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5G and Video

The Prospects of Sensory Transmission and UX in the 5G Era

Field Trials of Using 5G in Video Transmission

5G-AV-QoS Technology

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C O N T E N T S

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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.

The Prospects of Sensory Transmission and UX in the 5G Era

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1. Introduction

Fifth generation (5G) mobile communication systems are now being introduced in various countries around the world. Radio communication began in the early 1900s. It was initially used for military and special industrial applications, and was later developed as an important means of civilian communication. By the time third and fourth generation (3G, 4G) communication systems arrived, it had become a popular way of connecting people and had transformed our communication lifestyle.

In the 2000s, 5G is set to change the industrial world by providing a platform that supports objects-to-object communication and enables the transfer of large quantities of information, such as 4K, 8K and immersive VR video. This is expected to evolve not only as a simple communication platform, but also as an infrastructure to support everyday living and social activity. Compared to the time when radio communication was used for special industrial applications, the transmission cost per bit has become about a trillion times smaller. It is thus expected that radio communication in the so-called “Beyond 5G” era will be widely used as a system that supports society with services such as telepresence and telexistence.

Sony has conducted research and development on various 5G applications, and we have published the results of various demonstration experiments based on our R&D of key technologies and their applications with regard to “remote” operations, primarily in our main business areas of entertainment but also in various other sectors. We believe that we can contribute to the solution of diverse social issues by further developing the remote technology that has been realized in the pursuit of ultimate reality and real-time performance for the Beyond 5G era.

There are four major categories of solutions to social issues that can benefit directly from remote technology.

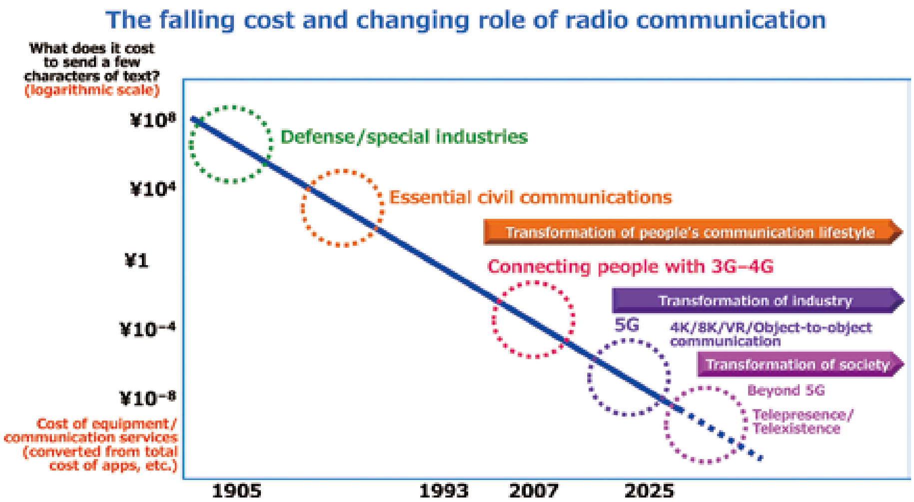
The first is energy consumption. It is considered that the resources, time and physical effort expended in moving people from one place to another can be reduced by developing remote technology, and that the realization of a society where it is unnecessary for people to move around will help to address issues such as the concentration of population in urban areas.

The second is climate change. Remote technology allows people to continue working in a comfortable indoor setting without being exposed to an outdoor environment of extreme high or low temperatures, heavy rain and strong winds all over the world.

The third is mitigation of the effects of natural disasters to ensure the safety of society. According to recent data, the numbers of natural disasters and disaster victims more than tripled between the 1970s and 2000s. It is expected that this will not only contribute to teleoperation activities in dangerous locations and the reduction of unnecessary and non-urgent excursions, but also lead to the realization of virtual experiences in extreme environments where people cannot go.

