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Disaster Prevention and Mitigation with ICT

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About ITU-AJ

The ITU Association of Japan (ITU-AJ) was founded on September 1, 1971, to coordinate Japanese activities in the telecommunication and broadcasting sectors with international activities. Today, the principle activities of the ITU-AJ are to cooperate in various activities of international organizations such as the ITU and to disseminate information about them. The Association also aims to help developing countries by supporting technical assistance, as well as by taking part in general international cooperation, mainly through the Asia-Pacific Telecommunity (APT), so as to contribute to the advance of the telecommunications and broadcasting throughout the world.

Initiatives for Securing Communications during Disasters

Network Safety and Reliability Division
Telecommunications Business Department
Telecommunications Bureau
Ministry of Internal Affairs and Communications

1. Introduction

In recent years, natural disasters such as earthquakes, typhoons, heavy rains, floods, landsides, and volcanic eruptions have been occurring with increasing frequency in Japan, disrupting communication services through power outages, failures of communication equipment, severance of cables, etc. These include the earthquake that occurred in the Noto region of Ishikawa Prefecture on January 1, 2024 (referred to below as "Noto Peninsula earthquake") followed by heavy rains in the same area, large-scale damage from flooding in the Kyushu region, and in 2025, large-scale forest fires in Ofunato City, Iwate Prefecture.

At the time of a disaster, communications serve as a vital lifeline not only for residents to convey information but also for disaster response organizations to coordinate information. In addition, lifelines such as communications, power, and transport have an interdependent relationship in which problems in one lifeline can affect other lifelines. Here, a speedy response and restoration of communication services are essential to the speedy restoration of other lifelines.

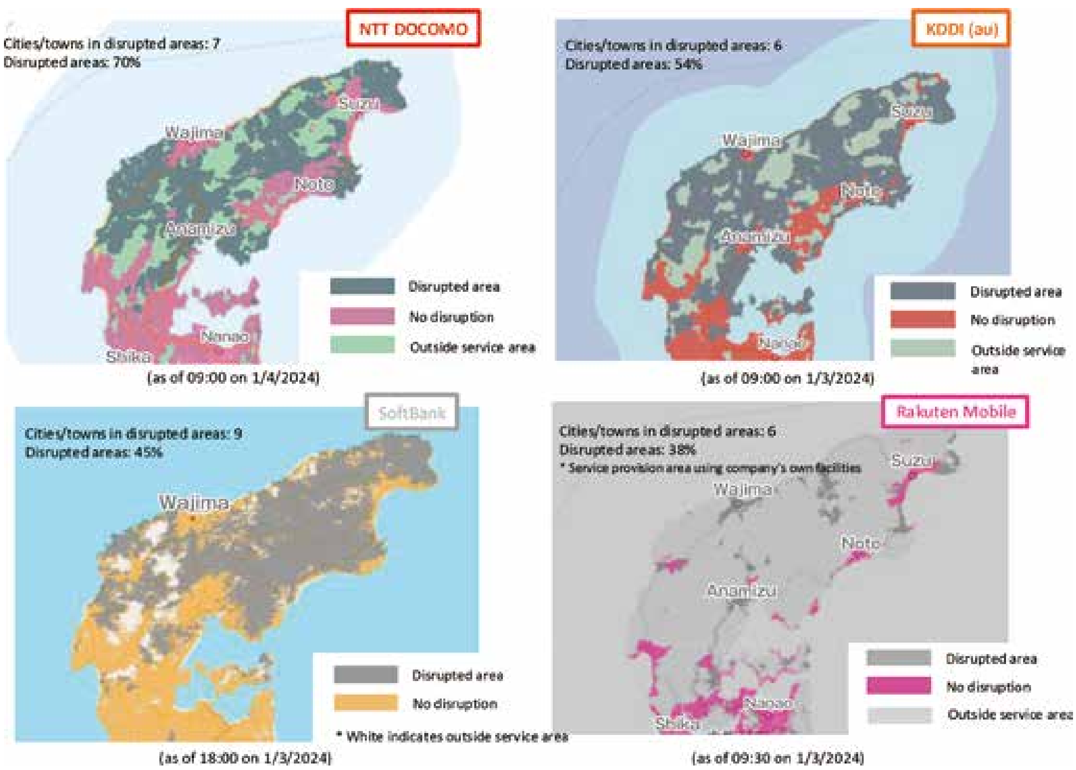
Based on the lessons learned from the Noto Peninsula earthquake, the Ministry of Internal Affairs and Communications (MIC) is strengthening its initiatives for securing communications with a focus on widespread damage from a large-scale disaster such as a Tokyo Metropolitan earthquake or Nankai Trough earthquake that is expected to occur sometime in the future.

This article first surveys the damage to communication services caused by the Noto Peninsula earthquake. It then introduces efforts made by MIC and telecommunication carriers to secure communications during this disaster and the strengthening of initiatives for securing communications in the future.

2. Overview of Damage to Communication Services in the Noto Peninsula Earthquake

In the Noto Peninsula earthquake, it was reported that a maximum of 839 base stations (799 in Ishikawa Prefecture) for mobile phones, etc. of NTT DOCOMO, KDDI, SoftBank, and Rakuten Mobile combined (Figure 1) stopped operating due

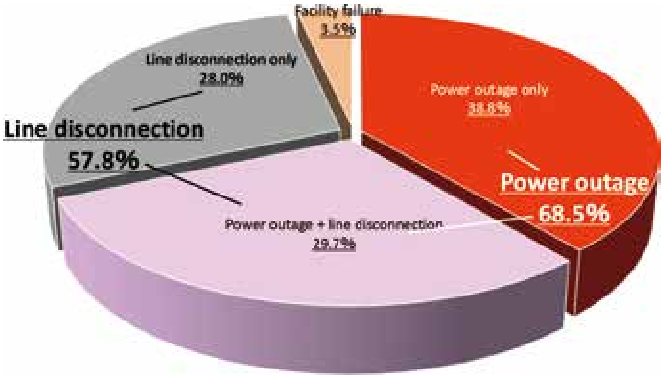
■ Figure 1: State of area disruption for mobile phones (during maximum area disruption)



to disconnected transmission lines caused by long-term power outages, landslides, and other issues occurring immediately after the disaster (as of January 3, 2024), as shown in Figure 2.

Amid a number of problems such as road closures due to landslide disasters, liquefaction, etc. and congestion on highways leading into affected areas, the above mobile phone companies brought in portable base stations, portable satellite antennas, portable generators, and other types of emergency restoration equipment. As a result, emergency restoration was completed for the most part by January 17, 2024 except for areas difficult to access because of landslides, etc. (remaining work was completed by the end of June of that year). In addition, steady progress was made in fully restoring base stations to their original functions in parallel with the above emergency restoration.

■ Figure 2: Causes of mobile-phone base station stoppage in the Noto Peninsula earthquake



In terms of fixed communications, a service-unavailable state occurred centered on cities and towns such as Wajima, Suzu, and Shika, in Ishikawa Prefecture. A number of communication buildings lost power because of the earthquake, and in addition, relay transmission lines and cables were damaged and large-scale service failures occurred due to landslides, etc. affecting a maximum of 20 communication buildings.

With the aim of reopening services, restoration of core facilities proceeded by supplying power to communication buildings using mobile power supply vehicles and portable generators, repairing damaged cables, installing new cables in disconnected-line intervals, and rerouting to undamaged relay transmission lines. In this restoration work, priority was given to emergency restoration of circuits connected to important hubs and circuits connected to base stations of the various mobile phone companies. Additionally, in the event of breaks in fixed telephone lines to city halls and town halls, communications were secured using a call forwarding service as an emergency response.

3. Efforts in Securing Communications in Noto Peninsula Earthquake

In the Noto Peninsula earthquake, telecommunication carriers made a variety of efforts to restore communication services. The following introduces some of these efforts.

(1) Deployment of mobile/vehicle-mounted base stations, mobile power supply vehicles, and portable generators

To deal with disconnections in transmission lines due to landslides and other calamities and prolonging of power outages that began immediately after the earthquake, mobile phone companies put into operation a maximum of about 100 mobile and vehicle-mounted base stations while the public and private sectors together deployed a maximum of about 200 mobile power supply vehicles and portable generators (Figure 3).

■ Figure 3: Vehicle-mounted base station and mobile power supply vehicle

(2) Use of mobile base stations

NTT DOCOMO and KDDI jointly deployed shipboard base stations for part of the coastal area of Wajima city difficult to access and restore by land routes. This means the installation of mobile-phone base station facilities on an ocean-going vessel, which was accomplished using the cable-laying vessel KIZUNA owned by the NTT DOCOMO Group. In addition, SoftBank deployed drone base stations capable of long-term flight by supplying power over a wire from ground power supply equipment. By mounting wireless relay equipment on these drones, radio signals could be delivered to terminals from the air thereby supplementing the communication area (Figure 4).

■ Figure 4: Shipboard base station and wire-powered drone base station

(3) Use of satellite communication services

In the Noto Peninsula earthquake, communication services became unusable in many areas due to disconnected transmission lines, power outages at base stations, etc. Under these conditions, Low Earth Orbit (LEO) satellite communication services were widely used for emergency restoration. KDDI, for example, worked to restore communications by replacing communication cables such as optical fibers (base-station backhaul circuits) severed by landslides, etc. with satellite circuits to serve as backhaul circuits.

In addition to KDDI, NTT DOCOMO and SoftBank provided LEO satellite communication services to evacuation centers and Disaster Medical Assistance Teams (DMAT) to enable Internet communications via Wi-Fi. In total, 660 units of LEO satellite communication services (KDDI, SoftBank, and NTT DOCOMO) were provided to evacuation centers and elsewhere.

(4) Lending of communication equipment

The Noto Peninsula earthquake significantly affected telephone, Internet, and other communication services forcing the use of satellite mobile phones especially in hard-hit areas. The MIC lent out a maximum of 102 satellite mobile phones, which had been stockpiled as mobile communication devices for disaster response, to local governments and other entities free of charge. Telecommunication carriers likewise lent out mobile terminals and satellite communication equipment free of charge.

(5) Other efforts by telecommunication carriers

Telecommunication carriers were also involved in the following activities.

a) Roll out of disaster message services

During the disaster, NTT East, NTT West, NTT DOCOMO, KDDI, SoftBank, and Rakuten Mobile rolled out disaster message services.

b) Provision of free Internet connection services

From January 1, NTT DOCOMO, KDDI, SoftBank, Wire and Wireless, and Rakuten Mobile provided public wireless LAN free of charge in Ishikawa, Niigata, Toyama, and Fukui prefectures using “00000Japan” (Five Zero Japan) as a uniform Service Set Identifier (SSID).

4. Strengthening the Securing of Communications based on Response to Noto Peninsula Earthquake

At MIC, we have been working even in normal times on initiatives for securing communications in collaboration with telecommunication carriers and other related institutions. The following introduces the strengthening of initiatives in normal times for securing communications based on the response to the Noto Peninsula earthquake disaster.

(1) Establishing standards on measures that telecommunication carriers should adopt

At MIC, Standards for the Safety and Reliability of Information and Communication Networks (Ministry of Posts and Telecommunications (MPT) Notice No. 73 of 1987), which specify earthquake countermeasures, power-outage countermeasures, and fire prevention measures that telecommunication carriers should adopt, are regularly revised requesting, for example, the installation of backup power supplies and redundant transmission lines.

Specifically, as to base stations and communication buildings (referred to below as “base stations, etc.”) that cover prefectural offices and city, town, and village offices that serve as hubs of disaster response activities, power-outage countermeasures that last for at least 24 hours are required, and power-outage countermeasures that last for at least 72 hours are recommended in the case of base stations, etc. that cover prefectural offices. Based on these safety and reliability standards, telecommunication carriers have implemented certain initiatives for making base stations, etc. more resilient.

On the other hand, as made clear by the Noto Peninsula earthquake, there are locations with limited access routes such as those on a peninsula. As a result, roads may become difficult to use due to disaster-related landslides or other problems thereby prolonging the disruption of commercial power supplies and breaks in transmission lines. It may also take time to mount an emergency restoration in such areas. Furthermore, while mobile phones and other devices have been used for collecting information in relation to disaster response activities by national government institutions, no rules have existed on power-outage countermeasures for base stations, etc. that cover the buildings of such national institutions. For this reason, revisions were made to the Standards for the Safety and Reliability of Information and Communication Networks in March 2025. These revisions recommended power-outage countermeasures for base stations, etc. that cover city, town, and village offices and the buildings of national government institutions in peninsula areas, as summarized in Table 1.

■ Table 1: Standards for the Safety and Reliability of Information and Communication Networks (excerpt)

“Standards for the Safety and Reliability of Information and Communication Networks” (Notice)

＊ Underlined items correspond to March 2025 revisions

Power-outage countermeasures

- Mobile phone base stations, etc. that cover prefectural offices, city, town, and village offices, and special ward offices
  → Power-outage countermeasures for at least 24 hours (obligatory)
- Mobile phone base stations, etc. that cover prefectural offices and city, town, and village offices on remote islands and peninsulas
  → Power-outage countermeasures for at least 72 hours (recommended)
- Mobile phone base stations, etc. that cover national institutions
  → Power-outage countermeasures for at least 72 hours (recommended)
- Mobile phone base stations, etc. that cover disaster base hospitals
  → Power-outage countermeasures for at least 24 hours (recommended)

In addition, the following measures are obligatory from the viewpoint of preparing for large-scale disasters.

- Formulation of plans for deploying emergency restoration equipment
- Study of methods for coordinating restoration activities including priorities in restoring damaged facilities

(2) Making mobile-phone base stations resilient in a disaster and strengthening functions of information-communication hubs

In addition to formulating standards as described in (1) above, there is a project at MIC for making mobile-phone base stations resilient to prevent them from stopping operation due to power outages or breaks in transmission lines at the time of a disaster. This would be accomplished through a variety of measures including the use of large-capacity storage batteries and power generators plus solar panels and satellites to maintain base-station functions.

Furthermore, in addition to the above initiative toward resilient base stations, there is a need for early deployment of equipment essential to emergency restoration in the event that the communication infrastructure is damaged in a disaster. The aim here is to secure communications of disaster-prevention hubs such as prefectural offices, city, town, and village offices, and disaster base hospitals. To meet this need, there is also a project at MIC for strengthening the functions of information-communication hubs by accelerating the deployment of emergency restoration equipment and securing communications at disaster-prevention hubs such as city, town, and village offices and disaster base hospitals at the time of a disaster. To this end, subsidies have been established for some of the expenses incurred by mobile phone companies and fixed-communication carriers when purchasing emergency restoration equipment such as mobile power supply vehicles and portable base stations for deployment to government offices and elsewhere.

(3) Other initiatives for securing communications at MIC

In addition to initiatives (1) and (2) described above, MIC promotes collaboration among related parties essential to maintaining and restoring communications such as telecommunication carriers, power companies, fuel suppliers, road administrators, local governments, and MIC itself and conducts training annually to improve effectiveness.

Moreover, to ensure communications related to emergency restoration activities at a local government even if existing communication services have failed at the time of a disaster, MIC has established a system to enable wireless equipment such as satellite mobile phones to be quickly loaned out to local governments. Additionally, to ensure communications at evacuation centers, mobile power supply vehicles that can quickly secure power supplies will be deployed to the MIC Regional Bureau of Telecommunications in the affected area.

Additionally, to provide support for disaster response and secure means of information-communications, MIC launched the MIC-Telecom Emergency Assistance Members (MIC-TEAM) in June 2020 as a mobile communications support team (Figure 5). The MIC-TEAM provides support in the event of a large-scale disaster or its likelihood of occurrence. It is dispatched to affected local governments to assess the extent of damage to information-communication services, to coordinate collaboration with related government institutions, businesses, etc., and to provide support in the form of technical advice to local governments, lending of mobile power supply vehicles, etc. In 2024, MIC-TEAM was dispatched to local governments hit by natural disasters, such as the Noto Peninsula earthquake in January and the Noto Peninsula heavy rains in September.

At MIC, the goal is to enhance the effectiveness of the MIC-TEAM liaison dispatch system through joint training as mentioned above.

