# 5G Field Trials in the Smart City and Medical Service Areas toward Social Implementation of 5G

*Yukihiko Okumura, Satoshi Suyama, and Jun Mashino*

**Abstract**

In this article, we describe two examples of field trials contracted by the Ministry of Internal Affairs and Communications of Japan concerning application of fifth-generation mobile communications systems (5G). The first example was in the area of smart city/smart area and was focused on providing a safe and secure society. The results of experimental trials confirmed that the transmission and aggregation of high-resolution video to a monitoring center enabled facility monitoring and wide-area monitoring in places where many people gather such as public facilities and sports events. The second example was in the medical area and involved the provision of remote medical services. Video interviews conducted via a high-resolution television conference system and multiple high-resolution videos obtained for diagnosis were simultaneously transmitted between a general hospital in a city and a rural clinic.

*Keywords: 5G, security, medical care*

## 1. Introduction

NTT DOCOMO was contracted by the Ministry of Internal Affairs and Communications as the main implementing entity for a fiscal year 2017 project to examine the technical specifications for fifth-generation mobile communications systems (5G) that can achieve a data communication speed exceeding 10 Gbit/s in densely populated areas (study group GI). This article introduces examples of experimental trials conducted in the areas of smart city/smart area and medical services. The organizations participating in the experimental trials in these application areas are listed in **Table 1**.

## 2. Experimental trial in smart city area

With the aim of establishing the advanced security services required for smart cities, namely, services for addressing premeditated crimes (e.g., terrorism, random attacks, and child kidnappings) that cannot be prevented by existing deterrence measures alone, we carried out experimental trials on a new security model for detecting and predicting signs of crime by utilizing high-resolution images and artificial intelligence (AI) via 5G in cooperation with Sohgo Security Services Co., Ltd. and NEC Corporation (**Fig. 1**).

This initiative is based on the concept of modern-day fire watchtowers, with the ultimate goal being to achieve an urban-space security system that monitors an entire urban space by analyzing various camera images corresponding to the three eyes described below (**Fig. 2**).

(1) *Insect eyes* for detecting suspicious persons and people in trouble from camera images captured at facilities
(2) *Fish eyes* for analyzing field video in real time from images captured by cameras worn by guards and attached to drones
(3) *Bird eyes* for promptly detecting fire and damaged and/or impassable roads as well as vehicle attacks by terrorists from images captured by high-elevation cameras

In fiscal year 2017, we carried out experimental trials on two monitoring services, namely, facility monitoring and wide-area monitoring.

Table 1. Organizations participating in experimental trials in areas of smart city/smart area and medical services and their roles.

| GI-participating organization | Role |
|---|---|
| NTT DOCOMO | • Promotion and supervision of all experimental trials in GI<br>• Provision of experimental environment (5G Trial Site) |
| Sohgo Security Services (ALSOK) | • Experimental trial of security operations concerning in-facility monitoring and wide-area monitoring<br>• Provision of high-resolution camera system for wide-area monitoring |
| NEC | • Experimental trial of security systems such as face-authentication gate for in-facility monitoring<br>• Provision of 5G wireless devices (for smart city/smart area, and medical area) |
| Wakayama Prefecture<br>Wakayama Medical University | • Experimental trial of remote medical service utilizing high-resolution video transmission<br>• Provision of experimental environment (at medical university and clinic) |
| NTT Communications | • Experimental trial of high-resolution television conference system for interviews via remote medical service<br>• Provision of 4K television conference system |