And the fourth category relates to the management of epidemics such as the one in which we currently find ourselves. A reduction in the movement of people is expected to help alleviate

Figure 1: The falling cost of radio communication



the everyday difficulties faced by people during the spread of an infectious disease.

In this article, we discuss UX proposals and verification tests that assume the availability of 5G/Beyond 5G wireless communication technology, and we discuss the key technologies that will be needed to realize these proposals.

2. Supporting remote technology

The realization of remote technologies such as telepresence and telexistence requires processes that are capable of sensing environments and information, performing signal processing on this data, transmitting it via communication networks, and displaying/presenting it to people and/or objects in visual, auditory, tactile or other forms. Figure 3 summarizes the key technologies required at each stage. In sensing, image sensors and other sensor devices are used to acquire information of various types, including not only images and positional data but also acoustic data from multiple microphones and tactile

Figure 2: From 5G to Beyond 5G

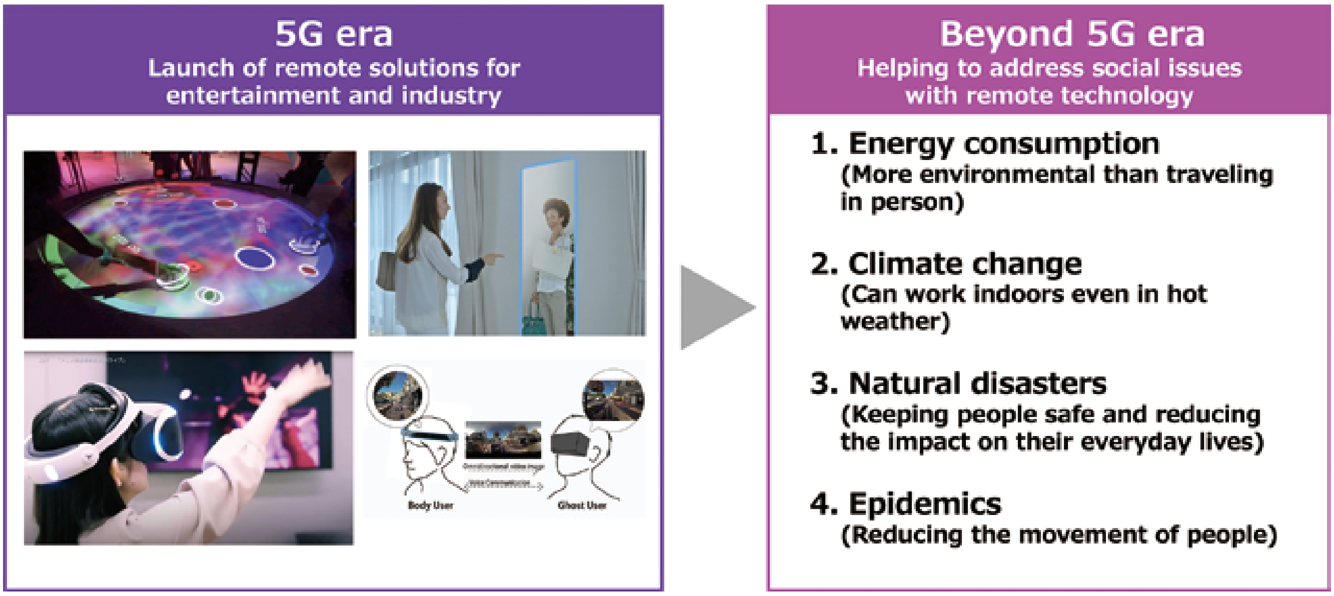
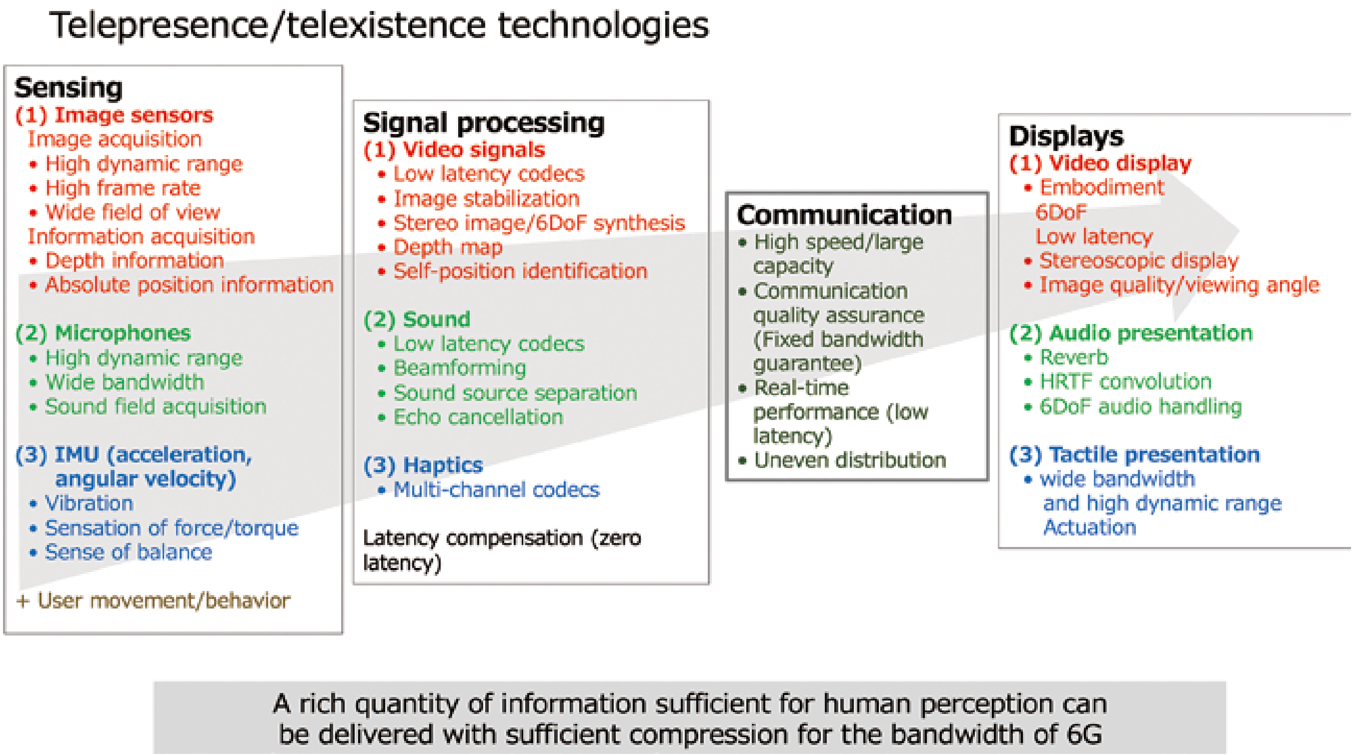


