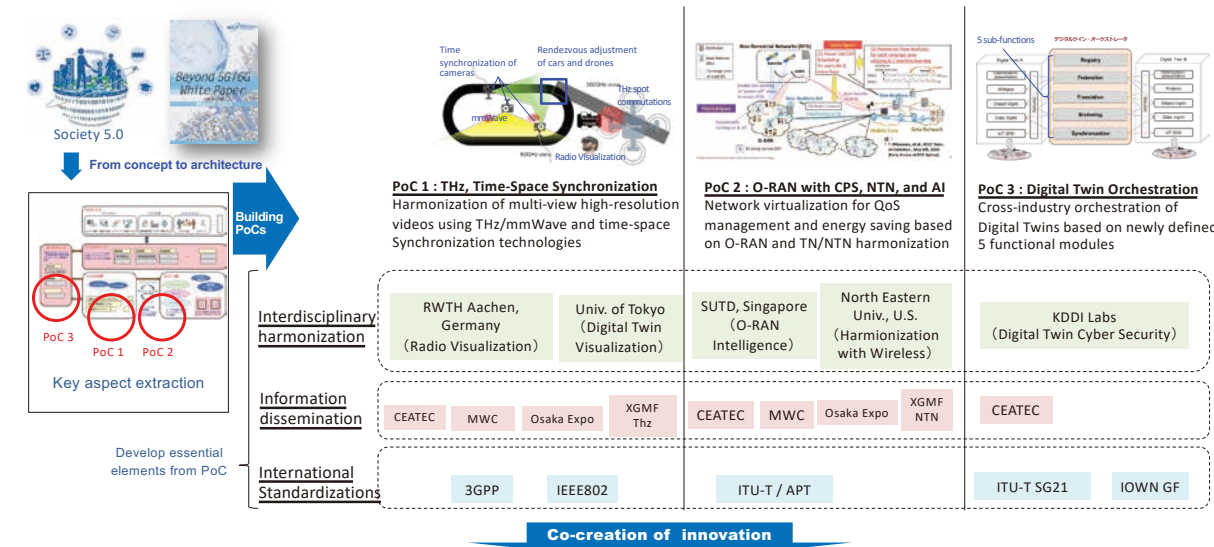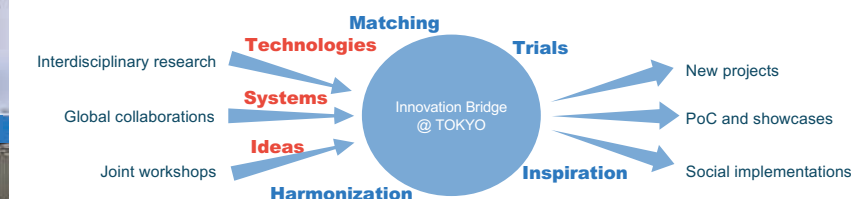

■Strengthening of International Competitiveness

International collaboration is an indispensable element to accelerating Beyond 5G / 6G research and development. The Beyond 5G architecture presented in the White Paper is a high-level concept compatible with CPS, O-RAN, NTN, AI, and other advanced technologies, and as such, it has played an important role in international collaboration.

In the research and development of fundamental technologies, Japan and Germany happened to prepare funds of a similar amount and commence research and development at the same time. Taking advantage of this opportunity, we deepened the strategic partnership between our two countries. Following an intergovernmental policy agreement concluded in May 2023, collaboration expanded with the German "6G Platform" national project under the German Federal Ministry of Education and Research. Events such as research workshops are being held twice a year, which have helped the research community grow to a level of about 100 persons. Concrete steps toward joint research have progressed such as by establishing joint-research schemes between NICT and projects under the 6G Platform and promoting collaborative fund initiatives between the two countries' funding agencies.

These series of schemes were established over a short period of only three years. They have been a fortunate outcome of a good combination of chance and necessity, and we are applying this successful model to expand our collaborative efforts with other countries and further accelerate research and development.

We have also been proactive in expanding international dissemination of information. At Mobile World Congress (MWC) Barcelona 2025, the world's largest exhibition for the mobile industry, we secured our own booth as a first for NICT and exhibited some of our PoC successes. Additionally, at the "Beyond 5G ready showcase" held by the Ministry of Internal Affairs and Communications (MIC) at Expo 2025 Osaka, Kansai, Japan, we were involved from the conceptual stage of the exhibit and showcased our PoC achievements at the venue, which were well received.

■Cross-field Co-creation Activities and Building of an Innovation Hub

To realize Society 5.0 using Beyond 5G, it is essential to involve a wide variety of stakeholders in addition to experts. Strategic participation in exhibitions such as CEATEC (since FY2022) and MWC has created a cycle of "exhibition, engagement, and collaboration" consisting of technology consultation, joint research, and collaboration toward standardization and has led to a search for new partners.

