General Outline of 5G Field Trials

1. The start of commercial 5G services

In March 2020, mobile phone carriers began offering commercial 5G (5th generation mobile communication system) services. The three main benefits of 5G are that it enables ultrahigh speed communication, has ultra-low latency, and supports multiple simultaneous connections. It is expected that these benefits will enable the development of completely new services, such as allowing people to view realistic live images of remote locations like tourist spots and sports stadiums from various different angles.

In particular, 5G is the only technology that supports ultralow latency and multiple simultaneous connections. The former allows real-time communication to be implemented with low delays, while the latter makes it possible to connect multiple IoT devices at the same time (Figure 1). Applications that take advantage of these features are being considered for use in various industrial fields, such as automatic farm management in agriculture, smart factory applications in the manufacturing industry, and the remote control of construction machinery in the construction industry.

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2.5G Field Trials

The Ministry of Internal Affairs and Communications (MIC) has promoted efforts aimed at the realization of 5G, including research and development, international cooperation and standardization, allocation of frequencies to 5G, and the formulation of technical standards. As a part of this, with the aim of creating new markets through the realization of 5G, a three-year program of 5G Comprehensive Demonstration Tests (hereinafter referred to as "5G Field Trials") was performed from FY2017 through FY2019 with the participation of stakeholders from various fields related to the use of 5G technology (Figure 2). In this article, we look back on the achievements of this program.

In the first year (FY2017), mobile phone operators proactively selected multiple themes and locations in which 5G is envisaged to be used in practice, and performed technical studies relating to the benefits of 5G with regard to speed, latency and connectivity.

In FY2018, 5G technical verification and performance evaluation tests were conducted for various use cases based on eight issues identified by the ICT Infrastructure Regional Development Strategy Study Group of the Ministry of Internal

Figure 1: What is the 5th generation mobile communication system (5G)?



Figure 2: Implementation status of 5G Field Trials

- In the first year (FY2017), technical verification of the fields in which the use of 5G was envisaged were investigated based on themes that business operators wanted to implement.
- In the second year (FY2018), technical verification and performance evaluation tests were conducted for various use cases based on eight issues identified by the ICT Infrastructure Regional Development Strategy Study Group. In addition, a 5G Utilization Idea Contest was held to attract proposals for verification tests based on regional ideas.
- The third year (FY2019), which is the third year of this project, based on the results of previous technical verifications and the Idea Contest, we are working with regional business partners to implement comprehensive verification focused on utilization models that use 5G to address regional issues.

	Business proposal demonstrations				F	tegi	ional problem-solving demonstrations
The eight challenges of ICT infrastructure	Demonstration themes (2017)	Demonstration themes (2018)					Demonstration themes (2019) 2020-
Workforce	 Remote control of construction machinery Teleworking 	Remote control of construction machinery Teleworking Smart factories			s from		 Ensuring the safety of crane operations Remote control of construction machinery, etc.
Local industry	-	 Smart agriculture 	ontest	Ι	n ideas		Improving the efficiency of the dairy and livestock industries Support for breeding light horses
Tourism	 High-definition content distribution 	 Inbound measures 8K public viewings 	ea Cc	Π	zatio	ons	Using VR to promote tourism Event management support
Education	-	Smart schools	pI u	Ι	utili	: regi	Preserving traditional performing arts
Mobility	Convoy driving	Convoy driving	tilizatio		• Convoy driving • Remote vehicle monitoring • Driving assistance in bad weather		Convoy driving Remote vehicle monitoring Driving assistance in bad weather
Medicine/ nursing	Telemedicine	Telemedicine	5G U		Instration	.,	Advanced remote medical care Advanced emergency transportation Safeguarding nursing care facilities
Disaster countermeasures	 Emergency supplies storehouse 	 Smart highways Drone photography 		Π	Demo		Supporting safety assurance in underground railway sections
Administrative services	-	Snowplow driving support		Ί			Snowplow driving support Watching over mountain climbers

Figure 3: Outline of 5G Field Trials (FY2019)