5. Conclusion

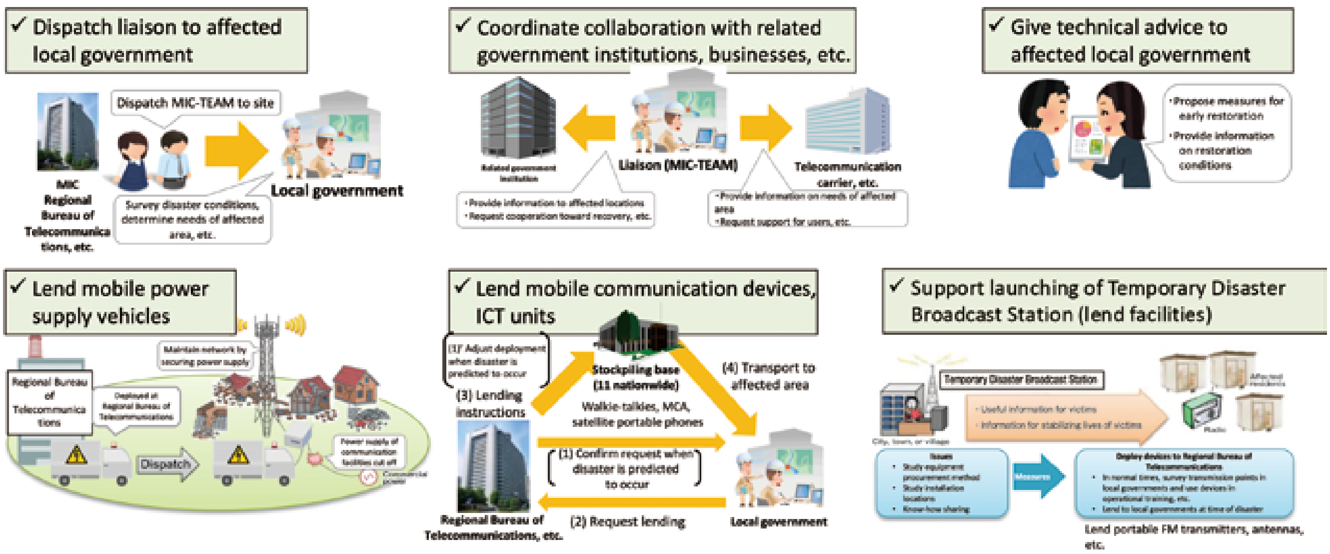
The Ministry of Internal Affairs and Communications conducts necessary investigations of the causes of disaster damage and response to that damage. In this article, we reported on the progress made in initiatives that make use of new technologies such as satellites and drones and initiatives that aim to further strengthen the communication environment and prevent breakdown of communications at the time of a disaster based on advances in public and private collaboration.

Additionally, we are working on an initiative that aims to implement “emergency inter-carrier roaming” by the end of FY2025 to enable mobile phone users to temporarily use another carrier’s network at the time of an emergency such as a natural disaster or communications breakdown.

More recently, moreover, we have been working with related businesses on an initiative for implementing services that would enable calls to be made or e-mail to be sent/received by smartphone using satellites, unmanned aerial vehicles flying in the stratosphere, etc. Using new technologies in this way, initiatives are currently underway to enable mobile phone services to be used even if base stations have been damaged and terrestrial networks have stopped operating.

Going forward, it is extremely important to strengthen measures for securing communication services envisioning the occurrence of a large-scale disaster that can cause damage over a wide area such as a Nankai Trough earthquake or Tokyo Metropolitan earthquake. At MIC, we will continue in our efforts to collaborate with related institutions such as communication carriers and to contribute to the securing of communications.

Figure 5: MIC-TEAM overview



Real-World Applications of Connected Car Technologies in Disaster Response: Current Status and Future Outlook

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1. Introduction

In recent large-scale disasters, such as the Great Hanshin (Kobe) Earthquake on January 17, 1995, the Great East Japan (Tohoku) Earthquake on March 11, 2011, and the Noto Peninsula Earthquake on January 1, 2024, failures in communication networks increasingly created obstacles for resident wellness checks, first-aid activities and saving lives. For use in such cases, implementation in society is advancing using connected car technology equipped with batteries, communication functions and mobility. However, there are many other issues in introducing such measures, such as acquiring the necessary budget and personnel. As such, we introduce cases implementing connected car technology in society, summarize various issues identified from a survey conducted by municipalities, and give an overview of what information and communications systems during disaster should be like.

2. Examples Applying Connected-Car Technology during Disaster

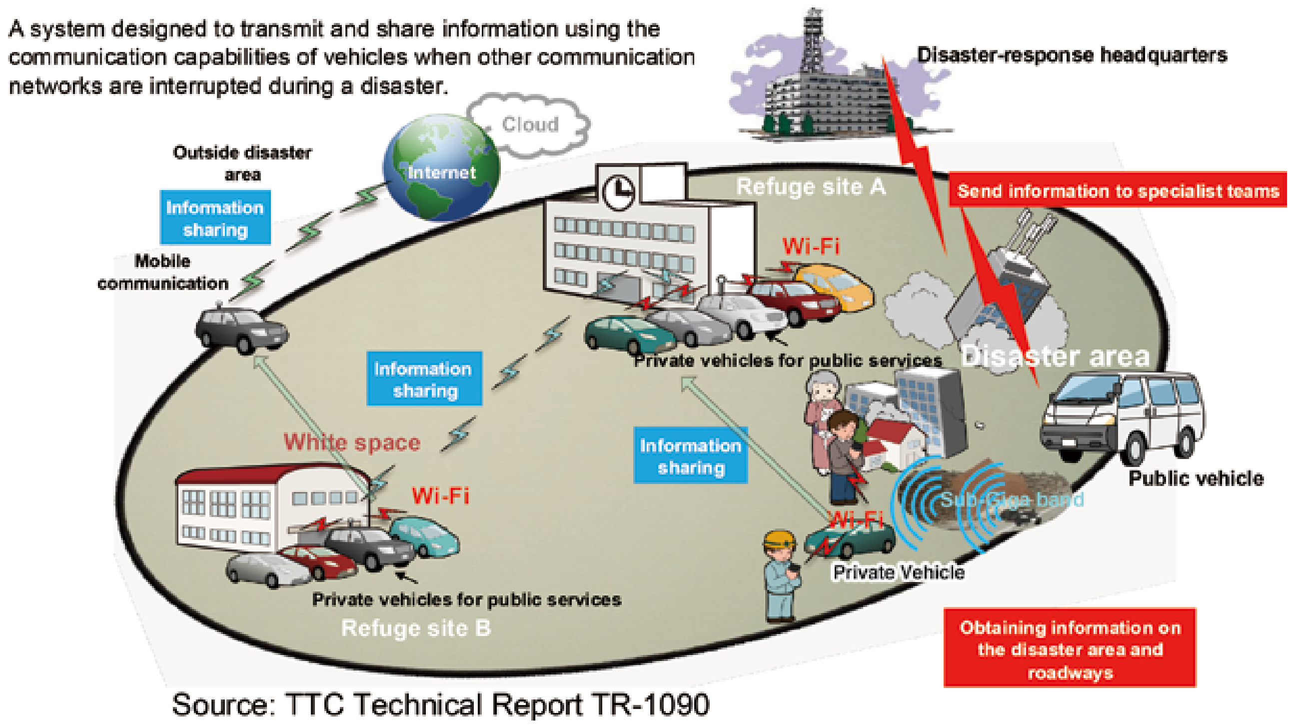
Here we introduce the main examples of systems using connected car technology available during disaster.

(1) V-HUB

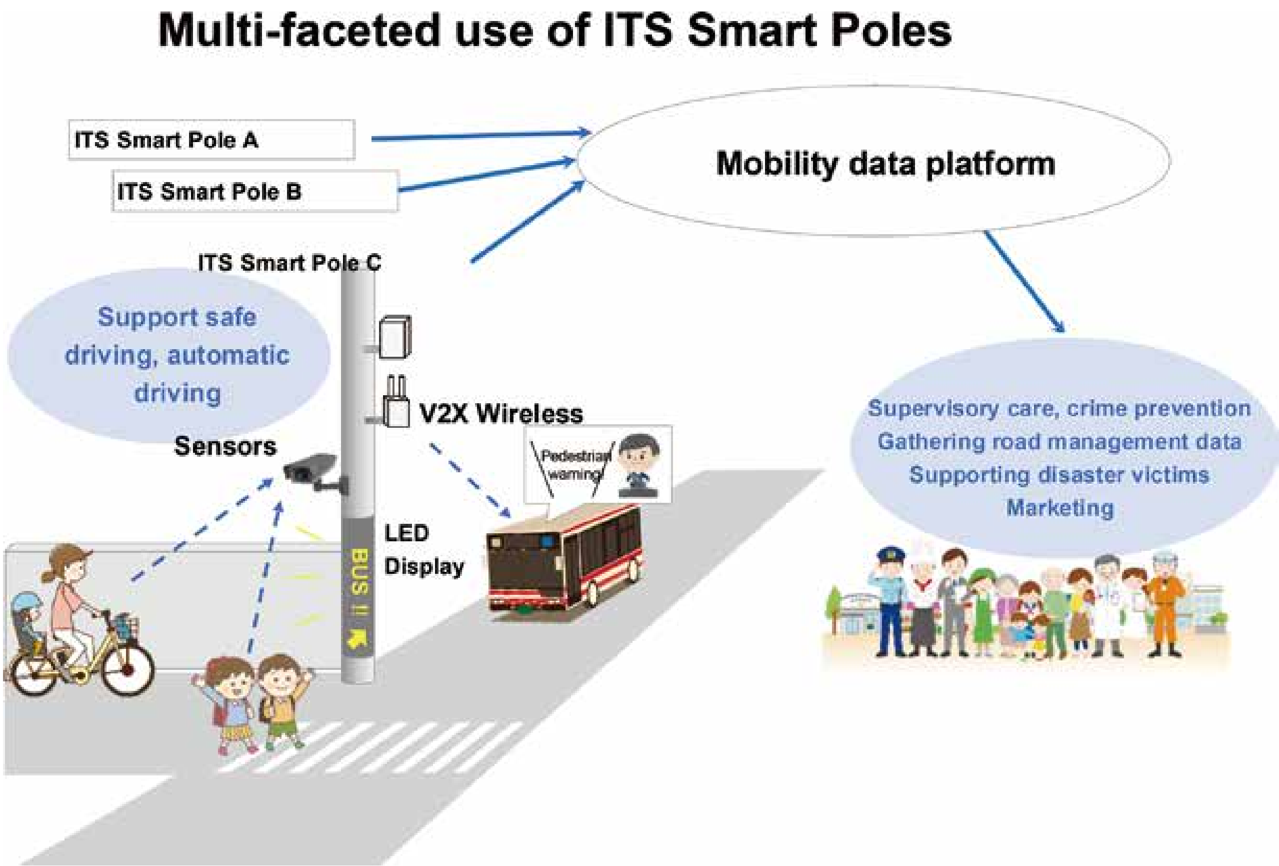
In 2018 at the Asia-Pacific Telecommunity (APT), a proposal from Japan for an "Information and Communication System using Vehicles During Disasters (Vehicle-HUB, V-HUB)" was adopted as a recommendation[1].

V-HUB uses connected-car technology such as vehicle-to-vehicle communication and vehicle-to-roadside communication during a large-scale disaster, when other communication networks are interrupted, to perform wellness checks and share disaster information. This recommendation was not for developing new technology, but to examine the needs of the various countries in Asia during disasters, and to provide a system structure and applications to support them using existing technology (Figure 1).

Figure 1: V-HUB Overview
Source: TR-1097[2], CES-0070-1[3]



■ **Figure 2: ITS Smart Pole multi-faceted use**
Source: TR-1109[4], CES-0090-1[5]



(2) ITS Smart Pole

ITS Smart Pole is a system that supports safer and more efficient traffic by exchanging information between vehicles and infrastructure equipment installed along the roadside. During normal times it can, for example, notify if a person or bicycle is emerging from a narrow alley, and during disaster, it can share disaster information or notify of evacuation routes.

This standard is being studied and verified by the non-profit organization, ITS Japan (Figure 2).

3. Examples of Implementation in Society

Here, we introduce examples of connected car technology being implemented in society.

1) Konan City, Kochi Prefecture

The city of Konan, in Kochi Prefecture, faces risk from earthquakes along the Nankai Trough, and has long considered and implemented measures to deal with them. One measure has been to equip municipal disaster-prevention vehicles with communication devices, which can provide their location of the vehicle and share disaster information. The Konan fire department has also distributed tablet devices with communications capability to their vehicles and fire-fighting staff, to work in cooperation with fire-fighting headquarters (Smart Fire Department). The Fire Department also cooperates with the municipality and conducts frequent disaster-prevention training so that the system can work effectively. They are also sharing know-how gained in this disaster-prevention training nationally, through the DREAMS (Disaster Response and Recovery Management Systems/Services) Utilization Research Center (Figure 3).

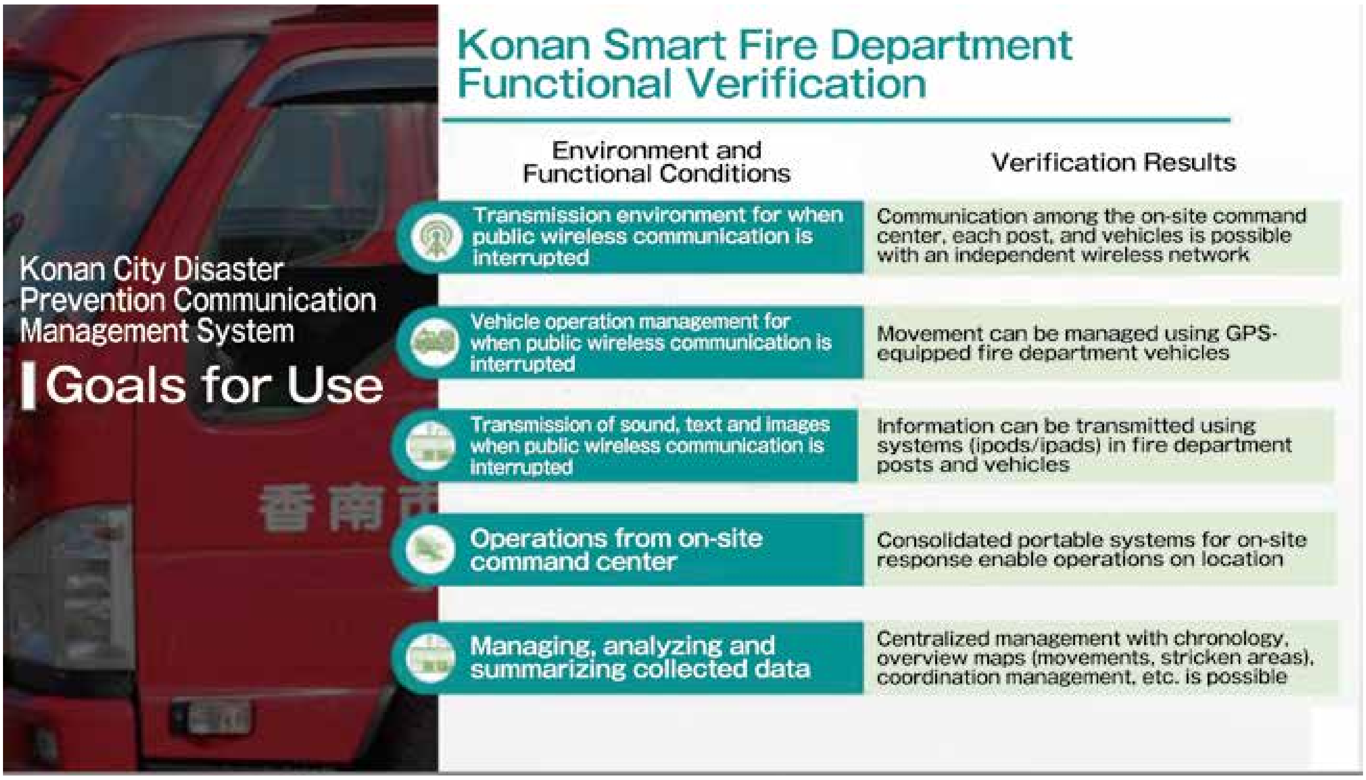
2) Toyota City, Aichi Prefecture

Toyota City in Aichi Prefecture has installed ITS Smart Poles in the city and is running trials using them for traffic-accident prevention and information sharing during disaster. Through these trials, they are collecting and analyzing traffic conditions during normal times and working to prevent traffic accidents (Figure 4).