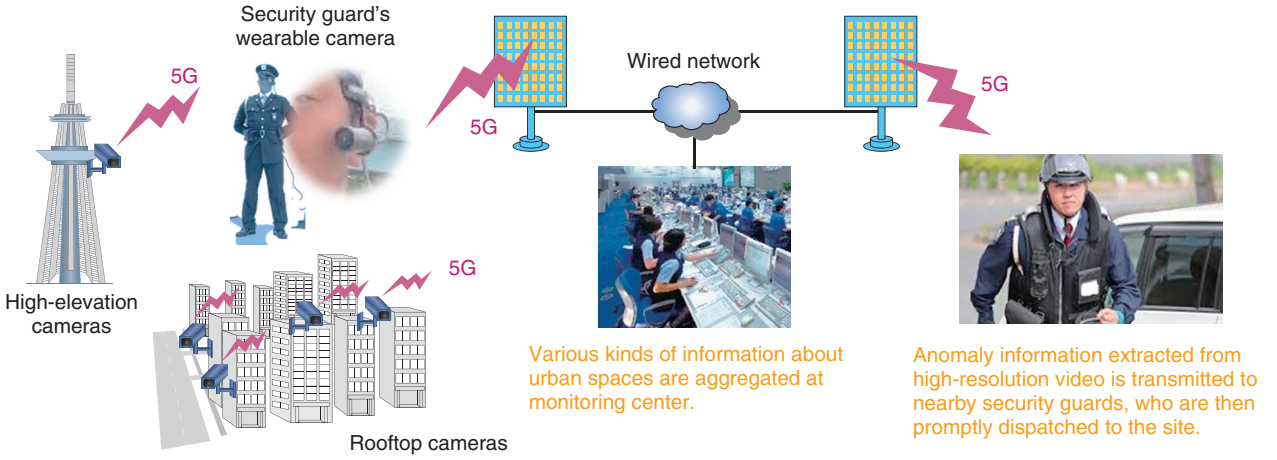



Fig. 1. Overview of experimental trial in smart city area.

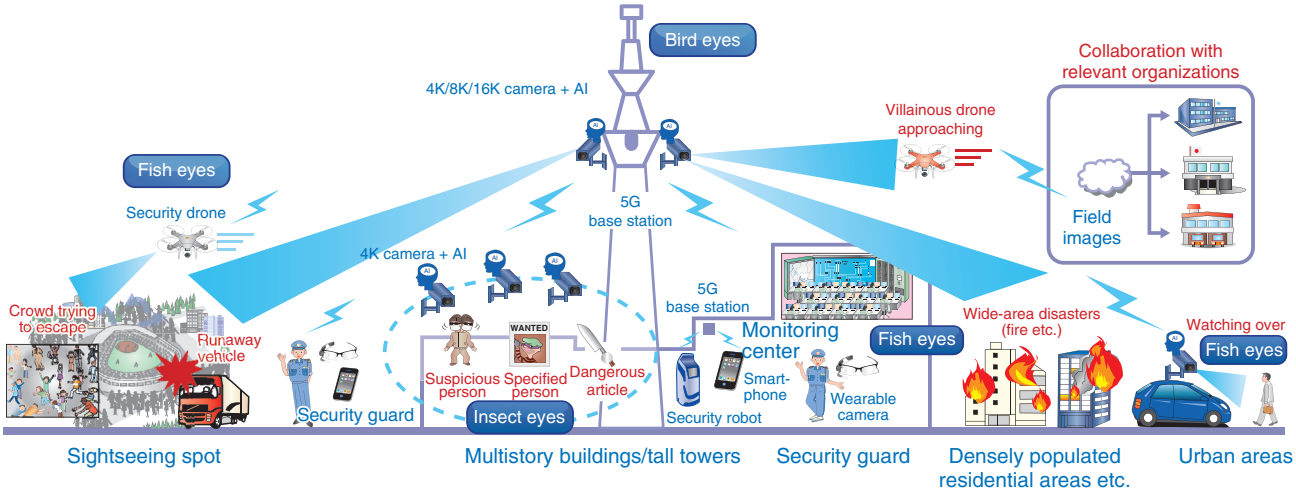



Fig. 2. Modern-day fire watchtower concept.


Experimental trial of facility monitoring using face authentication

Experimental trial of high-resolution video transmission for security guards

Fig. 3. Experimental trial of facility monitoring.

- Facility monitoring (insect eyes and fish eyes): The goal here was to understand actual site conditions by transmitting high-resolution video and identifying dangerous persons by facial detection by inputting high-resolution images to AI recognition systems.
- Wide-area monitoring (bird eyes): The goal was to detect wide-area disasters and understand traffic conditions by utilizing AI and high-resolution cameras mounted high above the ground.