To promote discussion across industry borders, we have been holding our "Beyond 5G Zero Gravity Event" (held so far for a total of eight times). To this event, we have been inviting business leaders in different industries as well as high-school and university students and overseas researchers to hold conversations on the possibility of creating new value based on use cases in the White Paper.

With the aim of establishing obtained know-how as an intellectual asset of the entire organization and of improving Japan's international competitiveness, planning and construction activities for "Innovation Bridge @TOKYO" as an international Beyond 5G / 6G innovation hub began in FY2024. Taking advantage of its urban location and neutrality as a public research institution, this hub was designed to (1) facilitate agile initiatives and demonstrations, (2) build bridges to social implementation, (3) create new services through technology convergence, (4) merge and visualize technologies, (5) form cross-field, cross-industry connections, etc., and to lay a foundation for improving Japan's international competitiveness in the Beyond 5G / 6G field.

■Acknowledgments

The cooperation of many people is essential to realizing Beyond 5G. Thanks to the extremely positive cooperation that we have received from everyone including related research centers and departments within NICT, government ministries, universities and companies outside NICT, and overseas collaborators as well, we have been able to form spiral-shaped activities that reflect improvement × expansion in an ongoing upward manner. Our small boat has grown a little into a ship named "Beyond 5G / 6G Innovation Bridge @TOKYO." Although we are still on a voyage aiming for the "harbor (goal)" of socially implementing Beyond 5G / 6G and realizing Society 5.0, we plan to further accelerate our activities through the continued cooperation of everyone concerned.

An International Collaboration
Born of Chance yet Destined to Be

ISHIZU Kentaro

**Research Executive Director,
Director of Beyond 5G Design Initiative,
Beyond 5G Research and Development Promotion Unit**

Dr. ISHIZU received his Ph.D. in Information Science and joined NICT in 2005, where he has been engaged in research on cognitive radio systems, TV white space technologies, and Beyond 5G architectures. Ph.D. (Information Science).

"**G**lobal First" is one the basic policies in the Beyond 5G Promoting Strategy. This policy breaks away from the conventional idea of "first, solidify the domestic market, and then expand overseas." It instead places importance on activities with a view to expanding into the world from the very start. However, there is no classic approach to achieving this goal. In the process of searching for opportunities, encounters that may seem coincidental at first may eventually develop into collaborative relationships that were just meant to be. In this article, I would like to convey the true pleasure of international collaboration through examples that I have personally experienced.

Background

To dramatically expand the range of functions and data to be handled in Beyond 5G, a wide variety of technologies must be established to configure systems. Furthermore, in society of the 2030s, an approach that combines diverse industrial systems will be needed to solve complex social problems.

However, it is unrealistic to assume that individual universities, companies, or research institutions can develop all such technologies on their own. The key here is to have multiple organizations contribute their individual results and to then fuse those results together. In addition, this fusion of technologies should not be limited to domestic organizations—collaboration with overseas organizations is essential. Since each country differs in its technical strengths, collaboration beyond national borders is indispensable to achieving advanced and complex systems for Beyond 5G.

Nevertheless, even if the importance of such collaboration is understood, it is not a simple matter to decide on which countries and which organizations to collaborate with. There are cases in which collaboration is difficult due to different research phases or styles despite similar research themes. In the end, at the heart of all collaboration is "person-to-person relationships." In the process of searching for such collaboration, encounters that may seem coincidental at first may eventually develop into relationships that were just meant to be. In the following, I would like to introduce two examples of such collaboration that I have personally experienced, specifically, with Germany and Singapore.

Collaboration with Germany

On searching out opportunities for overseas collaboration, I was introduced to Professor Haris Gačanin ("Haris" below) of RWTH Aachen University in Germany through a Japanese university professor. Haris once served as an assistant professor in that professor's research laboratory, and during that time, he became familiar with the research style in Japan.

In April 2023, following an agreement between the Japanese and German governments, a workshop that brought together researchers involved in Beyond 5G / 6G was held at NICT Headquarters. Before the workshop, there was some concern over how many participants should be assembled and to what extent lively discussions should be held. On that day, though, more than 20 representatives of German universities and companies participated thereby providing an important opportunity for building bridges between the Japanese and German researcher communities.

The person acting as a liaison at this time was Haris. Since then, a biannual workshop has been held alternating between Japan and Germany, and the 7th workshop is scheduled to be held in January 2026. At present, this gathering has grown into a network of more than 100 researchers in total, and I am certain that someone in this community will be involved in future research projects launched by Japan and Germany.