4. Results of Municipality Survey

There are many cases of municipalities studying and implementing systems utilizing connected car technology besides those introduced in Section 3, but such implementations are still limited nationally. As such, for about two years starting in 2022,

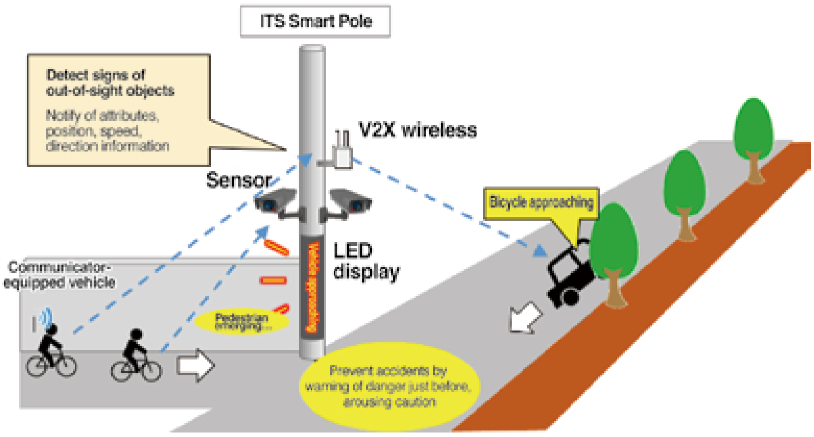
Figure 3: Overview of functional verification of Smart Fire Department in Konan City, Kochi Prefecture
Source: TR-1109[4], CES-0090-1[5]



the Telecommunication Technology Committee (TTC) and the Communications and Information Network Association of Japan (CIAJ) conducted a survey of the state of implementing recent information and communication technologies and related issues, including using vehicles during disaster, with cooperation from approximately 20 municipalities throughout Japan.

Figure 4: ITS Smart Pole trials in Toyota City, Aichi Prefecture
Source: TR-1109[4], CES-0090-1[5]

- Location: Toyota City, Aichi Prefecture
- Scope: 5 Intersections
- Method: Using infrastructure devices and V2X equipped vehicles, conducted effectiveness trials with cooperation from local high-schools and residents
- Time frame: from March, 2024



Source: Tateshina Council

In the results, approximately 60% of municipalities had plans to support evacuations, but only about 30% had evacuation plans involving vehicles (Figure 5).

Approximately half of municipalities were actively introducing information and communication systems for disaster response. Reasons for not doing so included not having the budget, not having personnel to study it, and not having the required technical knowledge (Figure 6).

5. Issues and Solutions for Introducing use of Information and Communication Systems during Disaster

There was great interest regarding information and communication systems for disaster response, and it became clear that, beyond just standardization of related technologies, creating models and linking data between systems would be essential to implementing the right technologies in the right places, with consideration for the size of the municipality and geographic requirements (Figure 7).

6. Future Prospects

Reference examples and model cases from municipalities throughout Japan are summarized in TTC standard TR-1109[4] and CIAJ standard CES-0090-1[5], based on the survey results to date. However, technologies are also changing quickly, such as expansion of satellite communication and use of new frequency bands (DR-IoT*). To implement such technologies, budgeting and cooperation with municipalities will be essential. We have organized a strategic road map for achieving this and it, along

Figure 5: State of evacuation support using vehicles during disaster
Source: TR-1109[4], CES-0090-1[5]

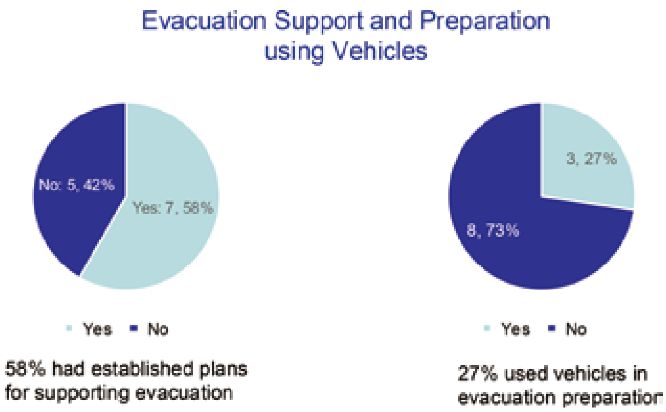


Figure 6: Reasons for not introducing information and communication systems for disaster response
Source: TR-1109[4], CES-0090-1[5]

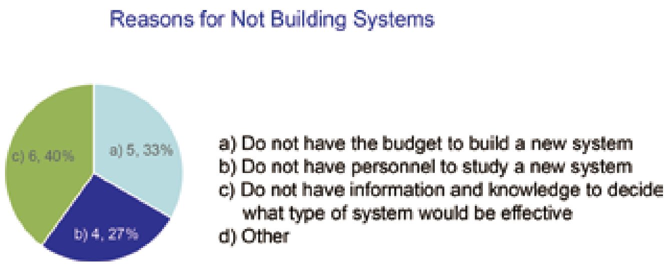
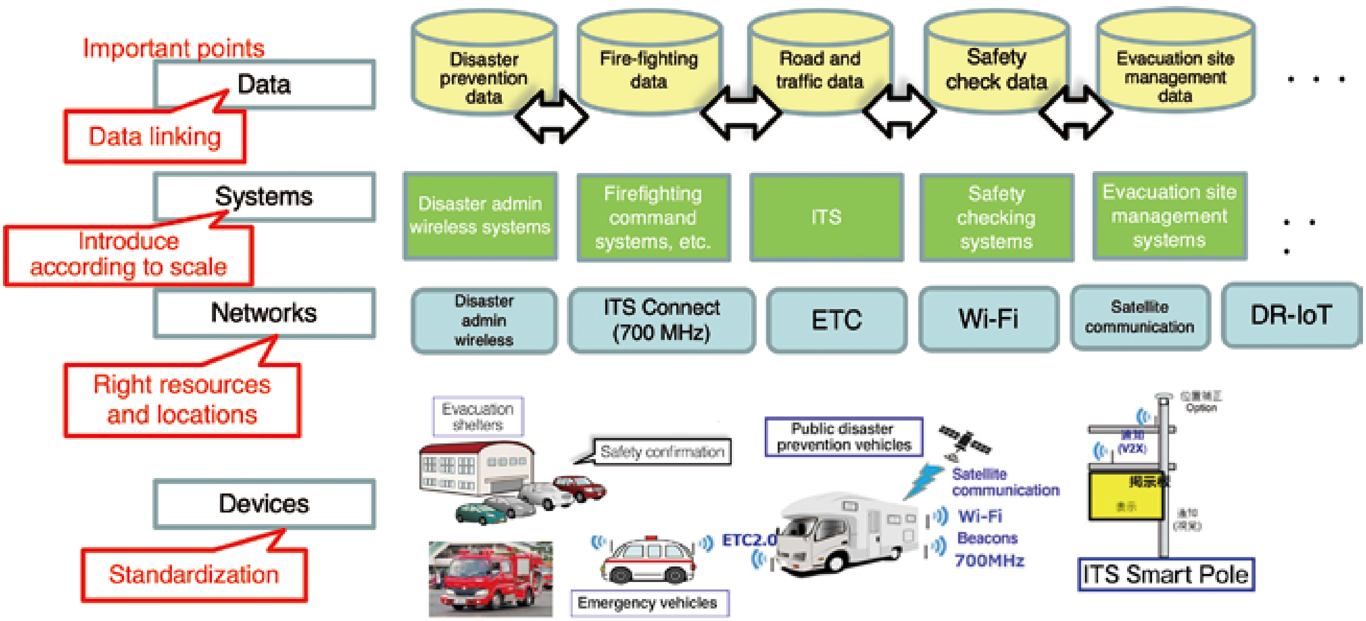
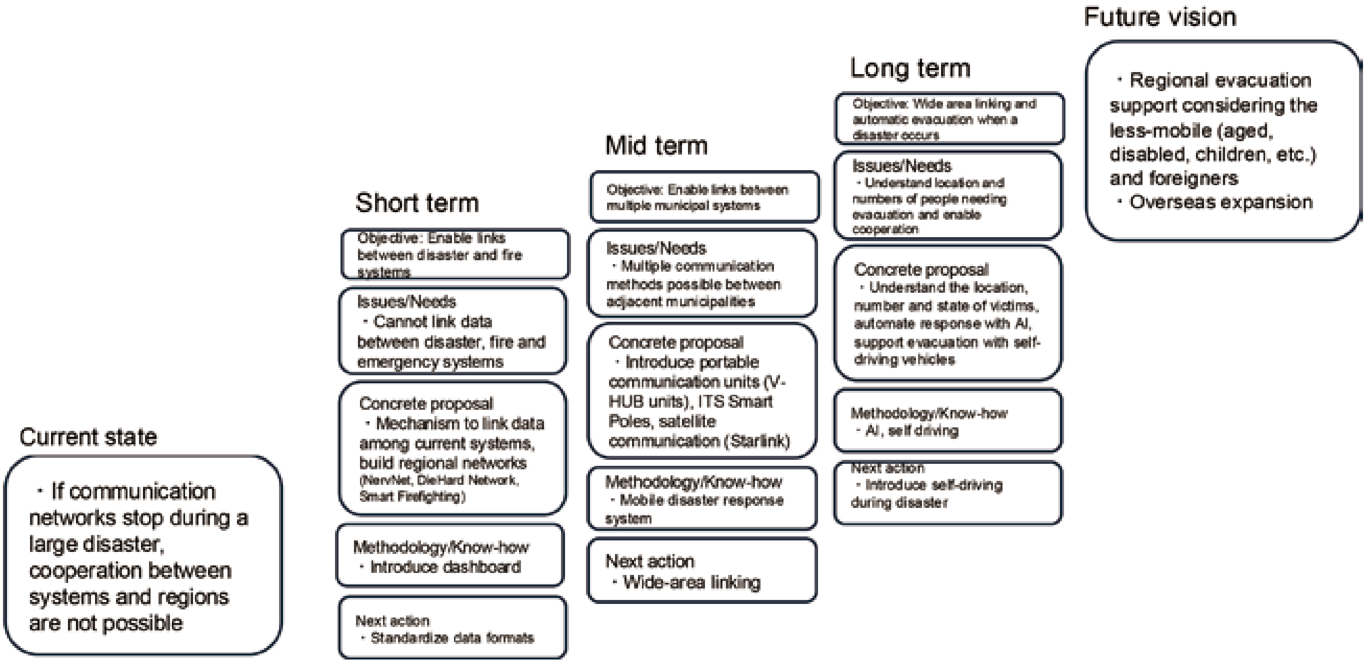


Figure 7: Information and communication system measures for disaster response
Source: TR-1109[4], CES-0090-1[5]



■ **Figure 8: Prospects for information and communication system during disaster**
Source: TR-1109[4], CES-0090-1[5]



with conditions in each municipality, will be needed for sharing this information and to introduce information and communication systems effectively for use during disaster (Figure 8).

7. Conclusion

The TTC Connected Car Experts Group has been proposing standards for utilizing connected car technologies during disaster, but has also been collaborating with various organizations, studying actual conditions in municipalities and participating in disaster-prevention training efforts. Results of these efforts were published in February 2025 in TTC[4] and CIAJ[5] standards, and give a view of the future of these efforts. We anticipate further progress implementing these technologies in society looking forward.

References

[1] APT/ASTAP/REC-002 (2018), “APT Recommendation on Standard Specification Information and Communication System using Vehicle during Disaster”
[2] TTC Standard TR-1097 (2022), “Guidelines for using the V-HUB Information and Communication System utilizing Vehicles During Disaster, Vehicle disaster-prevention system overview”
[3] CIAJ Standard CES-0070-1 (2022), “Guidelines for using the V-HUB Information and Communication System utilizing Vehicles During Disaster, Vehicle disaster-prevention system overview”
[4] TTC Standard TR-1109 (2025), “Guidelines for using the V-HUB Information and Communication System utilizing Vehicles During Disaster – Recent efforts for effectively linking with new initiatives including disaster prevention and fire-fighting systems”
[5] CIAJ Standard CES-0090-1 (2025), “Guidelines for using the V-HUB Information and Communication System utilizing Vehicles During Disaster – Recent efforts for effectively linking with new initiatives including disaster prevention and fire-fighting systems”

＊ DR-IoT: Abbreviation for a disaster-response IoT communication system using the V-High band.

Resilient ICT Innovation and Deployment

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1. Introduction

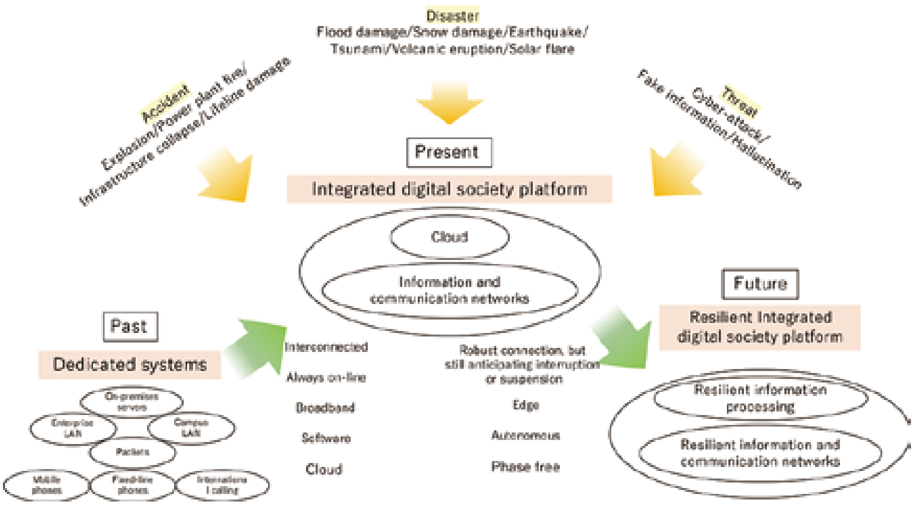
In this article, we discuss a current trend toward "Phase Free" information and communication networks with enhanced resiliency and some surrounding issues. We then introduce related NICT R&D efforts in resilient wireless communication technologies, optical fiber network technologies, edge-cloud technologies and natural-environment sensing technologies, and also efforts to deploy results of this research.

2. Information and Communication Networks and Resilience

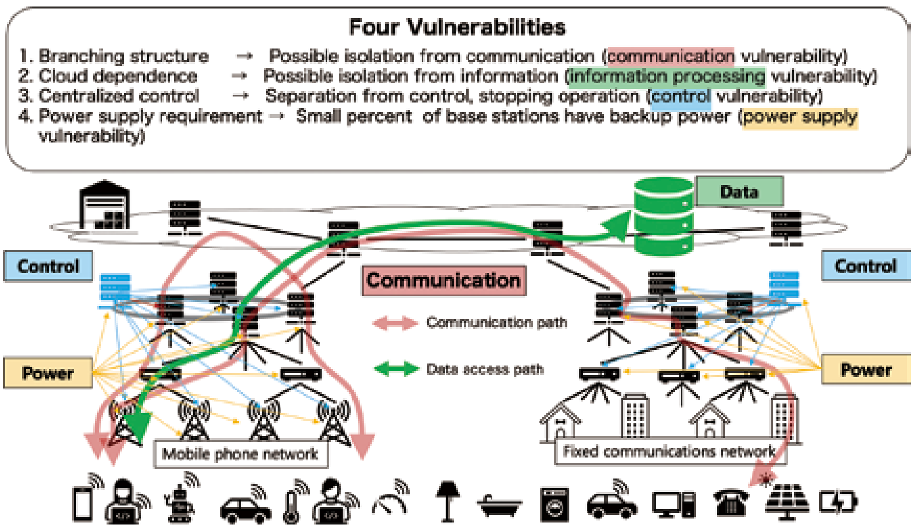
Network systems that exist for different purposes have become interconnected and grown into infrastructure for our comprehensive digital society (Figure 1). Large-scale disasters and accidents, cyber attacks and other cyber threats that are being realized with the spread of generative AI are all becoming potential threats to this infrastructure. As such, even though we are using this infrastructure in every-day circumstances, there is a need for it to have even stronger resilience than it does at present.

Our information and communication networks, which form the core of this infrastructure, have four fundamental vulnerabilities (Figure 2). The first is a "communication" vulnerability. Networks divide into branches from top to bottom, and a fault in any communication device can interrupt all communication below it. The second is an "information processing" vulnerability. With the current focus on cloud implementations, any intermediate degradation in communication or the cloud infrastructure will suspend services. The third is a "control" vulnerability. Most current systems utilize centralized control, in which a set of controllers controls the entire system, so there is a risk that if control communication between any device and the controlling device is obstructed, the service will be suspended. Finally, there is a "power supply" vulnerability. Prompted by The Great East Japan Earthquake and Tsunami in 2011, mobile base stations in important locations such as city offices and disaster hospitals have been equipped with batteries, but these efforts are still inadequate (they will be accelerated by revisions to the Radio Act).