### 2.1 Facility monitoring (insect eyes and fish eyes)

At the National Museum of Emerging Science and Innovation (Tokyo) from November 9 to 11, 2017, we experimentally demonstrated a new in-facility security system utilizing high-resolution images captured by surveillance cameras and a face-authentication gate (**Fig. 3**). This demonstration featured the utilization of face-recognition and image-recognition technology based on AI and recognition of necessary information in real time from images captured by surveillance cameras to achieve primary security in a specific space.

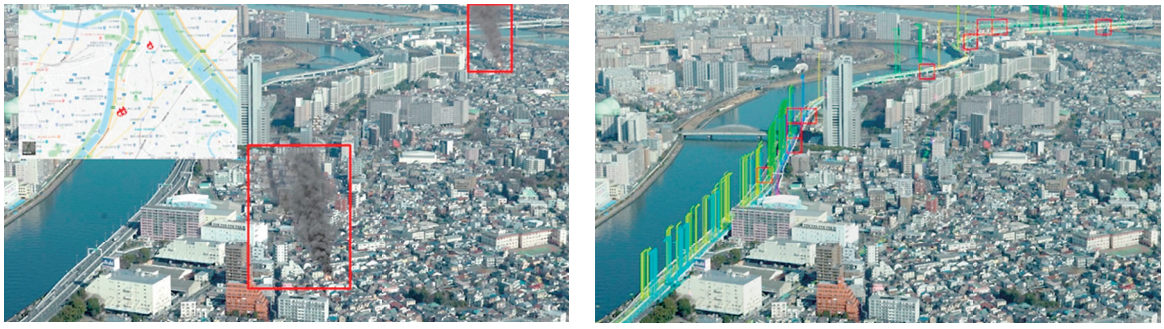
We confirmed that increasing the video frame rate by utilizing the ultrahigh-speed and large-capacity communication of 5G made it possible to increase face-collation frequency by up to six times in comparison with that of a system assumed to utilize 4G that uses the same face-collation algorithm. This system is expected to easily enable the construction of a security area for events. Visitors evaluated the system favorably with comments such as "Although I normally feel nervous in places where security guards are concentrated, I didn't experience that feeling at all with this new system."

Moreover, from February 13 to 16, 2018, in the vicinity of Yasukuni Avenue, Tokyo (Shinjuku Ward), we conducted an experimental trial on transmission of high-resolution video under the assumption that security guards will share security and warning information. We confirmed that even with 5G transmission, performance (throughput and response time) comparable to that achieved in an indoor test using a wired LAN (local area network) was obtained, and transmission was quicker and more stable than that of a conventional wireless transmission system.

### 2.2 Wide-area monitoring (bird eyes)

Since March 15, 2018, we have been conducting experimental trials on wide-area monitoring using 4K high-resolution cameras installed on the Tembo Deck (340 m high) of Tokyo Skytree® and an AI processing server (**Fig. 4**). The final goal of this trial is to achieve high-precision monitoring and real-time information sharing by transmitting on-site video captured by wearable cameras worn by security guards and by surveillance cameras via 5G. The assumed use case was monitoring the observation area for fires and traffic accidents, and this trial verified the effectiveness of this technology for detecting anomalies.

In particular, we tested 720p video transmission by 4G and 2160p (4K) video transmission by 5G in order to evaluate the network bandwidth capacity. With image analysis by AI, for example, for detection of fires by using images captured from the Tembo Deck, recognition of vehicles traveling on expressways, and recognition of locations of traffic jams where traffic accidents are expected, this test confirmed that the ability to discriminate distant objects greatly depends on the resolution of the image and also confirmed that 5G is clearly superior in terms of that ability to distinguish distant objects. The large-capacity data



Analysis of fire (fire synthesized by computer graphics)　　Monitoring of traffic conditions

Fig. 4.　Experimental trial of wide-area monitoring.