In addition, Haris has been actively collaborating with a number of research laboratories within NICT. For example, he engaged in joint research on visualization technology for wireless communications with the Social-ICT System Laboratory and presented a joint demonstration at the "Beyond 5G ready showcase" organized by the Ministry of Internal Affairs and Communications (MIC) at Expo 2025 Osaka, Kansai.

Since Haris and I became liaisons between the Japanese and German research communities, we have reached this level of growth in just a few years. Even now, we talk with each other on a practically daily basis by mail or chat while looking for new challenges to pursue. Going forward, I would hope that we can nurture this valuable relationship even further.

Collaboration with Singapore

The key person in our collaboration with Singapore is Professor Tony Quek ("Tony" below) of Singapore University of Technology and Design. We first met at the WWRF Huddle 2023 international conference (held in Singapore), which I participated in alongside Iwao Hosako, Director General of the Beyond 5G R&D Promotion Unit. I later learned that Tony had experience in studying abroad in Japan.

In the same year, at the Internet Governance Forum 2023 (IGF 2023), which was held for the first time in Japan, it was decided that NICT would organize a panel session under the theme of "Future Network Systems as Open Service Platform in Beyond 5G / 6G Era." At that time, I asked Tony to speak as one of the four experts that we invited from various countries. These discussions later evolved into talk on technology policies at MIC.

Tony is also a leading researcher in the Open RAN field. He later collaborated with the NICT Network Architecture Laboratory in constructing a demonstration system equipped with AI-based power-saving functionality using Open RAN. Additionally, at Mobile World Congress 2025, we presented a live demonstration connecting Singapore, Japan, and Spain.

In Asia, Tony has taken on a leadership role in this field, and we inevitably meet several times a year at international conferences. If visiting nearby to each other on business, we will visit in person to exchange ideas and opinions, so we continue to maintain close ties.

For Japan to Thrive at the Center of the World

At actual sites of international collaboration, problems caused by difference in systems or procedures tend to pop up one after another. It is important that such problems be clearly resolved one by one while receiving the support of experts. In some cases, it may take even half a year to resolve issues related to just procedures. Nevertheless, the possibilities of research and development broaden significantly through international collaboration.

Research projects have their ups and downs, and they may be temporarily suspended due to organizational policies or funding issues. Nevertheless, the bonds between people are an irreplaceable asset. Trustworthy relationships like the ones I introduced here could continue for 10 or even 20 years. Relationships don't terminate just because a project ends. I would like to build lasting and indispensable relationships and live the life of a researcher while understanding each other's values, viewpoints, and challenges.

Photo 1　Group Photo at the 5th Germany-Japan Beyond 5G / 6G Research Workshop (January 2025 in Sendai, Japan; Haris is seated to the right of President Hideyuki Tokuda in the lower row at center)

Photo 2　Panel discussion at IGF 2023 (October 2023 in Kyoto; Tony is at the far right and the author is at the far left)

Photo 3　Tony explaining the joint demonstration with NICT during the visit to Singapore of Hideto Kawasaki, Parliamentary Vice-Minister for Internal Affairs and Communications (at that time) (May 2025 at Singapore University of Technology and Design)

Beyond 5G Ready Showcase
From Concept Planning to Exhibition Management

Photo 3　View of the venue entrance

Photo 4　"Beyond 5G Ready Showcase" signage @ WASSE

SHIROYAMA Naomi
Chief
General Planning Office,
Beyond 5G Design Initiative,
Beyond 5G Research and Develop-
ment Promotion Unit
Joined NICT in 2010, and she worked in the Management Planning Department for eleven years as a secretary. Then she has been with the Beyond 5G Research and Development Promotion Unit since 2021.

O n April 13, 2025, exactly 55 years after Japan's first World Exposition was held on the Senri Hills of Osaka, the Osaka–Kansai Expo opened once again, this time on the man-made island of Yumeshima. Under the theme "Designing Future Society for Our Lives," the Expo became a venue where wisdom from around the world converged through cutting-edge exhibits and immersive experiences that envision the society of tomorrow.

In this article, we look back on the behind-the-scenes story of the exhibit project for the Ministry of Internal Affairs and Communications' "Beyond 5G Ready Showcase," in which the NICT Beyond 5G R&D Promotion Unit provided support from initial planning to on-site exhibition operations.

■ **The Excitement behind the Scenes**

The Osaka–Kansai Expo set forth ambitious goals: showcasing advanced technologies, stimulating investment, fostering innovation through networking, revitalizing regional economies and small businesses, and promoting cultural exchange. The venue was Yumeshima in Osaka, marking the city's second time hosting a World Expo since 1970.