■ **Figure 1: Trend toward resilient social infrastructure**

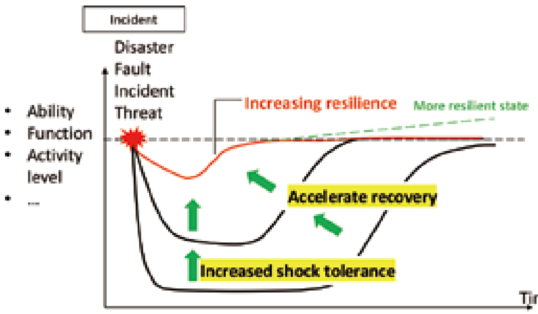


■ **Figure 2: Information and communication network vulnerabilities**



Resilient information and communication networks can be defined as providing performance and functionality that can minimize any degradation in information and communication capability and minimize the time to full recovery to pre-incident performance, even when incidents such as natural disasters or faults occur, or even provide better performance than before the incident (Figure 3). Ideally, this will include a systematic and quantitative approach, with research and development on individual technologies, but also on overall network system architectures.

■ **Figure 3: A definition of resilience of information and communication networks**



Source: Based on a figure provided by the Cabinet Secretariat, National Resilience Promotion Office

3. Resilient ICT Innovation and Deployment

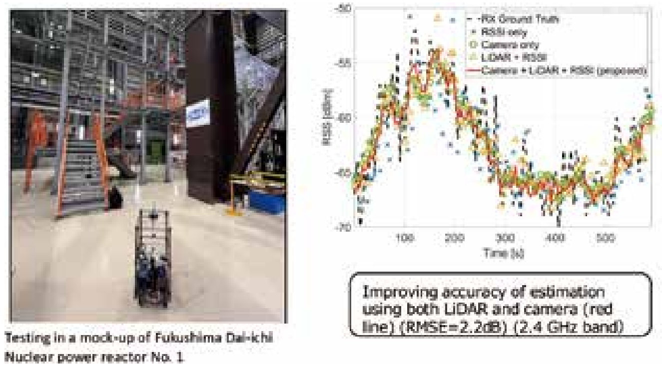
The NICT Resilient ICT Research Center was established in 2012, prompted by the 2011 Great East Japan Earthquake and Tsunami, to perform research and development on ICT that is resilient in disaster, and to promote its deployment in society. Here, we introduce some of the R&D since FY2021 and deployment of the results.

3.1 Resilient Wireless Communication Technology

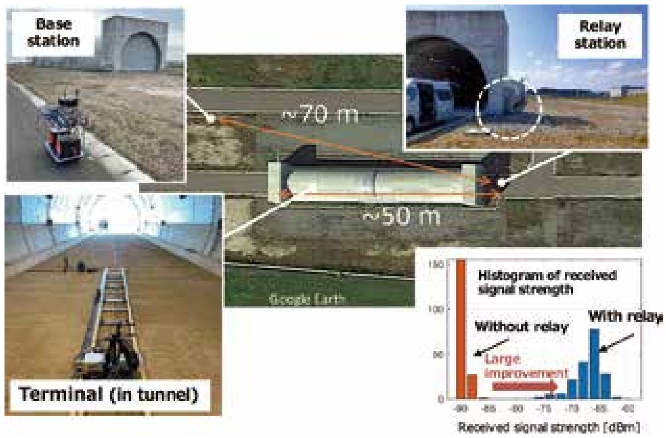
With earlier technologies, the objective was to realize low-latency, highly reliable communication even in the most difficult radio-wave environments, such as when propagation losses exceed the 150 dB permitted by 5G (3GPP Release 17), or when the frequency band is crowded with much noise. A typical example of a difficult environment is a nuclear power plant, where the internal structure is complex and covered with lead. In development of technology to accurately predict radio-wave propagation several seconds into the future, we used AI with data on spatial unevenness of internal structures, collected using camera video and LiDAR. As a first application we aim to use it for wireless control of swarm robots performing work to decommission the nuclear reactor in Fukushima. We have conducted R&D on methods for multiple frequency bands, conducted tests in a mock-up of the Fukushima Dai-ichi nuclear power plant (at the Japan Atomic Energy Agency), and confirmed the ability to predict approximately one second into the future with over 95% accuracy (estimates within ±3 dB of signal strength).

For cooperative control of swarm robots, sub-millisecond low latency is essential. When extending the communication range with relays, this was difficult to attain using conventional technologies. As such, for the 2 GHz and 4.9 GHz bands available for wireless robot control, we conducted R&D on new methods to greatly reduce relay processing time. For the 4.9 GHz band,

■ **Figure 4: Estimating radio wave propagation (reception field strength) using AI**



■ **Figure 5: Successful short-range radio relay in a tunnel, outside of communication range**



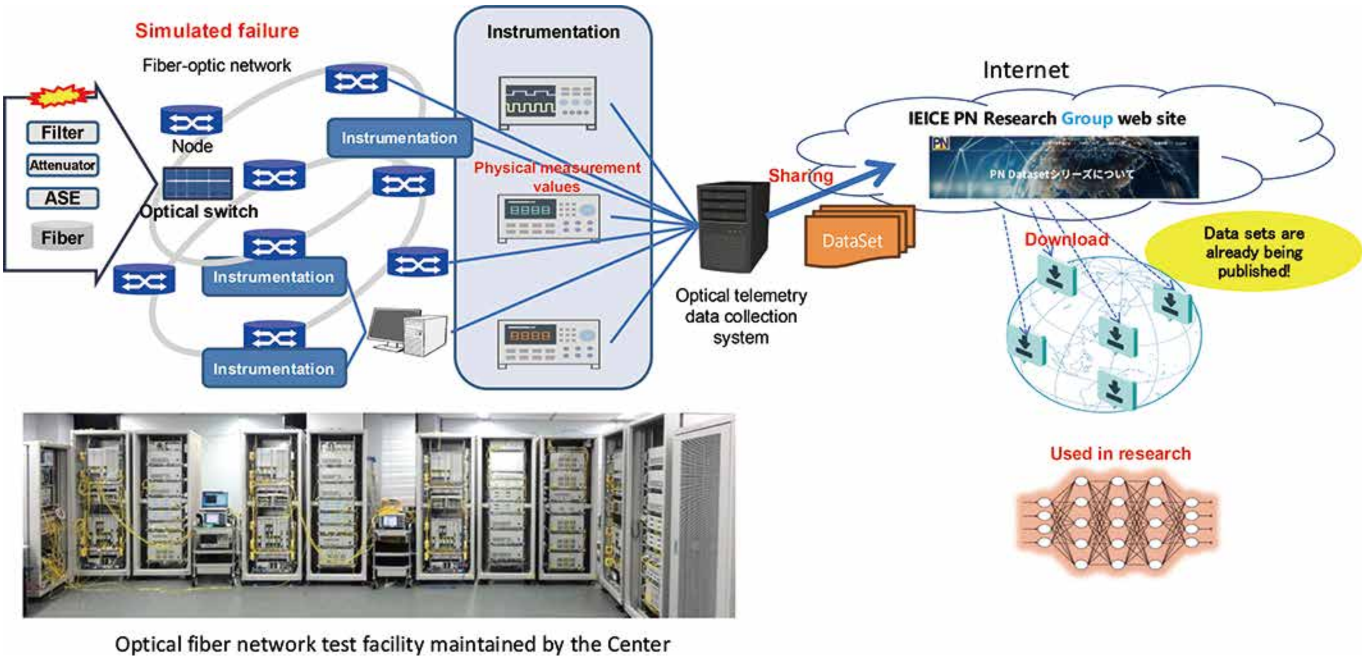
we have confirmed relay processing with latency far below target, in less than two microseconds, in practical testing. This result has already been adopted in 3GPP Release 18 (5G-Advanced) Network-controlled Repeater Standard TS38.213 and others. The method also has strengths independent of communication formats and standards, and can be used to expand the communication range of wireless communication systems already installed in plants and other facilities.

In another case, we are developing a method for synchronization between stations, which applies to cooperative coherent communication among multiple distributed stations and achieves both gain preservation and reduced overhead. This is expected to be adopted in the 3GPP Release 19 NR MIMO Phase 5 standard. We are also researching a method to apply quantum annealing to multi-user detection on base stations, and have demonstrated simultaneous connection to four devices for the first time in field testing.

3.2 Resilient Optical Network Technology

Optical networks have characteristics that support long distances and high capacity, so they are used widely in core, metro and access networks. Any interruption or reduction in throughput, whether due to disaster, break-down or device degradation with age, can have an extremely broad effect, so prior prevention is important. For this reason, we have utilized our large-scale optical-fiber network test facilities and conducted R&D on optical telemetry data-gathering systems, which can collect various types

Figure 6: Collection and publication of data on network failures to promote research for detecting early signs of them



of physical measurements from optical fiber networks over long periods of time. We simulated various types of network failure while switching aspects such as network configuration, so that we can detect even early-warning signs for network failures. We have begun sharing the data set obtained for research purposes, through the web site of the IEICE Technical Committee on Photonic Network. Use of this data set can enable research on network control methods that can detect signs of network failures and actively adjust to avoid them. In fact, by focusing on degradation in transmission quality due to cross-talk between cores in multi-core fiber optical networks in optical signal data over time, we designed a machine learning model able to predict loss of logical communication links based on the data, and can now detect such warning signs successfully.

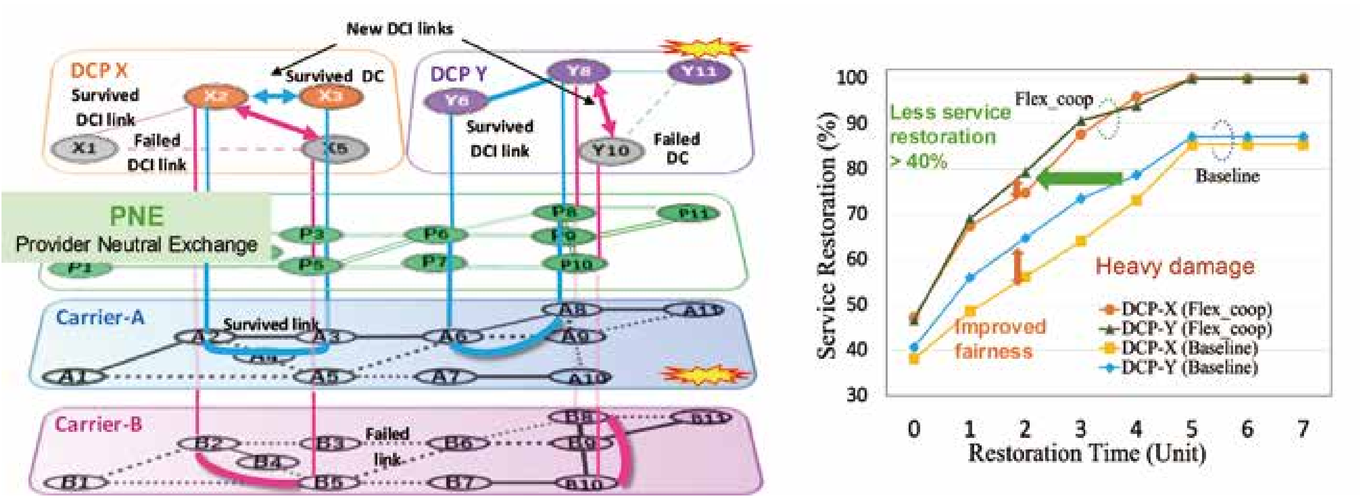
As with efforts to implement roaming between operators during and after disaster, there is great anticipation of cooperation among operators and also among cloud service providers as cloud services expand. In collaboration with University of California, Davis in the USA, we have conducted R&D on new architectures for cooperation between communication and cloud service operators.

A provider-neutral exchange (PNE), which is independent of all operators, receives abstracted resource information from each operator and by matching it with data center needs for some failures, the time required to reach 80% recovery from when the cloud service fault occurred was reduced by more than 40%, compared with earlier research. This confirms a clear effect of cooperation between operators.

3.3 Resilient Edge/Cloud Technology

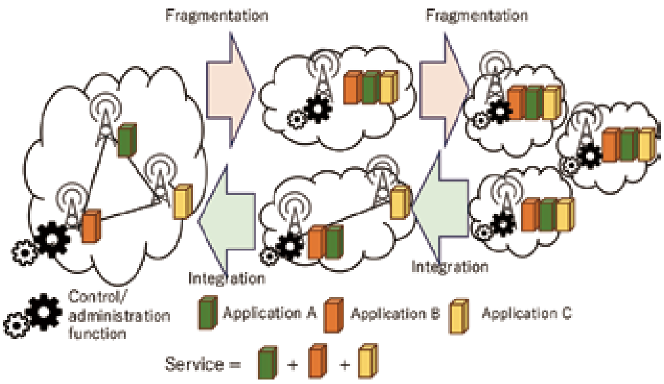
Cloud and edge-cloud services are assumed to be stable and always on-line, so they are vulnerable to communication

Figure 7: Reduction in recovery time through cooperation among communication and cloud operators



disruptions. With the assumption that communication disruptions will occur, we propose an "autopoietic" edge-cloud architecture that is able to continue providing functionality virtually, even when communication becomes unstable, and we are conducting R&D on this approach. Autopoiesis is a concept in theoretical biology whereby the organic structures and expression of life are generated. Figure 8 gives an image of how services could reorganize autonomously through autopoietic edge-cloud architecture. Normally (on the left), a single service composed of applications A, B and C is controlled by an independent control/administration function. Even if the network becomes fragmented (on the left), control and administration functions and applications can be regenerated according to changes in resources within the network, continuing to provide their services. Details of the technologies implementing this are beyond the scope of this article.

■ **Figure 8: Autopoietic reorganization of edge-cloud services**

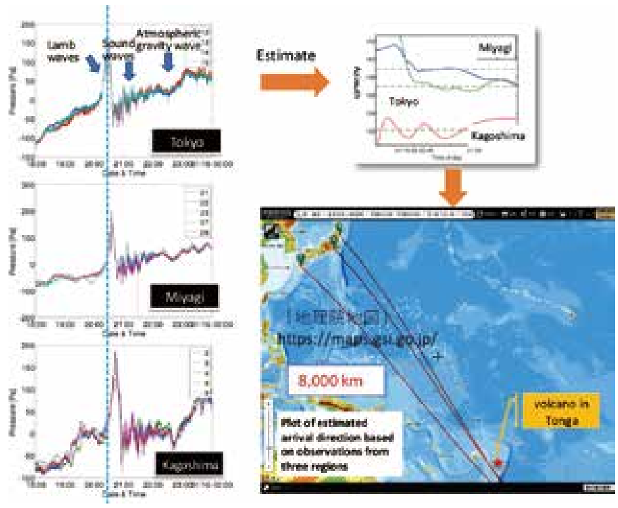


The predecessor of this technology is the Cross-Agency Information and Communication System (X-ICS, "cross-ics"), which is a cloud sharing system able to collect and share information among disaster response agencies (fire, police, self-defense force etc.) during a large-scale disaster, even if public communications networks are interrupted. We are conducting R&D on this system jointly with other organizations and under the umbrella of the Cabinet Secretariat Strategic Innovation Program (SIP). Each node of X-ICS is composed of computers with multiple communication interfaces and operation is autonomous and distributed, with no facility performing overall control and administration. In areas where public communication is suspended, information can be transmitted directly between the nodes by packet relay over Wi-Fi, and capacity of communication with the internet is maximized by bundling multiple connections. In FY2025, development of functionality was completed, and we are conducting field testing with disaster response agencies.