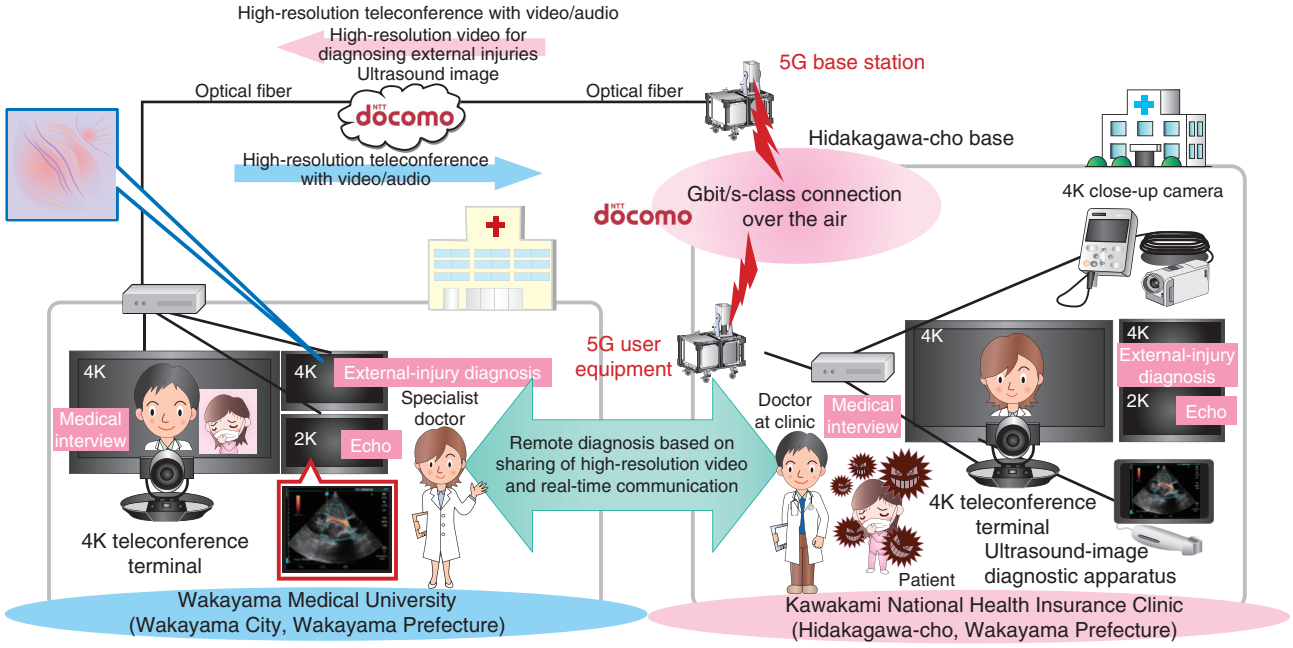


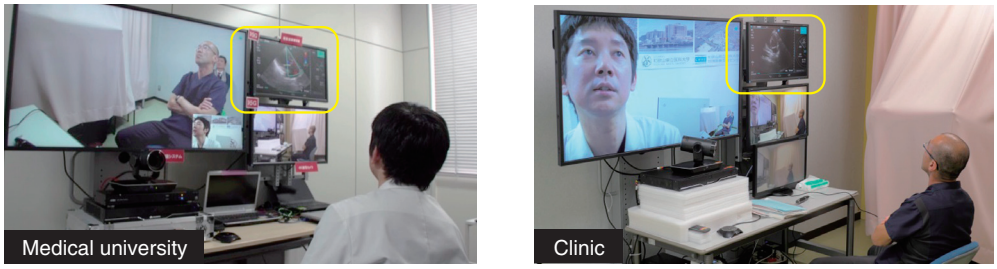

Fig. 5.　Overview of experimental trial by study group GI in the medical area.

communication made possible by 5G enables wide-area monitoring and thereby contributes to creating safe and secure cities. It is also expected to contribute to early detection and prevention of crimes and disasters and to reduce work flows for security operation.