The official mascot Myaku-Myaku, along with frequent media reports on construction progress, kept public attention, both positive and negative, firmly fixed on the Expo. In the spring of 2024, I had the chance to encounter Myaku-Myaku at another exhibition venue and even had the opportunity to "greet" it. Standing face-to-face with its strange yet oddly endear-

ing appearance, I couldn't help but exclaim, "Oh!" It was an emotion difficult to put into words. But when we took a photo together, I suddenly felt a quiet joy, as if the Expo had become something personally familiar.

■ **Moving toward the Exhibition**

In the spring of 2024, less than a year before the Expo's opening, the Ministry of Internal Affairs and Communications (MIC) formally requested NICT's cooperation for participation in the Osaka–Kansai Expo. In response, the Beyond 5G R&D Promotion Unit joined the project, taking the lead on ZONE 3 (Beyond 5G Technology Exhibits) while also supporting planning for ZONE 1 and ZONE 2.

The starting point was "NICT Open House 2024." While staffing the exhibition at NICT headquarters (Koganei, Tokyo), members of the MIC-contracted company responsible for Expo planning and operations visited our booth and approached us with the cheerful introduction, "We are here to learn about Beyond 5G and orchestration!" Their enthusiasm and bright smiles made me think, "This is going to become a major project." From that moment, preparations for NICT's Expo exhibit began in earnest.

At the weekly joint meetings, representatives from MIC, the contracted company, and all relevant NICT departments gathered to thoroughly discuss every aspect of the exhibition, from the overall structure and visitor flow to the precise wording of explanations, down to individual phrases.

With every session, discussions grew more energetic. Through close coordination among all parties, we steadily refined the exhibition content and strengthened the coherence of our messaging. It was clear that the project was steadily taking shape.

■ **A vision of the Future through Three ZONES**

ZONE 1: Prologue Theater

Stepping into the immersive theater, which is surrounded by a 180-degree screen, visitors are taken on a sweeping journey from the histo-

ry of communications to the future world of Beyond 5G. From the planning stage onward, we were deeply involved in shaping the storyline, revising and editing the footage repeatedly to ensure intuitive understanding for all visitors. The moment I experienced the completed space firsthand, I felt my heart race at its beauty and impact.

ZONE 2: Future City Area + Technology Experience Booths

Five interactive booths were designed to allow visitors to experience a future society enabled by Beyond 5G:

- Remote Moon Operation — repair a lunar robot remotely via VR
- Ocean Cleaning — control an underwater robot through human motion
- Virtual Pitching — play catch with people or AI players in remote locations
- HAPS Recovery — restore communications from a tablet using HAPS technology
- Cross-Connect City — visualize industrial collaboration networks

We faced the challenge of translating advanced technologies into tangible, engaging visitor experiences, and carried out repeated discussions and testing to refine each booth.

In particular, Cross-Connect City was created through the collective effort of the entire Beyond 5G R&D Promotion Unit. We wrestled with the question of how to translate the concept of "industrial orchestration," featured in the NICT White Paper, into an accessible scenario that general visitors could intuitively grasp. After much trial and error, the booth finally took shape. Seeing the finished exhibit brought an immense sense of relief and accomplishment.

ZONE 3: Beyond 5G Technology Exhibition

The ten booths showcasing cutting-edge research in progress were truly impressive. Through panels, video presentations, and hands-on demonstrations, researchers conveyed their passion directly to visitors.

- Foundational technologies for all-optical networks
- Power-saving base station technologies using AI and NTN
- "Just for Now, Just for Here, Just for You"—technologies enabling digital-twin services
- New communication technologies for underwater and marine environments
- Private-network communications enabling drone control beyond line-of-sight, even outside mobile coverage
- Ultra-wide-area communications via airborne base stations (HAPS)
- Three-dimensional space communication networks linking space, sky, and ground
- Space-weather forecasting technologies that support stable communication
- Cyberattack observation and analysis system "NICTER"
- Human augmentation and remote-work support systems

Each booth clearly illustrated how the respective technology could transform society. Standing on the exhibition floor as an attendant, I could directly sense visitors' enthusiasm and engagement.

Over the nine-day run, the exhibition attracted more than 40,000 visitors, far exceeding the initial target of 20,000, and underscored the strong public interest in Beyond 5G.

■ **The Energy on the Ground**

When I first visited the Yumeshima site in March 2025, the scene left a vivid impression. Construction of national pavilions was progressing at a rapid pace, with the sounds of heavy machinery echoing across the grounds as exhibitors raced to prepare for opening day.