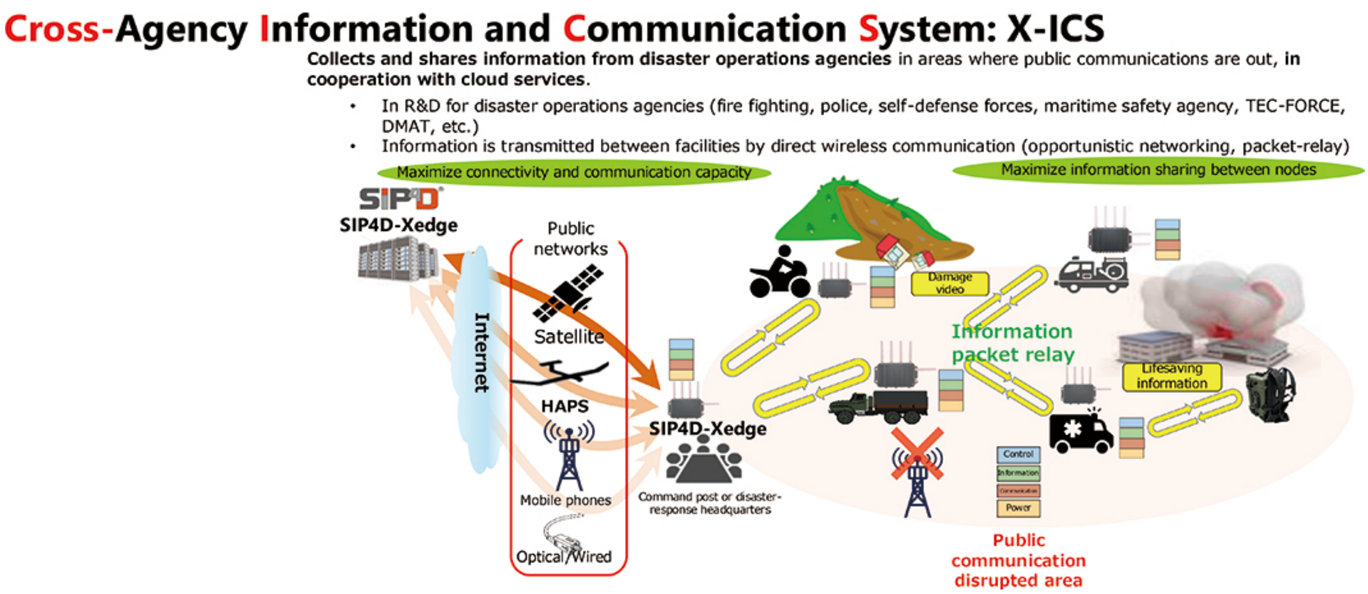
3.4 Resilient Natural-Environment Sensing Technology

We have developed sensors for infra-sound (sound-waves below the audible frequency band, produced by phenomena such as tsunami and volcanic eruption) using MEMS sensors and small microphones, that reduce cost and power consumption while having the same bandwidth and sensitivity as conventional precision microbarometers. We have installed them in 25 locations

■ **Figure 10: Estimating the sound source from the Tonga underwater volcanic eruption**



■ **Figure 9: X-ICS ("cross-ics") overview**

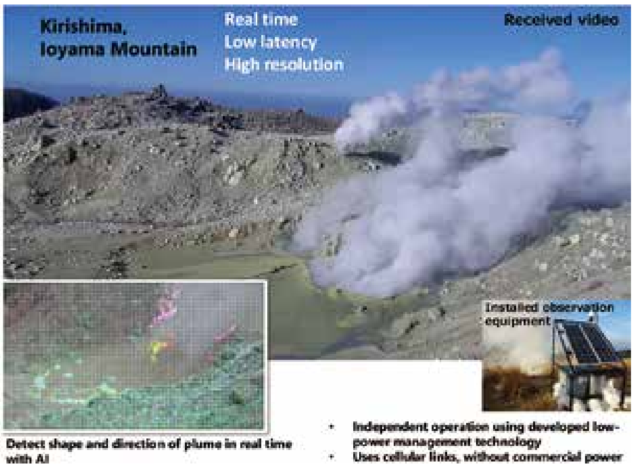


throughout Japan and are collecting observations. Some of this data is published for research purposes on the Japan Weather Association web site. We have developed a method for analyzing and visualizing sound-source location (i.e., where the tsunami or eruption occurred) and as an example, were able to estimate the source location and direction of arrival of the tsunami caused by the Tonga underwater eruption in November, 2022.

We have conducted R&D on a method to detect eruption plumes, wave height, affected birds and other wildlife and other factors using machine learning to process received images, based on a technology able to compress and transmit high-resolution images from off-the-shelf cameras over public mobile networks. For example, we developed a method able to detect eruption plumes, which are particularly difficult to detect, with high rates (F-value over 90%). By reducing the computation load we were able to detect plumes in areas surrounding a volcano, where power and computing capability are limited. This is being field-tested near Sakurajima, a volcano in Kagoshima Prefecture.

We have installed a wave-height measuring system on a

■ **Figure 11: Volcano observation using high-resolution video with independent power supply**



seawall in Toyama Prefecture, and are conducting continuous testing, including overnight. We have confirmed the ability to measure heights exceeding the heights of the seawall through the night, which was difficult to do using the previous, contact-type sensors.

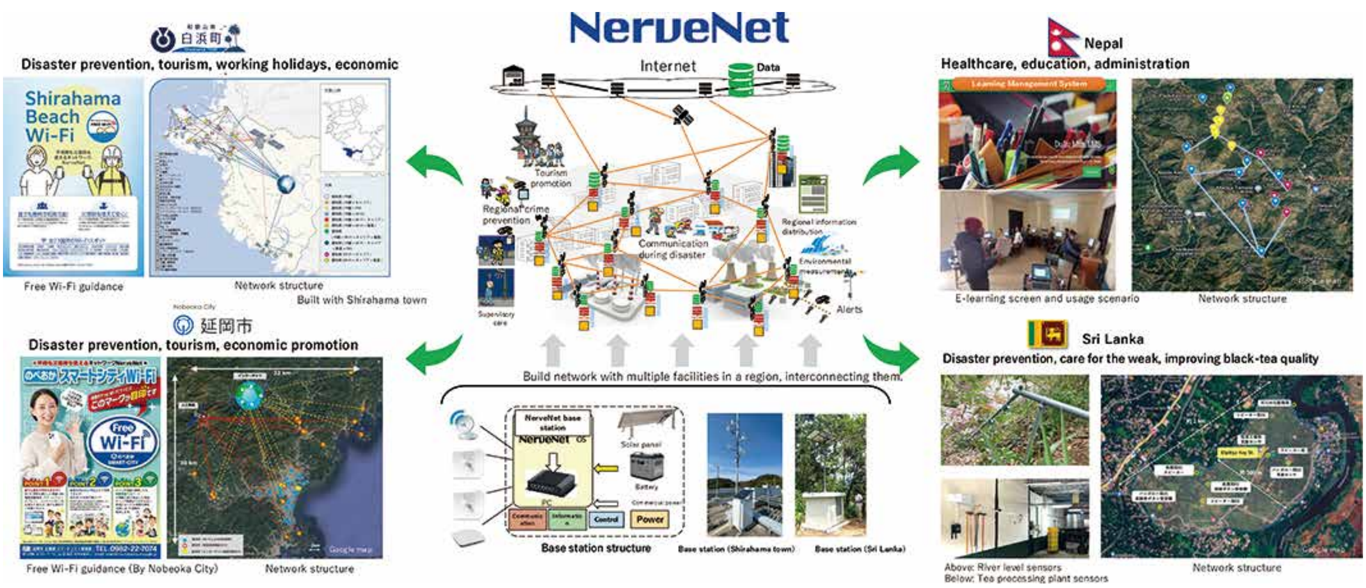
We have developed an original low-power management technology and enabled long-term infra-sound and video observations using only self-generated power that relies mainly on solar battery. This has been operating at Kirishima Ioyama, a volcano located at the border of Miyazaki and Kagoshima prefectures, for more than three years (Figure 11). The received video has been provided on a trial basis to three surrounding municipalities and been used daily to assess the volume, direction and other aspects of volcanic plumes, as well as in volcano disaster prevention by the municipalities.

3.5 Resilient ICT Deployment

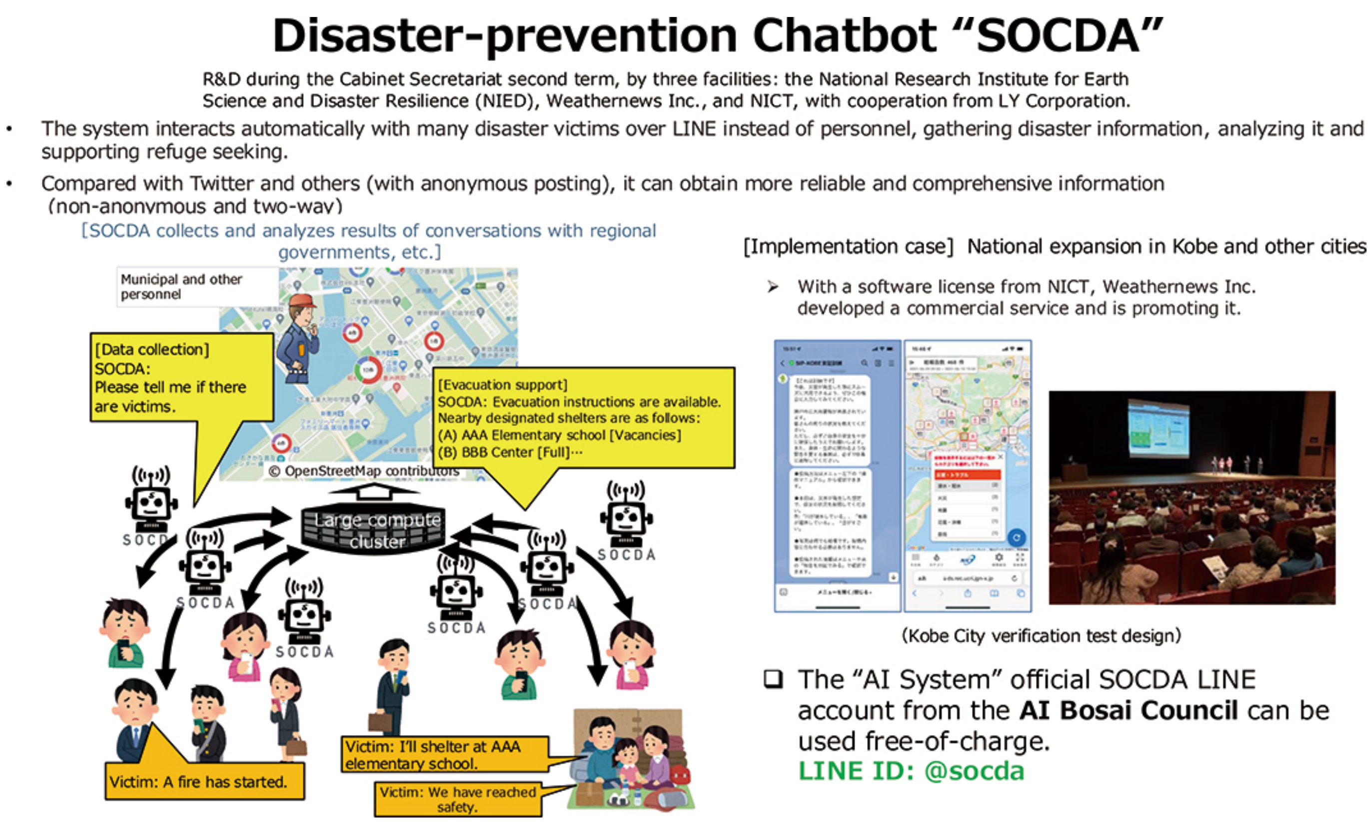
NerveNet, a kind of X-ICS predecessor, is a network composed of multiple base stations that have overcome the vulnerabilities, installed and mutually interconnected within a region, and providing the four functions shown in Figure 2. If it experiences a partial failure, the entire network does not fail, and if the fault is recovered, the whole network automatically returns to normal operation. The network can maintain communication using a route that avoids the damaged part, and even if the Internet connection is lost, it can maintain certain services using internal information processing functions. It consumes less power than a public mobile phone base station, and can operate for at least three days if there is a power outage, using solar panels and batteries. Practical application of this has begun as a disaster-resilient regional communication and digital platform in some locations in Japan, Nepal, and Sri Lanka.

The "SOCDA" ("soku-da") disaster prevention chatbot that we have researched, developed and implemented under the Cabinet Secretariat SIP, is a system that can automatically converse with affected residents in place of municipal staff who

■ **Figure 12: Example deploying NerveNet, a regional digital communication platform**



■ **Figure 13: Overview of the "SOCDA" disaster prevention chatbot**



will be busy with other disaster response, gathering and analyzing victim information and providing support. Currently, it has been introduced by 120 municipalities.

■ **Figure 14: Contributions to ITU, APT and 3GPP and guidebook publication**

Each of these research results has been reflected in ITU or APT reports or 3GPP standards. The Resilient ICT Research Forum, which our office is part of, has also created, published, and posted on the web, the "Introducing Disaster-Resilient Information and Communication Networks" guidebook, oriented mainly for municipalities, working to improve resilience both domestically and internationally.

4. Conclusion

The demand for resilience in everything holds great promise and is an ongoing theme. Technically, research and development on both individual parts and the overall architecture are needed, and adoption of the results requires creation of resilience standards and evaluation methods. Measures must then be taken to introduce the technology based on the standards and evaluation methods, implemented by society as a whole and including industries beyond ICT. As a member of society, we will continue to engage in technical R&D and deployment of these results.

Acknowledgements

I would like to express thanks to everyone at the Resilient ICT Research Center, who created the technologies described here.

R&D and International Expansion of Portable Local ICT Systems for Disaster Response

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Wave Engineering Laboratories
Advanced Telecommunications Research Institute International

1. Introduction

The rapid, widespread expansion of Internet services in recent years has made our lives easier and increasingly prosperous. On the other hand, the occurrence and scale of natural disasters such as earthquake, typhoons, and flooding are on an upward trend throughout the world. These events can degrade the quality of communication services or even disrupt them including Internet-based services as communication facilities become damaged or power supplies are cut off. At the same time, the demand for communications in the aftermath of a disaster often increases sharply, for example when confirming the safety of others, checking disaster conditions, and coordinating disaster-response activities. Such a large gap between the supply and demand of communication functions can stall disaster-response activities or delay recovery in the stricken area.

To deal with such a communications interruption or gap in the supply and demand of communication functions at the time of a disaster, we have been proposing portable local information and communications technology (ICT) systems for disaster response and have been conducting research and development toward their implementation and international expansion. In this article, we provide an overview of our activities to date in this area.

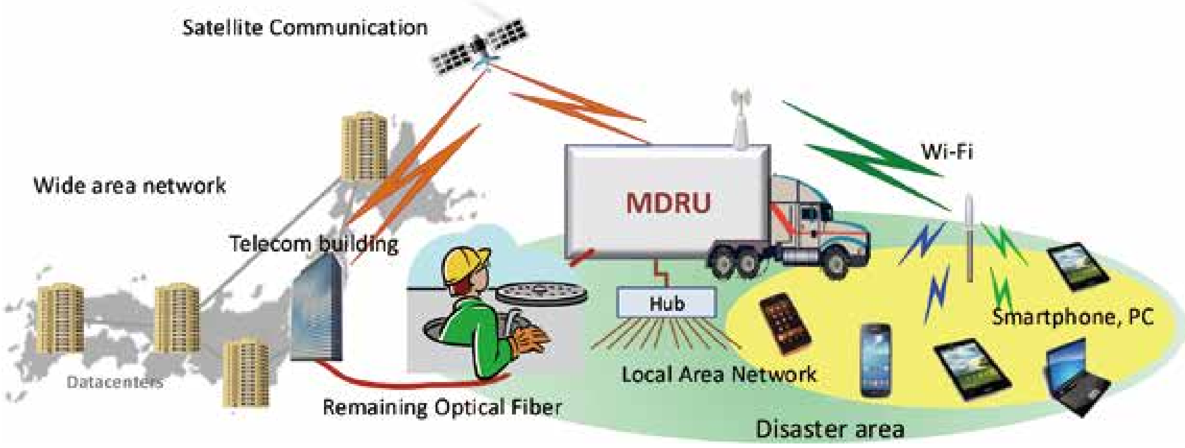
2. Background and Overview of Research and Development

The Great East Japan Earthquake that struck in March 2011 affected 1.5 million NTT fixed-line telephone circuits due to damage sustained by telecom buildings, the severance of communication cables, and other problems. It took several months to recover from this damage[1]. Since then, disaster victims and agencies responsible for recovery activities have not been able to sufficiently grasp conditions in many disaster-stricken areas giving them no choice but to grope for evacuation services and rescue/recovery activities in a trial-and-error manner.