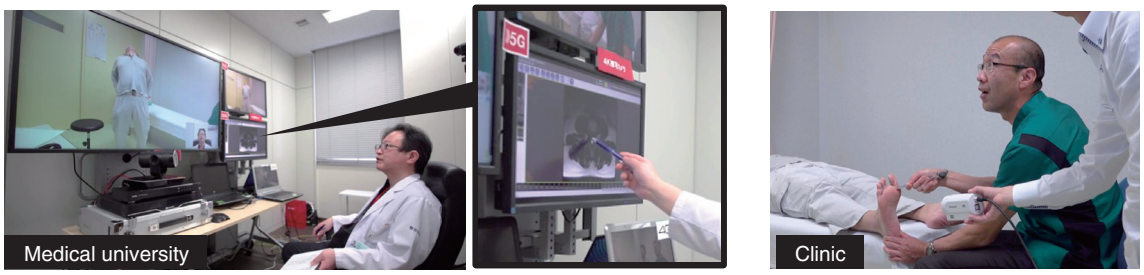
## 3. Experimental trial in medical area

In collaboration with Wakayama Prefecture and Wakayama Medical University, we conducted an experimental trial of advanced telemedicine services utilizing high-resolution video transmission via 5G (**Fig. 5**). The objective of this test was to evaluate the effectiveness of the video transmission system in medical consultations. The goal is to develop a system for providing advanced medical treatment equivalent to that available at urban general hospitals, in rural areas such as mountainous areas, and to eliminate medical disparities between urban and rural areas.

A large portion of Wakayama Prefecture is taken up by mountains, and in many areas, it takes a long time to get to a secondary medical institution. Large hospitals with more than 500 beds are only available in




Real-time transmission of echo images from clinic to medical university to confirm internal disease




Examination of patient is instructed by physician via 4K teleconference system.

MRI image is transmitted in real time.

The doctor at the clinic conducts the response-confirmation test according to the instructions of the doctor at the university.

Fig. 6. Experimental trial of telemedicine.

Wakayama City. The Regional Medical Support Center of Wakayama Medical University (Wakayama City, Wakayama Prefecture) has already introduced a remote medical support system that enables various kinds of support for remote medical institutions. This system connects remote medical institutions with the university via television conferences (teleconferences) using an Internet connection to support local medical care services throughout Wakayama Prefecture. However, in the case of rural clinics, where FTTH (fiber-to-the-home) services are not available, the xDSL (x digital subscriber line) service provided by cable television operators and 4G (LTE: Long-Term Evolution) services are the current means of Internet access, so the video quality of the teleconferences has been restricted.

In this experimental trial, a network was configured connecting the Regional Medical Support Center of Wakayama Medical University and the neighborhood of the Kawakami National Health Insurance Clinic (Hidakagawa-cho, Wakayama Prefecture) by optical fiber and the last-mile communication to the clinic by using 5G. This test confirmed that through the ultra-high-speed communication enabled by 5G, it was possible to correctly comprehend symptoms such as skin diseases by transmitting high-resolution video. It also confirmed that doctors at Wakayama Medical University and doctors at the Kawakami National Health Insurance Clinic can cooperate and smoothly diagnose patients while communicating via the high-resolution teleconference system.

In concrete terms, as diagnostic equipment for the imaging system, a 4K high-resolution close-up camera (used for diagnosis of skin diseases and injuries as well as intraoral diagnosis), an ultrasound-image diagnostic apparatus (echo) (used for diagnosis of internal diseases etc.), and video output from an MRI (magnetic resonance imaging) device were set up in a manner enabling communication between the university and the clinic. In addition, a 4K high-resolution video conference system was implemented to enable doctors to exchange opinions and interview patients.

In this experimental trial, which was conducted from February 20 to March 6, 2018, we utilized the framework of the remote outpatient service provided by Wakayama Prefectural Medical University to conduct examinations according to medical practice and a demonstration for media in a total of five cases (three cases of dermatology, one case of orthopedic surgery, and one case of cardiovascular internal medicine) (**Fig. 6**). Utilizing 5G made it possible to share high-resolution video, which requires a data rate over 100 times faster than past rates, between the two sites. Listed below are the impressions of doctors

and patients who participated in this experimental trial.