Figure 3: Telepresence/telexistence technologies



sense data from IMUs (inertial measurement units). The data collected in this way is subjected not only to appropriate signal processing, but also to processes such as compression to facilitate efficient transmission through the communication transmission environment at the next step. At the communication stage, due to the development of technologies such as 5G, it is possible to transmit large amounts of data at high speed with high quality and high reliability. This data is then displayed and presented via visual, auditory and tactile means in order to deliver a sufficient quantity of information needed for perception and intuitive understanding by humans.

Here, we introduce the elemental technologies that Sony is developing to help users achieve expanded perception and intuitive understanding.

2.1 Volumetric 3D video capture

First, we will introduce some examples of how images can be captured and displayed.

People intuitively understand their environment by observing it from different angles with six degrees of freedom (6DoF). However, much of this information is lost when images are presented on current 2D display devices.

We have therefore developed a technique whereby an object is simultaneously captured by multiple cameras from multiple different directions, and then image processing technology is used to combine these images into a 3D spatial image that can be transmitted and displayed as 3D data.

By incorporating this spatial three-dimensional information, we can produce video works that would have been impossible to implement with a single camera due to physical constraints and the difficulty of camera work. In this way, we can reproduce the 6DoF environment expected by users. Since this technique can reproduce features including the smooth surfaces of clothing with high quality, it allows data to be presented to users without compromising on the required amount of video information[1].

Figure 4: Volumetric capture of a dancing couple

2.2 Spatial Sound technology: 360 Reality Audio

For this sort of spatial display to provide users with a sense of presence, it is essential to support the intuitive recognition abilities of the user by using not only visual means but also spatial sound technology, which is necessary for the auditory sense.

At Sony, we have developed signal processing technology based on Object Audio technology that can record and play back sounds to reproduce a realistic sound field. We have also defined a music distribution format conforming to MPEG-H 3D Audio specifications in order to provide a new "360 Reality Audio" music experience that surrounds listeners with an immersive spherical sound field.

With this technology, content creators can arrange multiple sound sources at any orientation in this sound field, and can faithfully reproduce these sources during playback so as to provide the user with an acoustic experience that feels just like listening to the real thing[2]. We also plan to develop next-generation 360 Reality Audio content that delivers an even more realistic experience by expanding it to include video and VR content.

2.3 Wide bandwidth and high dynamic range haptic presentation

The sense of touch is perhaps the third most important of the human senses.

Tactile sensations can provide a user with information about the surrounding environment without disturbing the user's visual and auditory awareness, and can even enhance audiovisual information by interacting with the visual and auditory senses (cross-modal effect).

We have developed highly realistic haptic technology that uses audio technology to present tactile feedback having a wide bandwidth and high dynamic range in multiple channels.

This technology can be used to implement haptic presentations of various forms, ranging from palm-of-the-hand presentations to whole-body presentations. In this article, we will focus on the latter. Here, we introduce a technique for reproducing a rich

Figure 5: 360 Reality Audio

360 REALITY AUDIO

virtual haptic experience by using multiple VCMs (voice coil motors) in a vest worn by the user to present vibrations with a wide bandwidth and high dynamic range in synchronization with video and/or audio content. This results in a more immersive experience than can be achieved with audio and video alone.

Technologies that contribute to the sensing and reproduction of the three senses that make the largest contribution to feelings of immersion and reality (sight, hearing and touch) have already been implemented in practice[3].

Figure 6: Users taking part in an immersive haptic experience

2.4 Presenting information on output devices with 6 DoF

To reproduce realistic sensations, it is important to consider how the acquired information can be correctly presented to stimulate these three senses simultaneously.

Here, we introduce two types of video device that can display 3D video information (including the abovementioned volumetric video) with a high degree of realism.

The first is an eye-sensing light field display with eye position recognition that allows the user to view images in 3D without having to wear special glasses. This device reproduces a realistic 3D virtual image inside a box, with the viewpoint of this image constantly adjusted to match the viewpoint corresponding to the position of the user's eyes[4].

The second is an optical see-through augmented reality (AR) HMD (Head Mounted Display) [5].

An AR display overlays virtual objects on real-world places or objects, thereby presenting users with additional information in a way that can easily be intuitively understood. When the user's viewpoint moves, even slight misalignment between real objects and overlaid virtual objects can cause them to lose their sense of presence and prevent users from understanding them intuitively. The main causes of this misalignment are errors in the viewpoint pose estimation, and the processing latency from sensing the user's eye position/gaze direction to drawing virtual objects in the AR visor.

To mitigate this problem, the AR visor performs pose estimation with a combination of an image sensor and an IMU to achieve both highly accuracy and low latency, and the rendered virtual image to be overlaid on the real world is modified immediately before display, depending on how the pose of user's viewpoint changes while rendering. As a result, it is possible to create overlaid images without any apparent delay. This technique is called latency compensation.