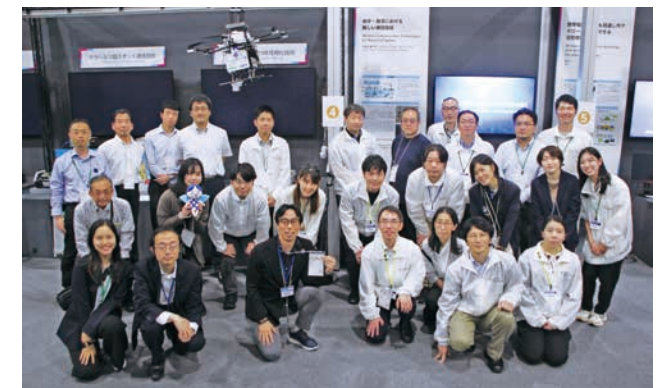Our own exhibition venue, EXPO Messe

Photo 5　NICT exhibition team

(WASSE), stood about a 20-minute walk from Yumeshima Station. Its exterior was modest, yet for those involved in the Beyond 5G Ready Showcase, it felt very much like a "mecca"—a sacred place at the center of our efforts and expectations.

■ **In Closing**

The Osaka–Kansai Expo was more than an exhibition, it became a stage for sharing the possibilities of a future society with a broad and diverse audience.

Throughout the event, we engaged directly with visitors of all ages, including many from overseas, listening to their questions and comments while deepening their understanding and interest in Beyond 5G. It was also a valuable opportunity to strengthen collaboration with domestic and international research institutions and industry partners, and to communicate our research outcomes to society.

This experience reaffirmed the importance of connecting research results to real-world impact.

Moving forward, the NICT Beyond 5G Research and Development Promotion Unit will continue to drive societal deployment and international outreach of our work, contributing to the realization of the Beyond 5G era.

Photo 1　Yumeshima Station, the main gateway to the Expo site

Photo 2　First encounter with Myaku-Myaku in 2023

Towards Beyond 5G Society
Industry Perspectives on NICT's Initiatives

TAKAHASHI Kazuaki

Managing Expert,
Beyond 5G Design Initiative,
Beyond 5G R&D Promotion Unit

After graduating with a master's degree in engineering, he worked at Matsushita Electric Industrial Co., Ltd. (now Panasonic Holdings Corp). He joined NICT in 2024 and has since been engaged in co-creation activities with global research institutions, companies, and industry consortia to realize Beyond 5G / 6G technologies. He holds a Ph.D. in Engineering.

Since joining the former Matsushita Electric Industrial Co., Ltd. in 1988, I have been engaged in research and development of mobile communications, particularly RF devices. In this article, I offer an external, industry-based perspective on Beyond 5G (B5G), drawing on my own career while reflecting on the evolution of the ICT sector.

■ Background (History of my work and the ICT Industry)

From the late 1980s through the early 1990s, commercial deployment of analog mobile phones (1G) had only just begun. Until around the introduction of the third generation (3G) in the early 2000s, Japan's mobile communications industry was leading the world. However, with the emergence of smartphones in 2008, the structure of the industry changed dramatically. Businesses that derived value directly from communication functions began to shrink, and the focus shifted toward industries that use communications and networks o deliver new value.

Against this backdrop, my company underwent a reform in which its research and development functions were transferred to business divisions. As engineers became dispersed across the organization, challenges emerged in maintaining company-wide technology strategies and standardization activities. To address this, a cross-organizational virtual structure—the "Core Technology Platform"—was established. Communication-network technologies were designated as one of its priority areas, and within this platform I was involved in identifying key technical issues and formulating medium- to long-term strategies.

This does not apply to all companies, but from the standpoint of a firm offering products that rely on Beyond 5G / 6G (such as network-connected home appliances), communication-network technologies were understood in the following way. As 5G and 6G increasingly serve as indispensable social infrastructure, "being connected" is now assumed, and thus

less likely to be recognized as a source of technical value. Consequently, communication networks tend to be viewed not as an investment but as a cost, prompting companies to reduce dependence on telecom carriers and to seek cost reductions through private networks.

In recent years, network virtualization has advanced. By combining diverse communication methods, such as cellular, Wi-Fi, and BLE (Bluetooth Low Energy), along with cloud and edge-computing technologies, companies are now able to construct flexible architectures. Many viewed this as an opportunity to generate new value through data utilization. Yet in practice, companies remain unable to break free from reliance on carrier networks, producing a persistent dilemma. Figure 1 illustrates this dilemma between the opportunities for new value creation resulting from changes in communication networks and the implementation challenges (upper direction: the ideal; lower direction: the reality). Big Tech companies are increasingly enclosing user data, and their interest has expanded to include home-appliance data. To enhance user convenience while protecting privacy, as well as to ensure that such data can also be leveraged for the company's business, optimal architecture design, including communications networks and edge processing, is essential. However, with a shortage of architect-type talent, companies struggle to utilize user data effectively; added value is absorbed by Big Tech; and the ability to cultivate architectural experts continues to erode. As a result, reliance on the architectures of telecom carriers becomes unavoidable, and the capacity to envision medium- to long-term technology strategies is further diminished, creating a chain reaction of challenges across the organization.