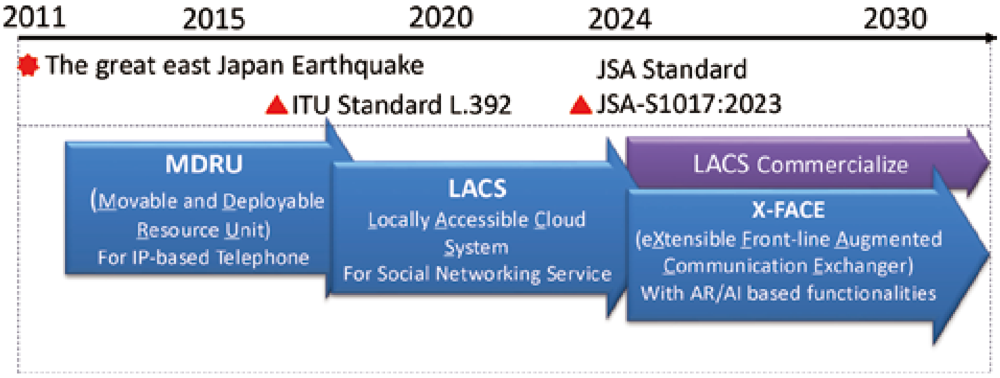
To prevent such a situation from occurring again, we proposed a portable local ICT system named Moveable and Deployable Resource Unit (MDRU) and began its research and development[2]. Figure 1 outlines the MDRU system. This system accommodates communications processing equipment, access network equipment, and communication equipment within a portable box for connecting to the existing network. It can be brought into an area having a demand for communications such as a disaster-stricken area and used for forming an immediate access network so that local communication services can be provided in a short time. In addition, when connected to an existing network such as the Internet, the MDRU can function as an edge node to meet the locally confined demand for communications on-site. The MDRU system became an ITU-T Recommendation (L.392) in 2016 as a system from Japan following the Great East Japan Earthquake[3].

After proposing MDRU and recommending its international standardization, we continued to research and develop portable

Figure 1: Conceptual diagram of MDRU system



■ **Figure 2: R&D transitions in portable local ICT systems**



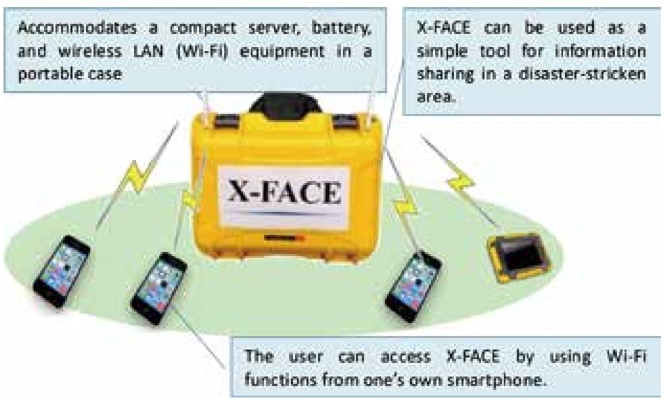
local ICT systems. Figure 2 shows the transitions in this research and development following our proposal of the MDRU system. Building on the MDRU, we proposed and promoted the research and development of a Locally Accessible Cloud System (LACS)[4] from 2018 and an eXtensible Front-line Augmented Communications Exchanger (X-FACE)[5] from 2023. Either of these services accommodates an access network device, server, battery, etc. within a portable case enabling the impromptu launch and provision of local ICT services. Both conform to the L.392 standard but each differs in the primary service functions provided. The initial MDRU provided telephone service, but LACS features SNS service functions of the Internet era while X-FACE features artificial intelligence (AI) and augmented reality (AR) functions such as voice recognition. In this way, the research and development of portable local ICT systems have been evolving along with the ongoing progress in technology and Internet companies.

3. R&D of Portable Local ICT Systems

The following gives an overview of existing development work in portable local ICT systems using X-FACE as an example. Figure 3 shows the X-FACE usage concept. The portable case accommodates a compact server, Wi-Fi access point, battery, and peripheral devices. To make use of services, the user accesses the X-FACE server via Wi-Fi from a handheld smartphone, tablet, AR device, etc. The compact server provides the user with a variety of functions such as chat and voice/video calls as provided by an ordinary Social Networking Service (SNS) as a Web service. Figure 4 shows examples of screen shots when accessing the X-FACE service via a Web browser. The screen on the left of the figure is the page displaying a list of provided functions while that on the right is what the user might see when viewing SNS-posted messages or images. In short, the X-FACE service features a user interface the same as an ordinary SNS making it easy for even first-time users to begin using it.

The main use envisioned for X-FACE is to enable disaster responders (police department, fire department, Japan Self-Defense Forces, Disaster Medical Assistance Team (DMAT), etc.) to share and record information within a team at a disaster-stricken site or to make contact with upper-level organizations. For this reason, the aim here is to enable information input/output and other operations to be performed in a hands-free manner without hindering the user through the use of AI technology such as voice recognition. Research and development are also proceeding with a view to making disaster response activities more efficient by superimposing disaster-related information on the video seen from a camera using AR technology.

■ **Figure 3: X-FACE usage concept**



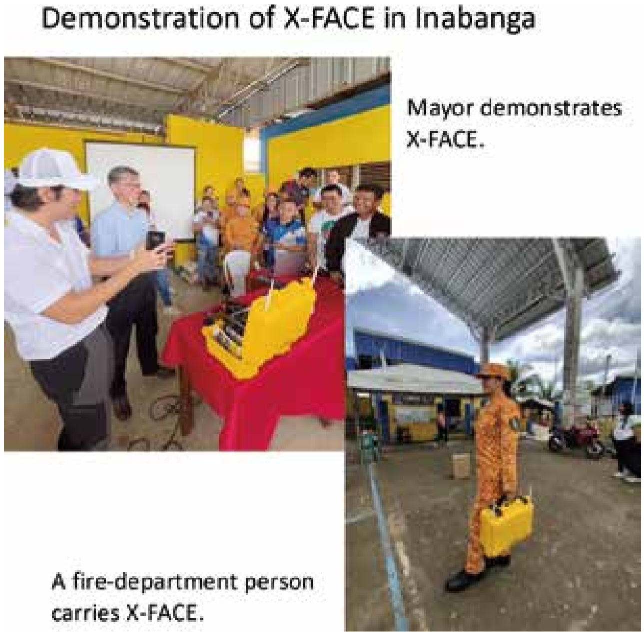
■ **Figure 4: Examples of screen shots of X-FACE services**

4. International Expansion Activities of R&D Results

We have been proposing and researching and developing portable local ICT systems to eliminate the significant supply-and-demand gap in information-communication services that occurs when communications are disrupted at the time of a disaster. Knowing that such a supply-and-demand gap is particularly noticeable in developing countries that are prone to natural disasters, we have been conducting a variety of demonstrations using developed systems at overseas locations such as the Philippines as part of our R&D work[4].

Figure 5 shows examples of demonstrations conducted in Cebu Island, Philippines from 2019 to 2023 using a LACS prototype. In the demonstrations, we carried prototype units into Cordova City located in the southern part of Mactan Island in the Cebu region and into Gilutongan Island located about 6 km off the coast of Cordova City and conducted multiple use cases. We mention here that schools around the country were closed due to the impact of the worldwide pandemic during this period forcing all education to be provided online. As a result, many students were unable to receive an education especially in areas that lacked a sufficient Internet infrastructure, which created a major social problem. Under these conditions, we conducted a demonstration using LACS for remote education. Furthermore, in cooperation with local governments, we conducted a LACS-based demonstration simulating the time of a disaster and a demonstration of managing residents under disaster conditions using a local server temporarily. Through these series of demonstrations, we were able to verify the usefulness of portable local ICS systems.

■ **Figure 6: X-FACE demonstration in Inabanga City, Philippines**



Next, Figure 6 shows a demonstration conducted in Inabanga City, Bohol Island, Philippines in 2025 using an X-FACE prototype to simulate the use of X-FACE at the time of a disaster. In the demonstration, we asked members of disaster responding agencies such as fire departments to try using a variety of functions some of which used voice recognition such as information input. We received good feedback on the usefulness of the X-FACE system.

■ **Figure 5: Examples of demonstrations in Cebu Island, Philippines**

Category	Activity	Main participants
e-Education	Trial of downloading the contents to student's smartphone and work out with the contents and then upload the reports by local students.	Local teacher/student, University Processor
Disaster response	Demonstration of LACS application in searching for a missing person	Municipal Official Stakeholders Community Residents
Platform as a service	Demonstration of a residents management system	Municipal Official Stakeholders Community Residents

Simultaneously with these demonstrations centered on the Philippines, we were also involved in publicizing activities for portable local ICS systems at forums sponsored by the United Nations with a view to international expansion of our developed systems. Figure 7 shows booth exhibits of developed systems at UN-sponsored Internet Governance Forum (IGF) events. Figures 7(a) and 7(b) show our exhibits at IGF 2023 held in Kyoto and IGF 2024 held in Riyadh, respectively. Through exhibits like these, the value of our developed systems can be recognized as tools for accelerating the elimination of gaps between regions originating in a lack of Internet availability, which is also a worldwide issue hindering the achievement of Sustainable Development Goals (SDGs). Global recognition is growing as reflected by inquiries that we have been receiving from African regions, the United States, and elsewhere on use cases of these systems.

5. Conclusion

This article introduced the research and development of portable local ICT systems that we have been promoting and associated international activities. These series of activities have led to international standardization, higher level of system completeness, and improved and advanced functions. Going forward, in addition to conducting further research and development and promoting international standardization, we aim to deploy the developed systems in disaster-prone countries and in areas where the Internet has not yet been restored so that they can be widely used as a tool for immediately launching a local network environment and accelerating the restoration of the Internet at the time of a disaster.

Acknowledgements

A portion of this research and development work was conducted through the support of the Ministry of Internal Affairs and Communications (MIC) and the Cabinet Office's Strategic Innovation Promotion Program (SIP) Phase 1–3. We extend our sincere gratitude for this support.

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Figure 7: Booth exhibits of developed systems at Internet Governance Forum (IGF) events

(a) IGF2023 in Kyoto (b) IGF2024 in Riyadh

APT Training 2025 Report

—Strengthening network planning for connectivity and development in rural areas —

Engagement Relations Department
The ITU Association of Japan

The ITU Association of Japan conducts training programs as part of the Asia-Pacific Telecommunity (APT) human resource development support program. This program, funded by contributions from the Government of Japan, provides training for practitioners and engineers from APT member countries to introduce Japanese technologies and services. The training aims to equip participants with the skills needed to develop network plans that help bridge the digital divide between urban and rural areas.

The FY2025 training program was held under the theme "Strengthening network planning for connectivity and development in rural areas." It took place over six weekdays between December 2 and December 9. Trainees were recruited by APT between September 3 and October 2, and ten participants were selected from nine countries: Bangladesh, Cambodia, Laos, Malaysia, Maldives, Mongolia, Nepal, Sri Lanka, and Tonga. The trainees stayed at Hotel Sunroute Plaza Shinjuku, located near the south exit of Shinjuku Station, and attended the training sessions in a conference room on the fourth floor of a neighboring building.

During the program, trainees studied methods for analyzing the current state of telecommunications networks in their home countries and learned fundamental network planning techniques aimed at addressing the digital divide between urban and rural areas in developing countries. On the basis of this knowledge, they acquired practical skills for designing telecommunications networks suited to the conditions of their respective regions.

The training consisted of lectures and practical exercises using drills focused on network planning. Mr. Takayoshi Hamano, formerly of NTT, delivered an overview of network planning. Mr. Aleman Shiraishi, formerly of Fujitsu Solutions Ltd., lectured on optical fiber technology. Mr. Yuki Shida of KDDI Corporation presented KDDI's initiatives in satellite communications and recent developments. The drill-based practical exercises were conducted by Mr. Hamano and Mr. Shiraishi.

■ **Figure 1: Group photo at the opening ceremony**

The six-day training schedule was as follows:

Day 1	Morning:	Orientation
	Afternoon:	Opening ceremony and presentation of country reports by trainees Evening: Welcome reception
Day 2	Morning:	Presentation of Japan's country report by Mr. Takashi Komoro, Secretary-General of the ITU Association of Japan
	Afternoon:	Lectures by Mr. Hamano, Mr. Shiraishi, and Mr. Shida
Day 3	All day:	Group exercises using drills and presentations
Day 4	Morning:	Visit to the NICT Advanced ICT Technology Exhibition
	Afternoon:	Visit to Jindaiji Temple and action plan guidance by Mr. Hamano
Day 5	Morning:	Group exercises using drills
	Afternoon:	Presentations of the group exercises and preparation of action plans
Day 6	Morning:	Presentations of action plans by trainees, closing ceremony, and farewell luncheon

On the morning of the first day, an orientation session was held, which included an overview of the ITU Association of Japan, an explanation of the training schedule, and a short guided tour of the area around the training venue. During the opening ceremony in the afternoon, Mr. Kaiho Aono and Mr. Katsuhiro Suzuki from the Ministry of Internal Affairs and Communications (MIC) attended the event, and Mr. Aono delivered the opening remarks. This was followed by presentations of country reports by all trainees. In their presentations, the trainees introduced their respective countries, outlined the current state of telecommunications and ICT technologies as well as their future visions, and described the rural areas they planned to address in their action plans (Figure 2). Later that evening, a welcome reception was held at a venue on the second floor of the trainees' hotel, with Mr. Ryo Horikawa from MIC attending as a guest. During the reception, games involving the trainees were organized, providing an opportunity for trainees to interact with one another and with the instructors, thereby fostering stronger connections among participants.

■ **Figure 2: Presentation of country reports**

On the morning of Day 2, a presentation on Japan's country report was delivered by Mr. Komoro, Secretary-General of the ITU Association of Japan. His presentation covered topics including the current state of mobile communications in Japan. In the afternoon, lectures were given by the instructors: Mr. Hamano spoke on network planning and wireless technologies, Mr. Shiraishi presented on optical fiber technology, and Mr. Shida introduced KDDI's initiatives in satellite communications and the latest developments in this field. Each lecture generated many questions from the trainees, reflecting their strong interest in optical fiber technologies and non-terrestrial network systems (Figure 3).

On Days 3 and 5, group exercises were conducted using drills based on three different types of terrain data. The trainees were divided into three groups, where they carried out self-study and group discussions. Each group then presented the optimal network plan they had developed, with the team leader delivering the presentation on behalf of the group. Team leaders had been assigned in advance by the program organizers, ensuring that nearly all trainees had the opportunity to take on a leadership role. After each presentation, the instructors provided feedback, allowing trainees to further deepen their understanding of network planning (Figures 4 and 5). On the afternoon of Day 5, following the group exercises, the trainees worked on preparing their action plans, while also engaging in question-and-answer discussions with the instructors.

■ **Figure 3: Lecture on network planning by Mr. Hamano**

■ **Figure 4: Group discussion using drills**

■ **Figure 5: Presentations following the drill-based group discussions**

On Day 4, the trainees visited the National Institute of Information and Communications Technology (NICT) as part of a study tour of Japan's advanced technology research facilities. They first observed the generation and distribution system of Japan Standard Time, as well as demonstrations related to remote sensing using aircraft to observe the Earth's surface. Afterward, they toured the exhibition area, where displays on Beyond 5G, multilingual simultaneous interpretation, and cybersecurity were presented. The trainees listened attentively to the explanations and showed particular interest in the hands-on exhibits, especially the "Multiple Sound Spot Synthesis Technology" and the "Multi-Aroma-Shooter" (Figures 6 and 7).

Following the visit, the trainees traveled to Jindaiji Temple in Chofu City, the second-oldest temple in Tokyo. After lunch, they took a walk around the surrounding area. Although the visit lasted only about two hours, the trainees fully enjoyed the traditional atmosphere of Japan. Afterward, they returned to the training venue, where Mr. Hamano provided guidance on preparing their action plans.

On the final day (Day 6), the trainees presented their action plans, followed by active question-and-answer sessions between the presenters, lecturers, and other participants (Figure 8). A closing ceremony was then held, during which Mr. Komoro, Secretary-General of the ITU Association of Japan, presented certificates of completion to each trainee (Figure 9).

Afterward, the trainees provided evaluation comments on the training program. The program concluded with a farewell lunch at

■ **Figure 6: Visit to the Japan Standard Time exhibition at NICT**

■ **Figure 7: Group photo at NICT**

a Japanese restaurant, where participants enjoyed Japanese cuisine while deepening their exchanges with one another.