Technology classification	echnical goals Main tasks		Main venues	Main implementers
Ultra-fast, large capacity	Implement ultra-fast communication (average 4-8 Gbps per base station) in an environment with multiple base stations and terminals (1) Using high-definition images to ensure the safety of crane work (2) Watching over and monitoring the behavior of care home residents (3) Editing and relaying video on the cloud in real time (3) Editing and relaying video on the cloud in real time (4) Preserving traditional performing arts (through remote education) (5) Supporting hearing-impaired people by visualizing sounds (6) Using VR and Body Sharing technology for experience-based sightseeing (2) Advanced emergency transportation (7) Advanced emergency transportation		 Ehime prefecture Hiroshima City Sendai City Sendai City Tono district, Gifu Tono district, Gifu Naha City, Okinawa Wakayama City, Wakayama etc. Maebashi City, Gunma 	NTT DOCOMO (1) Ehime University (2) SOMPO Holdings (3) Sendai Television (4) CBC Creation (5) Sun (6) H2L (7) Wakayama Prefecture (8) Maebashi City
	Implement ultra-fast mobile communications at average speeds of over 1 Gbps per base station in an environment with multiple base stations and terminals (1) Dealing with snow damage (more efficient snow removal) (2) Driving assistance in dense fog (3) Providing assistance for golfers (4) Supporting safety assurance in underground railway sections		 Eiheiji Town, Fukui Oita prefecture Nagano City Nagano City Osāka City, etc. 	NTT Communications (1) Eiheiji Town (2) Oita prefecture (3) MIRAIT (4) ITOCHU Techno-Solutions
	Implement ultra-fast communication indoors with an average terminal uplink speed of over 300 Mbps (1) Creating a sense of unity between sports players and spectators (2) Improving the efficiency of the dairy and livestock industries (3) Support for breeding light horses		(1) Higashi Osaka City, Osaka (2) Kamishihoro, Hokkaido (3) Niikappu, Hokkaido	Advanced Telecommunications Research Institute International (1) Jupiter Telecommunications (2) Tokachi Murakami Ranch (3) Hidak Keishuba Kyoudou Ikusei Kousha
Ultra-low latency	Implement highly reliable low- latency communication with transmission times of 10 ms end- to-end and 1 ms between wireless cells when moving at high speed (1) Evacuation guidance and traffic control in the event of a disaster (2) Remote monitoring and remote control of truck convoys		 Kitakyushu City, Fukuoka Hamamatsu City, Shizuoka etc. 	Wireless City Planning (1) Nippon Signal (2) Advanced Mobility
	Support the needs of users while providing ultra-fast low-latency communication (average uplink speed 300 Mbps) in an environment with multiple base stations and terminals (1) Watching over mountain climbers (2) Sports (slacklining) event management support (3) Using VR to promote tourism (4) Remote control and integrated construction management system for construction machinery		 Komagane City, Nagano Obuse Town, Nagano Minamiaso Village, Kumarnoto Iga City, Mie 	KDDI Corporation (1) Shinshu University (2) Goolight (3) Tokal University (4) Obayashi Corporation
Many Simultaneous connections	Implement communication with support for simultaneous connection requests from a large number of terminals	 Safety management of tunnel workers Using visualization to improve the efficiency of logistics 	(1) Hokkaido (2) Nerima-ku, Tokyo	Wireless City Planning (1) Taisei Corporation (2) Nippon Express Co., Ltd.

Projects shown in blue are based on the 5G Utilization Idea Contest

Figure 4: 5G Field Trials around Japan (FY2019)



Affairs and Communications. The ministry also organized a 5G Utilization Idea Contest with the aim of soliciting unique ideas from around Japan that provide solutions to various local problems. A total of 785 entries were received during October and November 2018. In December of the same year, primary screening was performed by the ministry's Regional Bureaus of Telecommunications and Offices of Telecommunications (11 locations nationwide), and in January 2019, the leading proposals selected in primary screening were entered into a contest (secondary screening) held at the Ministry of Internal Affairs and Communications. In the secondary screening, presentations were made by each proposer, and as a result of examination by a panel of judges, the overall grand prize was awarded to an entry from Shikoku, which proposed exploiting the characteristics of 5G to provide a better working environment, safer working conditions, and the transfer of skills from highly skilled workers (proposer: Distributed Processing Systems Laboratory, Ehime University Graduate School of Science and Engineering). Other proposals also received awards, including the 5G Characteristic Utilization Award and the Regional Problem-Solving Award.

In FY2019, based on the results of previous technical verification and the results of the 5G Utilization Idea Contest, we conducted demonstrations at 23 locations nationwide with an emphasis on models that use 5G to help solve local issues (Figures 3, 4).

The implementation status of the 5G Field Trials in FY2019 is introduced below.

For example, based on Ehime University's prize-winning idea mentioned above, NTT DOCOMO entered into a joint

verification trial aimed at ensuring the safety of crane operations through the use of high-definition images at a shipyard in Imabari City, Ehime Prefecture. To operate a shipyard crane more safely, ultra-fast high-capacity 5G communication was used to transmit high-definition video images of a crane's blind spot to the crane operator's cabin, thereby eliminating the blind spot and providing a safe work environment where the crane can be operated safely while checking this video.

KDDI Corporation and others demonstrated a remote control and integrated construction management system for construction machinery in Iga City, Mie Prefecture. This uses 5G's ultralow latency communication to resolve worker shortages and observe working conditions in real time by using remote control of construction machinery and management of construction work at a site where roadbuilding at a dam construction site was being simulated.