■ How industry views NICT's Beyond 5G efforts (reflections on the white paper)

NICT's Beyond 5G White Paper [*1] was first published in March 2021 and updated to its third edition in March 2023. When it was released, I was working in a corporate R&D division responsible for formulating
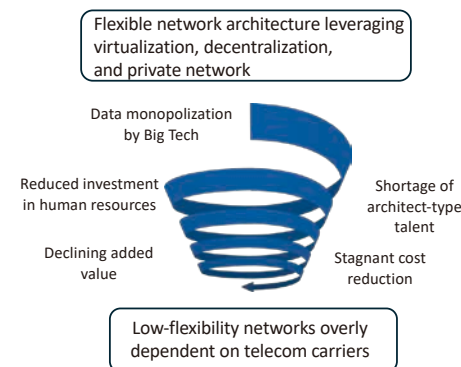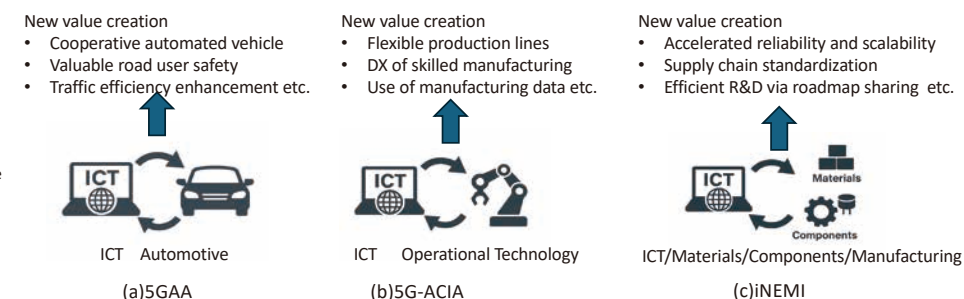
medium- and long-term strategies. Although the white paper served as one of several reference sources, I did not view it as highly important at the time. Despite its distinctive approach of backcasting from future scenarios, it did not seem to offer direct solutions to the immediate issues we faced.

Looking at it again now, I can see that it clearly addressed many of the challenges we were grappling with. For example, its discussion of network virtualization and hardware openness implied a shift away from traditional architectures dependent on telecom carriers toward architectures that users themselves can design freely in a Beyond 5G environment. This aligns well with the challenges recognized by industry.

The white paper also discusses distributed infrastructure, the use of private communication systems, and the transition from exclusive ownership to sharing and shared use. While not stated explicitly, these ideas can be interpreted as pointing toward reduced dependence on telecom carriers and opportunities for cost reduction.

In reality, however, the number of people capable of designing and implementing optimal architectures is extremely limited, both within companies and across Japan as a whole. To realize the world envisioned by NICT for Beyond 5G, it will be essential to cultivate such architect-type talent or to build mechanisms that can serve as a substitute. Establishing this human foundation is an urgent issue if we are to validate the soundness of new technologies and bring them into societal use.

■ What standardization and industry initiatives reveal about NICT's Beyond 5G Vision (What is needed for widespread adoption?)

Since around 2000, I have been involved in standardization activities in groups such

as IEEE 802.15 (wireless PAN) and IEEE 802.11 (wireless LAN). One of the key lessons from this experience is that excellent technology does not automatically become a standard. As communication systems become more complex and performance comparisons more difficult, the number of supporters who stand behind a proposed technology becomes the decisive factor. Once a technology is standardized and moves into practical use, investment across the industry increases, which in turn further refines the technology. In short, broad support is essential for any new technology to gain traction.

From around 2015, I also had opportunities to participate in the creation of de facto standards through industry consortia. Figure 2 shows examples of cross-industry groups I was involved in: (a) 5GAA (5G Automotive Association), which brings together the automotive and ICT sectors [*2]; (b) 5G-ACIA (5G Alliance for Connected Industries and Automation), which connects the manufacturing and ICT sectors [*3]; and (c) iNEMI (International Electronics Manufacturing Initiative), which involves companies from electronic devices, materials, telecom equipment, and more [*4].

What these organizations have in common is a commitment to creating new value through collaboration across different industries. For example, the group shown in Figure 2 (a) aims to enhance safety and energy efficiency by connecting vehicles with people and social infrastructure. The initiatives in (b) and (c) pursue new forms of value that would be difficult for a single company or industry to achieve on its own.

This philosophy aligns with NICT's concept of "inter-industry orchestration," which seeks to generate new value by linking data that has traditionally remained siloed within individual industries.