As in previous years, the organizing office also arranged catering with beverages and snacks at the training venue to encourage communication among trainees, lecturers, and staff. In addition, a post-program questionnaire on the program's operation was conducted on a voluntary basis. The results indicated a high level of satisfaction among nearly all respondents regarding the overall management of the program, the training venue, the accommodation hotel, the catering, and the lecture content. The survey results also showed that trainees had strong interests in topics such as future trends in 5G/6G, generative AI models, wireless network propagation, sustainability in rural and remote areas, frequency planning, and network optimization. As for preferred sites for future technical visits, trainees expressed interest in facilities of telecommunications operators and ICT companies, as well as network operation centers of mobile network operators.

■ **Figure 8: Presentation of action plans**

Finally, we would like to express our sincere gratitude to the APT and the Ministry of Internal Affairs and Communications for their guidance and support in organizing this training program. We also extend our appreciation to Mr. Hamano, Mr. Shiraishi, and Mr. Shida of KDDI Corporation for their efforts in preparing lecture materials and guiding the trainees, as well as to Ms. Hiroko Taga of NICT for supporting the study visit. Our heartfelt thanks also go to all others who contributed to the successful implementation of this training program.

■ **Figure 9: Presentation of certificates of completion**

Overview of the 2025 White Paper on Information and Communications in Japan

Economic Research Office
ICT Strategy Policy Division
Information and Communications Bureau
Ministry of Internal Affairs and Communications

The Special Feature of this year's White Paper on Information and Communications in Japan is titled "Digital Technologies as Spreading 'Social Infrastructure'." It provides an overview of the expansion of the digital ecosystem, which is functioning as a social infrastructure, the trend of explosive AI progress, and the rise of overseas businesses in the digital field. Based on this, the Special Feature looks ahead to the challenges brought about by digital technologies and the roles that they can play in resolving social issues in Japan.

Special Feature (Digital Technologies as Spreading "Social Infrastructure")

Chapter 1 Special Feature (Digital Technologies as Spreading "Social Infrastructure")

Section 1 Penetration, Expansion, and Trends of Digital Technologies as "Social Infrastructure"

As digital technologies permeate society and the digital ecosystem expands as an important and essential "social infrastructure" in social life and corporate activities, including social networking service (SNS) platforms and cloud services, major changes are occurring in information gathering, communication, and corporate economic activities.

1. Permeation and Expansion of Digital Technologies in Social Life

(1) Internet connection devices

In the past, personal computers were the main devices used to connect to the Internet. However, with the increasing speed of mobile networks, cheaper mobile phone charges, and the diversification of applications available on smartphones, people, including the elderly, are shifting to smartphones.

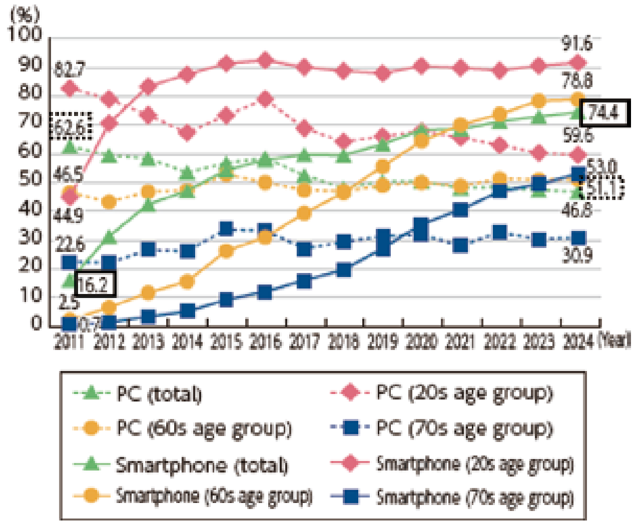
(2) Communication tools/SNS

The means of communication have shifted to mobile phones, and LINE has a major presence today. For example, overall LINE usage increased from 55.1% in 2014 to 94.9% in 2024. Even among the elderly, the usage rate among people in their 60s increased from 11.3% in 2014 to 91.1% in 2024.

(3) Video sharing and distribution services

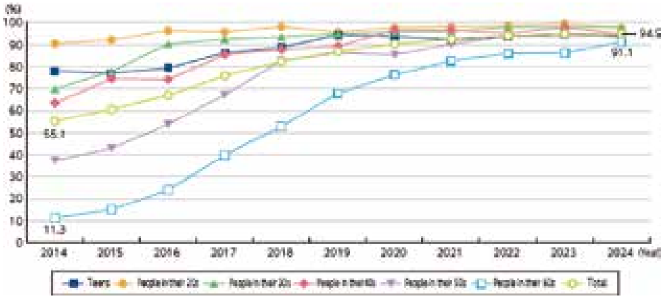
The number of video service users has increased significantly since 2020 as people spent more time at home during the COVID-19 pandemic, and usage rates still remain high. In

■ Figure 1: Changes in the usage rate of Internet connection devices (PCs*, smartphones)



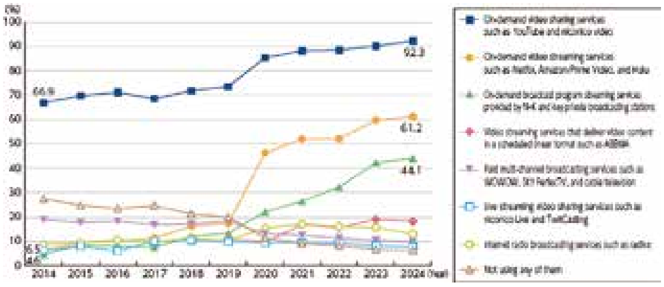
＊ Home computer" was used instead of "PC" before 2016.
(Source) Prepared from the MIC "Communication Usage Trend Survey"

■ Figure 2: Changes in the LINE usage rate (by age group)



(Source) Prepared from the MIC "Survey on Information and Communication Media Usage Time and Information Behavior"

■ Figure 3: Changes in the usage rate of video and radio services using the Internet



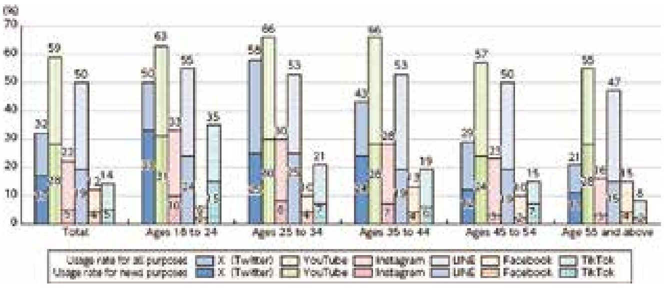
(Source) Prepared from the MIC "Survey on Information and Communication Media Usage Time and Information Behavior" particular, there has been an increase in the number of users of on-demand video sharing services such as YouTube, on-demand video streaming services such as Netflix, and on-demand broadcast program streaming services provided by television stations.

(4) Information gathering means

With the expansion of Internet portal sites and news distribution via social media, and the increasing SNS usage rate, the Internet is becoming an important means for people to gather information.

According to a survey conducted in 2024 by an organization affiliated with the University of Oxford in the UK, the usage rate of social media for news purposes in Japan is high for YouTube, X, and LINE. On the other hand, in terms of media reliability, Internet-based media are regarded as less reliable than TV and newspapers for all generations.

Figure 4: Usage rate of social media as a news source (by age group, all respondents in Japan, 2024)



(Source) Prepared from the Reuters Institute for the Study of Journalism "Digital News Report" (2024)

Figure 5: Reliability of media (by age group, 2024)

		Television	Newspaper	Internet	Magazine
Total	All age groups (N=1,800)	58.2%	59.9%	27.0%	15.7%
Age groups	Teens (N=140)	52.1%	57.9%	24.3%	18.6%
	People in their 20s (N=218)	46.8%	50.0%	28.0%	17.4%
	People in their 30s (N=237)	43.5%	43.0%	29.1%	17.3%
	People in their 40s (N=306)	54.6%	54.9%	31.7%	19.0%
	People in their 50s (N=330)	63.0%	66.4%	33.0%	15.2%
	People in their 60s (N=271)	66.4%	69.4%	22.5%	13.3%
	People in their 70s (N=298)	72.1%	71.1%	18.5%	11.4%

(Source) Prepared from the MIC "Survey on Information and Communication Media Usage Time and Information Behavior"

2. Penetration and Expansion of Digital Technologies in Corporate Activities

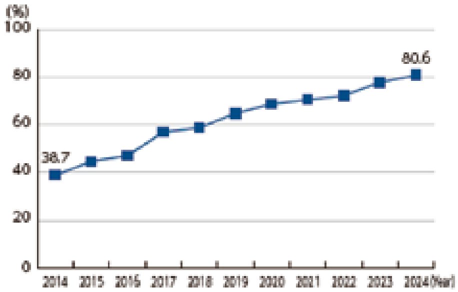
(1) Cloud services

In corporate activities as well, the penetration and expansion of the digital ecosystem have been remarkable. For instance, the use of cloud services in general by companies has been expanding year by year, and the usage rate of cloud services for companies has doubled over the past decade.

(2) Customer contact and transactions between businesses

Similarly, this applies to information dissemination from companies to customers, such as in advertisements. For example, Internet advertising expenditures reached 3.7 trillion yen in 2024, accounting for 47.6% of total advertising expenditures.

Figure 6: Changes in the use of cloud services



(Source) Prepared from the MIC "Communication Usage Trend Survey"
＊ Combined company-wide use and use at some business locations or departments

3. The Importance and Indispensability of Digital Services in Everyday Life and Corporate Activities

(1) Everyday life

A questionnaire survey of individuals was conducted regarding their usage of digital services, such as, among others, information gathering and dissemination on SNS. In the survey, respondents were asked about the impact of each digital service if the service were suspended, and the possibility of using other services as an alternative. As a result, for a wide range of digital services, a high percentage of respondents said that "although there are alternative services, the suspension of the service would be very inconvenient."

The results are considered to indicate that a wide range of digital services are widely recognized as being high in their "indispensability" and "importance."

(2) Business activities

Regarding business operations that use cloud services in companies, a questionnaire survey was conducted on the possibility of substituting other services for the operations that currently utilize cloud services. As a result, it was found out that the cloud services used by companies in many fields have a significant impact, such as "it would be difficult to continue business activities without the service" or "the suspension of the service would cause major disruption to business operations." cover a wide range of fields.

This is considered to indicate that cloud services have become an important and indispensable part of today's business activities.

Section2 Trends in Explosive AI Progress

1. Current Status and Trends in AI Technology Development

(1) The intensifying global AI development race

AI comes in many forms, but one of the major recent trends is "generative AI," which generates text, images, videos, etc. In particular, there is growing attention to large language models

(LLMs), which applies deep learning technology.

(2) Recent trends in AI research and development

A. Emergence of reasoning models

In September 2024, OpenAI announced the development of the "OpenAI o1" series as a reasoning model for solving difficult problems. o1 outperformed OpenAI's GPT-4o model on numerous evaluation metrics in the fields of science, code generation, and mathematics, areas where conventional generative AI has traditionally faced difficulties.

B. An open model developed by a Chinese AI startup and its impact on the market

In January 2025, the Chinese AI startup DeepSeek announced the development of "DeepSeek-R1." This model is said to achieve performance equivalent to OpenAI's reasoning model "o1" through various technical innovations. DeepSeek-R1 has garnered particular attention for being made openly available to anyone, being developed by an emerging Chinese startup, and its low development cost.

C. Development of relatively small language models

While the competition to develop LLMs is intensifying, attention is also being paid to the development of models that are composed of LLMs with relatively fewer parameters. Small-scale models are relatively lightweight and capable of faster processing, making them advantageous in environments without network connectivity (local environments) or for specific applications. As a result, their development is being actively pursued.

(3) Trends in AI development and business expansion in Japan

Considering various evaluation reports on AI, it cannot be said that Japan is highly rated compared with other world-leading countries in terms of its AI research and development capabilities and utilization of AI. For example, according to the 2023 Global AI vibrancy ranking released by Stanford University's Institute for Human-Centered Artificial Intelligence (HAI) in November 2024, Japan is ranked 9th overall, lagging behind countries such as the U.S., China, and the UK.

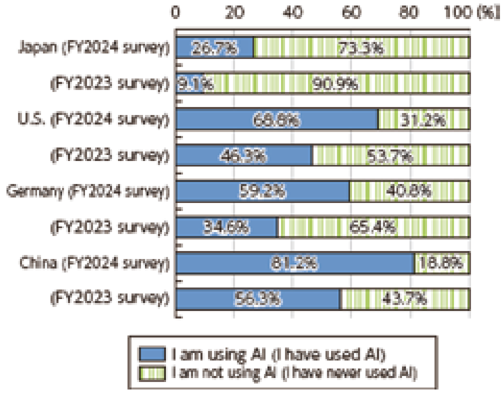
2. Current Status of AI use

(1) Current status of AI use among individuals

In order to understand the current state of AI use among individuals, a questionnaire survey was conducted. In Japan, the percentage of respondents who answered that they "use (or have used in the past)" some kind of generative AI service was 26.7% in the FY2024 survey (the percentage was 9.1% in a survey conducted in FY2023.), indicating that usage has been expanding. However, it remained lower than that of the other countries covered in the FY2024 survey.

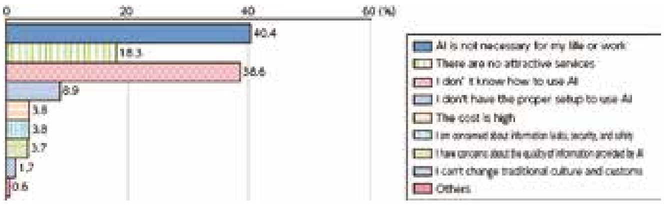
In Japan, respondents who did not use generative AI were asked about their reasons for not using it. The most common response was "not necessary for my life or work," followed by "I don't know how to use it," suggesting that the barriers to use are still high.

Figure 7: Experience using generative AI services (by country)



(Source) MIC (2025) "Survey on the latest trends in ICT, R&D, and digital utilization in Japan and other countries"

Figure 8: Reasons for not using text generation AI services

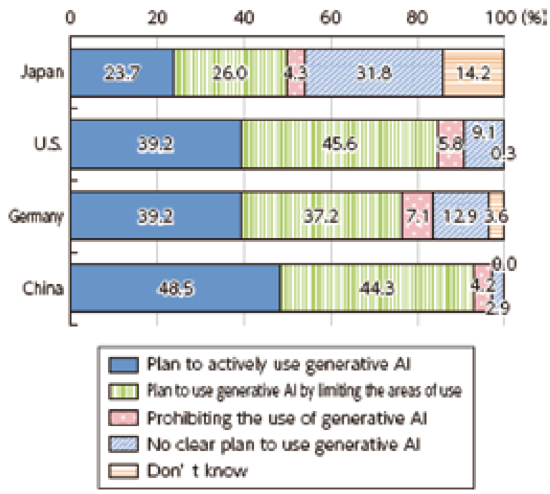


(Source) MIC (2025) "Survey on the latest trends in ICT, R&D, and digital utilization in Japan and other countries"

(2) Current status of AI use among companies

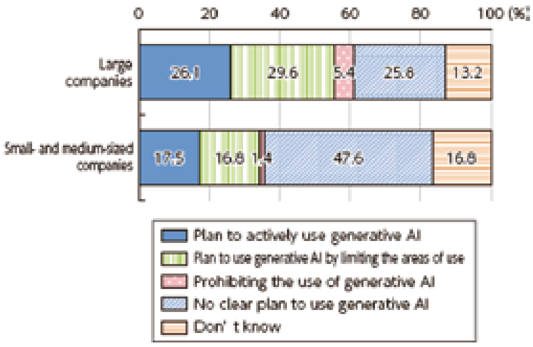
Based on a survey conducted in four countries, namely Japan, the U.S., Germany, and China, the current status of AI use in companies was summarized.

Figure 9: Status of policy formulation for using generative AI (by country)



(Source) MIC (2025) "Survey on the latest trends in ICT, R&D, and digital utilization in Japan and other countries"

Figure 10: Status of policy formulation for using generative AI (by company size (Japan))



(Source) MIC (2025) "Survey on the latest trends in ICT, R&D, and digital utilization in Japan and other countries"

Respondents were asked about the policy for using generative AI at their companies. The percentage of companies in Japan that reported having a policy for generative AI use was 49.7% in the FY 2024 survey, an increase from 42.7% in the FY2023 survey . On the other hand, compared with the other countries surveyed, Japan continues to show a lower tendency to use generative AI.