Experimental measurements of how the displayed positions of real and virtual objects change over time are shown in the graph below. Without latency compensation, the position of the virtual object lags behind the position of the real object by an amount corresponding to the processing delay, but with latency compensation it can be seen that the positions of the real object and the virtual object are almost identical. This makes it possible to line up the positions of real and virtual objects in a way that appears much more natural[6].

3. UX demonstration experiments

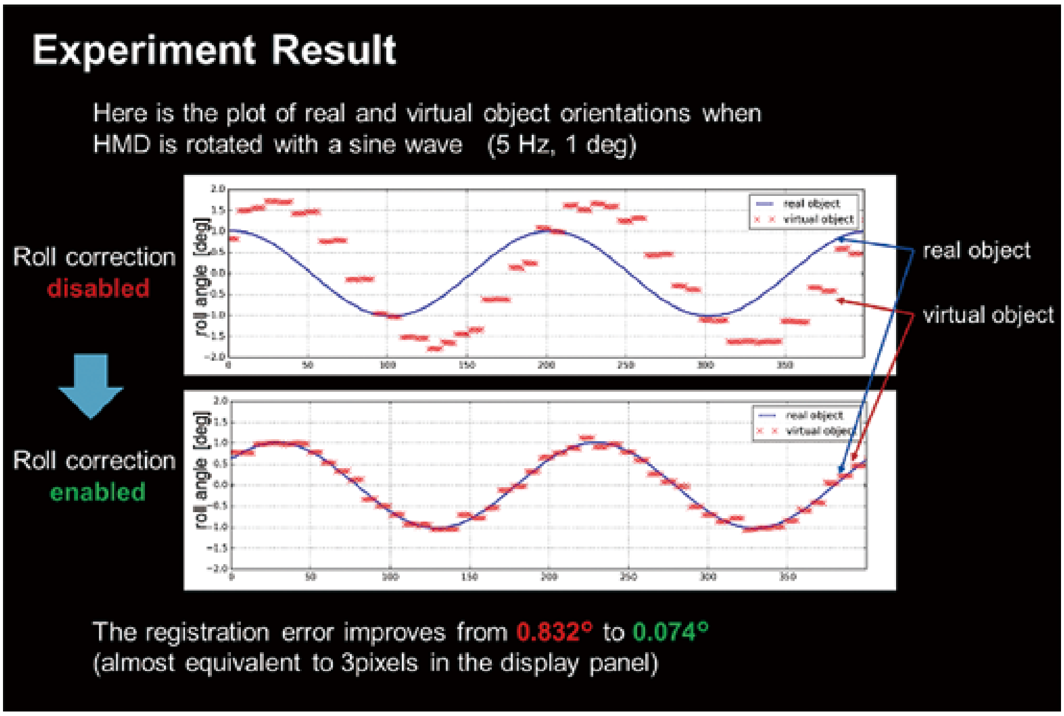
As an application that integrates the key technologies described above, we conducted demonstration experiments on several application cases.

In our research and development of these sorts of key technologies we have repeatedly built prototypes to evaluate what kind of user experience can be obtained by applications that

Figure 7: Eye-sensing Light Field Display

■ Figure 8: Optical see-through AR visor

■ Figure 9: Results of latency compensation experiment



combine these elements, and we have performed experiments to determine the necessary requirements and specifications. Some examples are presented here.

Virtual reality (XR) remote live experience

To develop this system, we teamed up with developers of various technologies, experts and artists in the entertainment field such as music and games to build and demonstrate XR entertainment prototypes that allow users to experience live music from a remote location.