**Doctors' impressions**

- "With the current remote outpatient system, signs of external injury could not be seen well; however, with the 4K camera, I could see the examination with the feeling that I was seeing the patient up close. That was quite incredible!" (dermatology)
- "Although it was my first experience of telemedicine, I was able to smoothly interact with patients, thanks to the realistic teleconference system, so I think the findings we obtained were appropriate." (orthopedics)
- "The clarity of the 4K image is excellent, and I felt that the quality of the echo image was in no way inferior to that of the image at hand. I expect this system to enhance regional medical care." (cardiovascular medicine)
- "I felt relieved with the sense that a specialist is 'nearby,' and I felt it was very effective as a tool for upgrading clinics and training young doctors." (a doctor at the clinic)

**Patients' impressions**

- "By seeing the medical professor on a big screen, I think I received medical treatment in exactly the same way as if I had gone to the outpatient clinic of the medical university. The system works for me because it is troublesome for the elderly like myself to take over one hour getting to the medical university."
- "I tried the remote diagnosis for a second opinion. Although I answered the doctor's questions via a screen, which still gave me a realistic feeling, as expected, the explanation of my symptoms and a new treatment policy appeared to be the considerations of a university-hospital specialist, so I was awakened to the truth about the severity of my condition."

Through the above-described tests, we clarified that at actual remote medical practices, it was possible to achieve increased presence, improve the accuracy of diagnosis, and reduce medical treatment time by utilizing the high-resolution video transmission provided by 5G. As a result, these achievements helped to reduce the burden on doctors at the medical university and also helped patients access the highest quality medical care without having to undertake a long and inconvenient journey. We also confirmed that this 5G system contributes to raising the level of local medical care and nurturing young doctors at remote clinics.

**Trademark notes**

**Yukihiko Okumura**
Senior Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.S. and M.S. in electrical engineering from Tokyo University of Science in 1989 and 1991, and a Ph.D. in engineering from Tohoku University, Miyagi, in 2006. In 1991, he joined NTT Radio Communication Systems Laboratories. Since 1992, he has been engaged in the research, standardization, and development of wideband/broadband mobile radio communication technologies, terminals, and systems at NTT Mobile Communications Network, Inc. (now NTT DOCOMO, INC.). He is currently involved in researching 5G system technologies. He is a senior member of the Institute of Electrical and Electronics Engineers (IEEE).

**Satoshi Suyama**
Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.S. in electrical and electronic engineering, an M.S. in information processing, and a Dr. Eng. in communications and integrated systems, all from Tokyo Institute of Technology, in 1999, 2001, and 2010. From 2001 to 2013, he was an Assistant Professor in the Department of Communications and Integrated Systems at Tokyo Institute of Technology. He has been engaged in research on OFDM (orthogonal frequency division multiplexing) mobile communications systems and applications of adaptive signal processing, including turbo equalization, interference cancellation, and channel estimation. In April 2013, he joined NTT DOCOMO and has been involved in research and development of 5G systems. He received the Young Researchers' Award from the Institute of Electronics, Information and Communication Engineers (IEICE) in 2005, the Best Paper Prize from the European Wireless Technology Conference (EuWiT) in 2009, the Paper Award from IEICE in 2012, and the Best Paper Award from International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) in 2016. Dr. Suyama is a member of IEEE and IEICE.

**Jun Mashino**
Manager, 5G Laboratories, NTT DOCOMO, INC.

He received a B.E. in electrical and electronic engineering and an M.E. in communications and computer engineering from Kyoto University in 2003 and 2005. He joined NTT Access Network Service Systems Laboratories in 2005. He has been engaged in the research and development of intelligent interference compensation technologies and signal processing for future wireless communications systems. Since 2016, he has been working as a research engineer at NTT DOCOMO 5G Laboratories. His current interests include wireless transmission technologies for 5G systems. He received the IEICE Young Researchers' Award in 2009 and the APMC 2014 Prize at the Asia-Pacific Microwave Conference in 2014. He is a member of IEEE and IEICE.