Also, a group including a company called Wireless City Planning demonstrated the provision of safety management for tunnel workers in Akaigawa Village, Hokkaido. Using 5G's support for multiple simultaneous connections, they made it possible to detect anomalies inside the tunnel with environment sensors during tunnel engineering works, and by performing remote operation of construction machinery in the event of a disaster or accident, they were able to ensure the safety of workers.

The Ministry of Internal Affairs and Communications has also been working on publicity and advertising related to 5G, including holding the 5G International Symposium 2020 in February 2020 in order to publicize the results of the 5G Field Trials in 2019 in Japan and around the world.

3. The deployment and evolution of 5G

To make 5G available throughout Japan, it will be necessary to set up as many 5G base stations as possible. Here, we introduce the frequency allocations for 5G.

On April 10, 2019, the Ministry of Internal Affairs and Communications allocated frequencies for 5G to four mobile phone carriers (planning and accreditation of specific base stations). In the 3.7 and 4.5 GHz bands, NTT DOCOMO was allocated 200 MHz of bandwidth (3600–3700 MHz and 4500–4600 MHz), KDDI Corporation and Okinawa Cellular Telephone Co., Ltd. were allocated 200 MHz (3700–3800 MHz and 4000–4100 MHz), 100 MHz (3900–4000 MHz) was allocated to SoftBank Corp., and 100 MHz (3800–3900 MHz) was allocated to Rakuten Mobile Inc. In the 28 GHz band, NTT DOCOMO was allocated 400 MHz of bandwidth (27.4–27.8 GHz), KDDI Corporation and Okinawa Cellular Telephone Co., Ltd. were allocated 400 MHz (27.8–28.2 GHz), SoftBank Corp. was allocated 400 MHz (29.1–29.5 GHz), and Rakuten Mobile Inc. was allocated 400 MHz (27.0–27.4 GHz).

To promote early deployment, the Ministry of Internal Affairs and Communications obliged each mobile phone operator to begin offering 5G services in all prefectures within two years when allocating frequencies for 5G in April 2019. To promote the broad expansion of 5G services across the entire country, these deployment guidelines divided the whole of Japan into a grid of 10 km squares, and evaluated the performance of 5G providers in terms of the number of squares in which they had deployed 5G base stations with advanced characteristics. According to the preparation plans of each mobile phone operator, 5G will have been deployed across 98% of the country by the end of FY2023, by which time 5G networks are expected to be deployed throughout the whole of Japan, including rural areas. 5G is expected to be rapidly deployed nationwide as a core infrastructure for the 21st century, which is indispensable for regional development.

4. Local 5G

Ministry of Internal Affairs and Communications is promoting an initiative called Local 5G, whereby organizations such as local companies and local governments can flexibly deploy and use 5G hotspots in their respective buildings and premises according to the individual needs of the region and industry (Figure 5).

In FY2020, to enable local businesses and other organizations to solve regional issues through the use of Local 5G, Local 5G technical verification tests were performed in use cases assuming a diverse variety of Local 5G base station installation locations and usage environments, and through these verification tests, development demonstrations are being performed in which Local 5G is used to construct regional problem-solving models. In FY2020, demonstrations are being performed to address issues in the fields of primary industries (agriculture, fisheries), factories, infrastructure/mobility, tourism/culture/sports, disaster prevention/crime prevention, work style reform, and medicine/ healthcare.

Through these efforts, the Ministry of Internal Affairs and Communications will continue to make a concerted effort to promote the development of 5G infrastructure and the promotion of 5G applications including Local 5G.

Finally, in order to solve regional issues with 5G, in addition to the knowledge of telecommunications carriers and equipment vendors, it is also essential to consider the viewpoints and ideas of 5G end-users. It is hoped that knowledge gained from the 5G Field Trials will be put to good use and that 5G will become more widespread and popular through the cooperation of various stakeholders including telecommunications carriers, equipment vendors, and end-users.

Figure 5: Overview of Local 5G

- Local 5G is a system that allows various local stakeholders such as businesses and regional governments to flexibly build access points in their own buildings or premises according to the individual needs of the region or industry.
- In December 2019, 5G became partly regulated in Japan and applications for radio licenses started being accepted

Comparison of features with other systems

- Unlike the 5G services of mobile operators,
 - it is possible to proactively build 5G systems in regions where area development by mobile phone carriers has been delayed.
 - > It is possible to flexibly set the required performance according to the intended application.
- > The system is not easily affected by communication failures or natural dissaters in other areas.
- Compared with Wi-Fi, it can be used more stably based on a radio station license