The difference is that industry consor-

tia typically limit their scope to a particular sector, while NICT's vision represents a far broader and more ambitious framework.

These consortia already include around one hundred global companies, research institutes, and universities, forming strong communities of aligned stakeholders. For NICT's Beyond 5G initiatives to gain widespread adoption, it will be essential to expand recognition and build a similarly broad base of supporters around the world. This is a critical area of activity for all of us involved.

■ Future Prospects

Reflecting on NICT's Beyond 5G vision through the lens of my experience in the private sector, it is clear that the key concept of inter-industry orchestration is well aligned with current industry trends. The underlying technical elements—virtualization, distributed networks, and the use of private networks—also move in the same direction.

However, achieving this vision and bringing it into real-world deployment will require a broad human network that connects people across industries and across the globe. Building a worldwide community of supporters who share and endorse this way of thinking will be essential for realizing a Beyond 5G society. I hope that many readers of this article will become part of that growing network of supporters.

Figure 1　Network transformation: new value creation vs. implementation dilemma

Figure 2　Examples of cross-industry collaborative consortia

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*1 Beyond 5G / 6G white paper version 3.0 (released in June 20) https://beyond5g.nict.go.jp/images/download/NICT_B5G6G_WhitePaperEN_v3_0.pdf
*2 https://5gaa.org/
*3 https://5g-acia.org/
*4 https://www.inemi.org/

Energy-efficient Power Management for Open RAN

Research Manager, Network Architecture Laboratory, Network Research Institute **MIYAZAWA Takaya**

The power consumption of base stations continues to increase posing a worldwide problem. This article focuses on the Open Radio Access Network (O-RAN) that is expected to drive innovation in RAN and introduces energy-efficient power management to reduce power consumption in O-RAN base stations from a network perspective.

As a next-generation RAN standard, O-RAN has recently been drawing attention with specifications being discussed and drafted at the O-RAN Alliance. The O-RAN standard features "openness" to enable the speedy provision of services and the accommodation of equipment from different vendors and "intelligence" to enable the automation and enhancement of network operations. In terrestrial RAN, the provision of services for a variety of coverage areas with diverse frequency bands such as existing 4G-LTE and 5G, local 5G, etc. is on the increase causing an upward climb in the number and types of wireless base stations. The resulting increase in power consumption is consequently becoming a worldwide problem. Furthermore, in the upcoming commercialization of 6G services, while it will be necessary to keep the system for existing services up and running for a while as a transition period, it will also be necessary to install new wireless base stations for 6G thereby exacerbating the problem of power consumption in terrestrial RAN. Moreover, all base stations are always ON in conventional RAN, which means that they are operating even in coverage areas having a small number of mobile terminals and a small amount of communications traffic causing power to be wasted.

On the other hand, there has recently been an upsurge in research and standardization discussions on the convergence of the Terrestrial Network (TN) with Non-Terrestrial Networks (NTN) circuits consisting of communication satellites and High Altitude Platform Station (HAPS) aircraft in the stratosphere, all with the aim of expanding covered areas and improving fault tolerance.

With the aim of achieving a mobile system conforming to O-RAN, we are researching and developing energy-efficient power management technology for base stations using both AI-based data analytics and NTN circuits. As shown in Figure 1, the upper Cyber Space uses AI to analyze and predict change in the number of mobile terminals, i.e., pedestrian flow for each base-station coverage area at fixed intervals. Then, based on prediction results, it schedules in advance power-ON/OFF for the base station in each coverage area likewise at fixed intervals. The scheduling performed at this time takes into account the NTN communication capacity that can be ac-
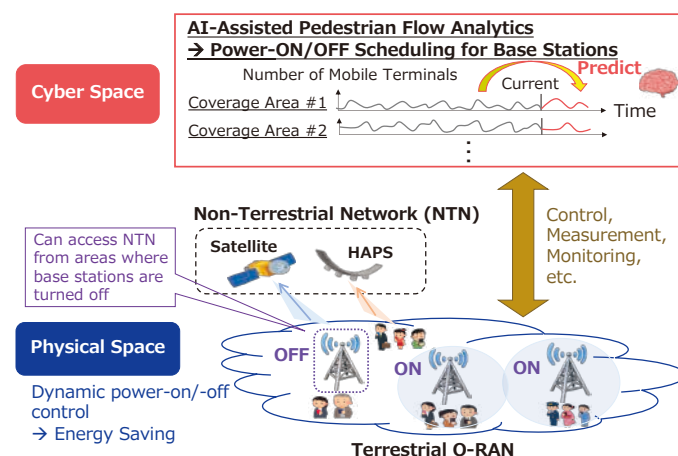

Figure 1   O-RAN power management utilizing AI-assisted pedestrian flow management and NTN

cessed from that area.