In addition, when looking at the situation in Japan by company size, the majority of small and medium-sized companies responded that they have "not clearly formulated a policy for using generative AI," accounting for about half of the total.

When respondents were asked about their thoughts on the impact that promoting the use of generative AI would have on their company, the most common answer in Japan was that it would "improve business efficiency and alleviate labor shortage." In the other three countries, respondents tended to cite business expansion, acquisition of new customers, and new innovations.

Section 3 Foreign Business Operators' Rise in the Digital Field and the Current Situation in Japan

1. The Rise of Overseas Big Tech Companies

(1) The growth of platform operators and its background

Overseas big tech companies, including digital platform operators, have a strong presence in providing SNS, cloud services, and other services that are forming the new digital infrastructure of society.

The rise of giant digital platform operators is driven by characteristics that can be explained by various economic concepts, such as "network effects," "low marginal costs," and the resulting "economies of scale." These characteristics are more likely to manifest in the digital market, and the market structure makes it easier for businesses that take the lead by using mechanisms that effectively utilize these characteristics to establish an overwhelming competitive advantage.

(2) Growing influence of big tech companies across fields

Big tech companies are expanding their influence across all layers of the digital industry through technological innovation and market expansion, operating across multiple fields. These companies initially started out by providing applications and services for users, but they have gradually expanded and become more involved in the physical infrastructure layer. Today, big tech companies are strengthening their influence across many areas, from digital industries such as cloud services, data centers, and communications infrastructure to power infrastructure. They are also taking the lead in new technological innovations such as generative AI.

2. The Presence of Foreign Business Operators in the Digital Market and the Current State of Japan's Competitiveness

(1) Trends in the share of Japanese companies in the global and domestic digital markets

Regarding cloud services, in the IaaS and PaaS market in Japan, three companies - Amazon Web Services, Microsoft, and Google - are significantly expanding their market share.

In terms of video sharing services and SNS in Japan, the usage rate of YouTube exceeded 80% in 2024, and the usage rates of services provided by foreign business operators, such as X, Instagram, and TikTok, are increasing year by year.

When it comes to digital devices, foreign business operators also accounted for a large proportion of the Japanese smartphone market share in 2024, with Apple at 59%, followed by Google at 10%.

(2) Trends in the balance of services of digital-related items

In the services account in the balance of payments statistics, the Bank of Japan Review titled "Globalization of Services Trade as Seen in Balance of Payments Statistics" classified certain items related to digital services. Among these items, an examination of the trends in the balances of (1) computer services, (2) copyright royalties, and (3) professional and business consulting services shows that the deficit has been rapidly increasing in recent years, drawing attention as the so-called "digital deficit." It should be noted, however, that this includes balance of payments related to services other than the digital field.

Figure 11: Changes in the digital-related services balance

(Source) Prepared from "Balance of Payments Statistics" by the Ministry of Finance

(3) Trends in trade statistics for ICT goods

Based on trade statistics from the Ministry of Finance, the difference between the amount of ICT goods exported from Japan and the amount imported into Japan shows that the deficit has been increasing in recent years, reaching approximately 3.4 trillion yen in 2024. Looking at the breakdown by item, the largest surplus in 2024 was recorded in "other electronic components," followed by "integrated circuits." On the other hand, the largest deficit was recorded in "mobile phones," and the deficit has been expanding in recent years. Parts and materials tend to have larger surpluses, while final products tend to have larger deficits.

Chapter 2 Challenges Brought about by Advancing Digital Technologies

Section 1 Securing a Reliable Digital Infrastructure that Supports a Digital Society

In Japan, where the population is aging and the economy continues to stagnate, there is a need to use advancing digital technologies, including AI, to advance solutions to social issues. Digital infrastructure supporting these technologies increasingly needs to be developed in a way that responds to the growing demand for communications, computing resources, and electricity, which comes with the expanded use of digital technologies, and the escalating risks of severe disasters. Furthermore, given the current destabilizing global situation and the increasing dependence on overseas countries in the digital field, concerns have been raised about excessive dependence on overseas countries from the perspective of maintaining stable economic and social activities and ensuring cybersecurity.

Section 2 New Challenges Accompanying the Advancement of AI

While likely to bring convenience to our social and economic lives, AI may also pose a wide range of risks. For this reason, it is important to simultaneously promote innovation and address these risks.

As previously suggested by the report's findings, Japan is lagging behind the world's advanced AI countries in terms of technology, industry, and usage.

From the perspectives of Japan's economic growth, addressing social challenges, and economic security, etc., it is becoming increasingly important to promote technology development, securing human resources, and the social implementation related to AI within Japan. At the same time, efforts to establish rules both domestically and internationally, manage risks, and foster international collaboration are also becoming increasingly important.

Section 3 Responses to dis-/mis-information on the Internet

As the survey mentioned in the previous part suggests, the Internet is becoming an important means for people to collect information. In particular, SNS is thought to be increasing its presence as social infrastructure for information gathering, dissemination, and communication.

In this context, problems surrounding the distribution of information in the digital space, such as the distribution and spread of dis-/mis-information on the Internet, defamation, and other information that infringes on the rights of others, are also becoming more serious.

To address these issues, it is necessary to proactively take comprehensive measures, including institutional actions, support for the development of countermeasure technologies, and the improvement of ICT literacy, while taking into account international trends and giving full consideration to freedom of expression.

Section 4 Cybersecurity

Cyberattacks are becoming more complex and sophisticated against the backdrop of a destabilizing and tense global situation, and the expansion of digital use is leading to increased system complexity and a broadening of the Internet attack surface. As a result, security risks are on the rise.

As society becomes more dependent on digital infrastructure, the scale and scope of damage caused by a cyber incident are expected to expand further, posing serious security concerns.

Ensuring cybersecurity in the digital space requires that stakeholders enhance their capabilities and work together. It is important for all stakeholders to take comprehensive measures, including government responses, public-private collaboration, international cooperation, technological measures, and the improvement of citizens' digital literacy.

Cover Art

The Pride of Tokyo's Twelve Months: April, Wisteria at Kameido

Tsukioka Yoshitoshi (1839-1892)

Source: National Diet Library, NDL Image Bank (https://ndlsearch.ndl.go.jp/imagebank)

= A Serial Introduction Part 3 =
Winners of ITU-AJ Encouragement Awards 2025

In May every year, The ITU Association of Japan (ITU-AJ) proudly presents ITU-AJ Encouragement Awards to people who have made outstanding contributions in the field of international standardization and have helped in the ongoing development of ICT.
These Awards are also an embodiment of our sincere desire to encourage further contributions from these individuals in the future.
If you happen to run into these winners at another meeting in the future, please say hello to them.
But first, as part of the introductory series of Award Winners, allow us to introduce some of those remarkable winners.

Kazuki Nakamura

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Fields of activity: ITU-R SG5 WP5A, WRC-19(Agenda Item 1.11), APT/APG, APT/AWG

Activities toward the international standardization of railway radio communication systems

I would like to express my sincere appreciation for receiving the prestigious ITU Association of Japan Encouragement Award. I would also like to extend my heartfelt gratitude to everyone who has supported my activities.

I have been involved in standardization activities at ITU-R and APT since 2017, I participated in discussions to promote frequency harmonization in support of Railway Radiocommunications Systems between Train and Trackside (RSTT).

Within ITU-R, I have been actively involved in WP5A for many years, contributing to the development of reports defining RSTT and summarizing national usage, and to the development of recommendations on frequency harmonization. During this period, I also contributed to the adoption of a WRC Resolution at WRC-19.

I have also been actively involved in AWG activities for many years, and more recently, have contributed to the development of reports compiling case studies on the application of other radio technologies to railway systems, such as satellite systems and 5G technologies.

Through these activities, I have worked to ensure that the frequencies proposed by Japan are included in the harmonized frequency bands.

I am eager to continue contributing to various standardization activities related to railway radiocommunication systems by leveraging these experiences.

Masamitsu Harasawa

Japan Broadcasting Corporation
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Fields of activity: Visual perception

Toward Standardization of Field of View and Spatial Resolution Characteristics for Optimal Head-Mounted Displays

I am deeply honored to receive the prestigious award from the ITU Association of Japan. I would like to express my sincere gratitude to the members of the ITU Association of Japan and all those who have supported our standardization activities.

Since March 2022, I have participated in ITU-R SG6 meetings, engaging in standardization efforts on the ideal specifications for head-mounted displays (HMDs). An HMD is a display device worn on the head that detects head direction and dynamically updates the displayed image, providing immersive and realistic experiences through omnidirectional visuals.

Our research group defines an ideal HMD as one that offers an experience equivalent to observing the real world with the naked eye. We examined the performance requirements necessary to achieve this based on the principle that "performance slightly exceeding human capability is optimal." For example, if the display field is narrower than human field of view, immersion is compromised; if excessively large, it becomes inefficient in terms of hardware and computational resources. Thus, the capabilities of the human visual system serve as a benchmark for determining optimal display performance.

To support this concept, we conducted two assessments of human visual function: the extent of the field of view and the peripheral decline in visual acuity. Since visual acuity decreases toward the periphery, reducing pixel density and rendering precision in peripheral regions may not degrade the experience. Based on these findings, we prepared ITU-R Report BT.2506, proposing spatial performance for ideal HMDs. This report informed updates to Recommendation BT.2123, which specifies video parameters for advanced immersive audiovisual systems and introduces HMD spatial characteristics to support a 360-degree video format with 30K × 15K resolution.

As a vision science researcher, I am honored that my expertise contributed to this achievement. Applying experimental psychology knowledge to international standardization and implementation of technology in society has been a source of great satisfaction.

Many challenges remain in defining the ideal HMD. I will continue to contribute, albeit modestly, by integrating academic insights into standardization efforts and advancing Japan's broadcasting and communication technologies.

Haruhisa Hirayama

KDDI CORPORATION
ha-hirayama@kddi.com https://www.kddi.com/english/
Fields of activity: O-RAN ALLIANCE

Standardization of RAN Slice SLA Assurance in O-RAN ALLIANCE

It is a great honor for me to receive the prestigious ITU-AJ Encouragement Award. I would like to express my deepest gratitude to everyone at ITU-AJ and to all those involved.

Since joining KDDI in 2017, I have been engaged in the operation and management, research, and standardization of radio access networks, particularly through the O-RAN ALLIANCE (hereafter, O-RAN). In O-RAN, I was a major contributor to the O-RAN Use Cases and Deployment Scenarios White Paper, published in February 2020. From November 2020 to July 2022, I served as a co-rapporteur for the "RAN Slice SLA Assurance Feature," a technology that ensures communication quality using RIC (RAN Intelligent Controller). During this period, I submitted numerous contributions and played a key role in driving and coordinating technical discussions. I fondly recall the passionate technical debates with global telecom vendors regarding control mechanisms and interface specifications in WG2, which is responsible for RIC-related specifications.

Since July 2024, I have been serving as a co-rapporteur for the "Filtered Measurements Feature," a technology that enables RIC to collect data from base stations efficiently and flexibly. As the use of AI/ML becomes indispensable for the operation, management, and control of RAN, I will continue to actively promote discussions to further establish these data collection technologies.

In O-RAN, discussion of 6G already started in 2025, and studies and specification work will become more active going forward. KDDI is committed to contributing to value creation for our customers and solving societal challenges in the 2030s. Drawing on the experience I have gained through standardization of RIC-related technologies, I will continue to make every effort to contribute to the further utilization of AI/ML for autonomous networks, the creation of new value through networks, and the resolution of new standardization issues in the 6G era.

Min Tianyang

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Fields of activity: 3GPP RAN WG2, RAN WG3

Standardization of Wireless Access Backhaul and 5G Femto in 3GPP

I would like to express sincere appreciation for this ITU-AJ Encouragement Award, and I sincerely thank everyone involved in 3GPP meetings for their support and collaboration.

WAB (Wireless Access Backhaul) was specified as a simplified version of IAB (Integrated Access Backhaul). While IAB offers flexibility, its complexity has posed challenges for implementation and commercialization. WAB addresses these by streamlining protocols and procedures to enable easier deployment and faster commercialization. WAB is intended for areas with limited backhaul and for emergency connectivity during disasters. The concept also includes mounting WAB nodes on satellite platforms, enabling Non-Terrestrial Network (NTN) backhaul and integrated terrestrial-satellite operations.

5G Femto, the successor to 4G Femto, supports multi-cell operation and is suitable for broader indoor coverage. It also supports the Closed Access Group (CAG) mechanism in Non-Public Networks (NPNs), enabling secure and flexible access control for homes, enterprises, and industrial sites.

As rapporteur, I prioritized practicality and simplicity and guided the development of scalable and implementable standards for both WAB and 5G Femto.

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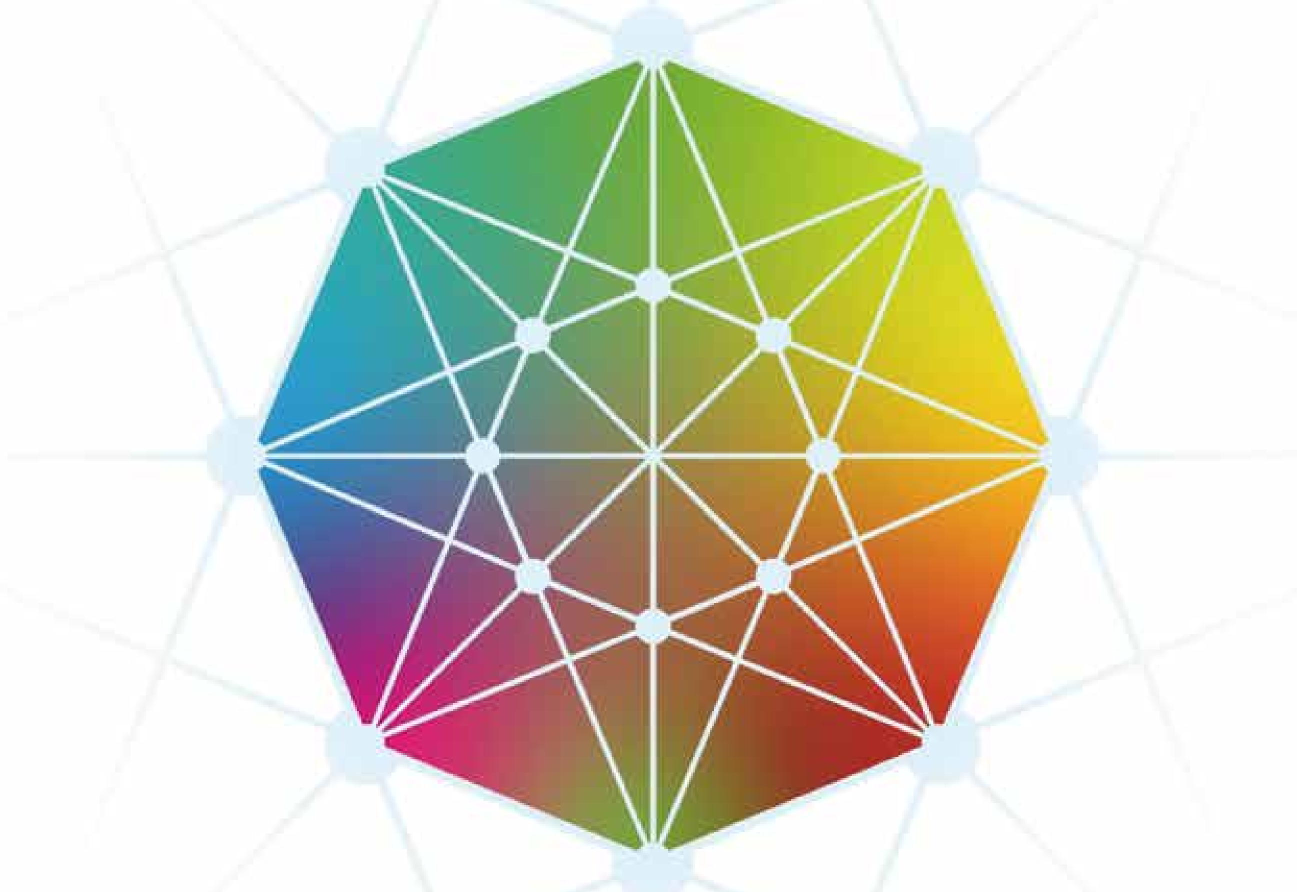

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