Then, based on the above scheduling results, the lower Physical Space automatically performs base-station ON/OFF control at the designated time. Here, mobile terminals in an area in which the base station is turned OFF will be able to continue communications by accessing NTN. Compared to terrestrial base stations, NTN has small communication capacity but an extremely broad coverage area per base, so it can accommodate many areas having little terrestrial communication traffic. This means that many terrestrial base stations can be turned OFF thereby reducing RAN power consumption.

Going forward, we will continue to research and develop methods of achieving further energy savings in O-RAN toward the realization of Beyond 5G / 6G.

＊ T. Miyazawa, K. Ishizu, H. Asaeda, H. Tsuji, and H. Harai, "Energy-Efficient Power Management for O-RAN Base Stations Utilizing Pedestrian Flow Analytics and Non-Terrestrial Networks," IEICE Transactions on Communications, vol.E107-B, Issue 11, pp.739-753, Nov. 2024.

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Agri-Chain 1st Networking Event Held!

Researcher, Beyond 5G Design Initiative, Beyond 5G Research and Development Promotion Unit **YAMASHITA Aika**

The Agri-Chain was launched with the aim of using ICT to link industries centered about the field of agriculture. The 1st Networking Event was held on September 4, 2025 as a forum for wide-ranging discussions and networking on a relatively large scale compared with other meetings of the Agri-Chain Event. Nearly 20 experts, business people, and others interested in agriculture and Beyond 5G technology participated, and the event came to a close with great success.

The Agri-Chain aims to create new value through the exchange of knowledge between people in different fields not limited to agriculture. In fact, the 1st Networking Event that was just held was a scene in which discussions expanded from agriculture to even refrigeration technology, robotics, profit-making mechanisms, logistics, and laws. I feel that exchanges and discussions like these were a first step toward co-creation by providing an opportunity for original ideas to grow.

In addition, a desire was expressed in the event's planning stage for deep and extensive discussions covering not only "current issues" but also "a bright future for agriculture." Group discussions at this networking event included opinions with an enthusiastic view of the future expressed by "It would be great if this were possible!" They conveyed the feeling that new forms of collaboration are possible. Going forward, the plan is to dig deeper into the themes that came out of the 1st Networking Event and to hold "agriculture get-togethers" connected to specific collaborative activities and to field trips and demonstrations too. We wish to collaborate with experts and experienced individuals in the agricultural field, of course, as well as with engineers and researchers with interest in Beyond 5G technology and those involved in agriculture × ICT.

By the way, on a personal note, I joined NICT in April of this year, and the first meeting that I attended was actually related to this

YAMASHITA Aika

**Researcher,
Beyond 5G Design Initiative,
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After completing a master's program at graduate school, joined NICT in 2025. Engaged in initiatives that promote collaboration and co-creation across industries.

Agri-Chain Event. On the fourth day after entering NICT with everything still new to me, I remember heading over to the NICT Innovation Center and attending the meeting while being somewhat confused about "agriculture" as a theme here. I first thought "Why is NICT holding an agricultural event?" and I've actually been asked the same question as well. The Agri-Chain is an initiative that, while focused on agriculture, provides an opportunity for cross-industry collaboration. From here on, I would sincerely like to create new value working together with all of you. I also find the gap between NICT and agriculture interesting, and I'm very excited that it's exactly this Agri-Chain where that gap may be narrowed.

At present, we are working on creating an Agriculture Room inside the "Innovation Bridge @TOKYO" collaboration hub for fostering innovation in Beyond 5G / 6G R&D, which is scheduled to officially open next spring. Specifically, we are preparing to create a space where visitors can not only view installations but also engage in new collaborative activities and co-creation by actually trying out various things. After the opening, I hope that many people have a chance to make use of the room and bring in their knowledge and experience in the spirit of "I want to incorporate this in the Agriculture Room!" This is cross-industry collaboration starting from agriculture, undertaken by NICT. Please watch out for future developments!

Photo 1   Group discussions on "agriculture issues" and "future agriculture" at Agri-Chain, 1st Networking Event (September 4, 2025)

Photo 2   The author serving as moderator at the same event.

NICT will be exhibiting at MWC again this year.

MWC
GSMA

2-5 MARCH 2026
Fira Gran Via, Barcelona

Toward AI-Native Beyond 5G/6G World

photo : MWC25

CONNECT

Sustainable O-RAN Intelligence

THz Mobile Backhaul

Space-Time Synchronization

Miniaturized Optical Terminals

EXPAND

AI-Empowered
Ultra-Spot Communication

Reliable Cybernetic Avatar

Localized
Multilingual Communication

SECURE

Tokyo QKD Network

Real-Time Cyberattack Monitor