Through prototyping, we are able to not only check the progress of XR technology under development, but also to accumulate know-how related to content production. For example, we found that a five-piece band and a solo singer require different shooting methods and expressions, and that the addition of game-like elements allows users to participate in live events with a greater sense of accomplishment. We have also been able to gain insights such as discoveries relating to the perceived value of new

■ **Figure 10: A virtual reality (XR) remote live experience**

■ **Figure 11: JackIn Head**

XR experiences[7]. For example, music fans do not feel particularly involved in a concert if they are situated too far away from the performing artists, but conversely feel more involved when they share a virtual environment that adapts to the direction in which they are looking.

JackIn Head

We are currently developing a technology called JackIn Head, which offers a way of sending omnidirectional video images from a "body user" (equipped with a wearable 360° omnidirectional camera) to a remote "ghost user" (who can watch this video on a screen or head-mounted display). The body user and ghost user can also communicate via a two-way voice connection. This system should enable the provision of services ranging from synchronous travel experiences and remote assistants to the real-time delivery of special experiences, sports-based entertainment, and professional training. It could also be used in situations where specialized knowledge is required such as medical cooperation efforts, or in disaster-affected areas[8].

Telepresence system

Next, we will introduce some examples of the development and demonstration of a telepresence system aimed at facilitating natural communication between people as if they were all present in the same space. This system uses a 4K vertical display to display images from remote locations in real time. By making use of sound quality enhancement and echo cancellation technology, it allows users to converse with people in remote locations just as if they were in the same room together.

In various demonstration experiments, we found that it is important to match the user's line of sight with the camera axis in order to achieve a realistic sense of communication with the remote images. We also found that hand gestures play an important role in communication, and that it is possible to provide a sense of unity by sharing information with no explicit purpose, such as background video and ambient sounds[9].

■ **Figure 12: Telepresence window**

AR applications

Next, we will introduce two examples of AR applications based on projection.

Both of them use system configuration and prediction algorithms that minimize the latency between the user's movements and the projection images in the same way as the AR visor described above, so that there is virtually zero lag between the user's movements and the displayed motion.

The Doodle Pen AR application allows users to draw virtual letters and pictures anywhere in the environment with a digital pen. By eliminating as far as possible the latency and misalignment between the movements of the user holding the pen and the characters and images drawn using this pen, this system allows the user to concentrate on content creation instead of having to keep thinking about how the system behaves[10].

We also built a prototype A(i)R Hockey application that combines haptic technology with zero-latency projection to give players the impression that they are really hitting a virtual puck. As the game progresses, the players tend to start losing track of whether the pucks they are hitting are real or virtual[11].

In projection examples, including the AR visor mentioned above, it is possible to reduce latency and improve quality by making the position sensing, information processing and prediction algorithms run as fast as possible.

Although we were able to improve the user experience by

■ Figure 13: Doodle Pen

■ Figure 14: A(i)R Hockey

minimizing latency in the examples shown here, we have also repeated these experiments in order to understand the network conditions that are required for these applications.

With the AR visor mentioned above, we are conducting a demonstration experiment in which multiple users share the same superimposed content while constantly communicating and interacting with one other, not only indoors but also outdoors. When used indoors, the devices are covered at the Wi-Fi level, but when users take them outside, the amount of communication increases greatly, even within the controlled space, due to the significantly increased reception of data such as background image information. This traffic requires 5G connectivity. If the devices are used in arbitrary locations that are not confined to a controlled space, then this exchange of information becomes extremely large, and would require communication with an even wider bandwidth.

4. Conclusion

5G has evolved from a conventional communication infrastructure to part of the social fabric, and its successor in the Beyond 5G era is expected to play an even more central role in supporting society's infrastructure. The digitization and low-latency transmission of information directly related to human senses are key requirements. In particular, in systems that integrate cyberspace with the real (physical) world and obtain feedback through communication based on sensing of people and things, we expect to be able to adapt to the diverse needs of people and industries by exploiting AI technology through advances in communication such as high speed/capacity, ultra-low latency, and the ability to handle large numbers of simultaneous connections. In the future, we will continue to work on core technologies for remote applications, and on field trials of applied technologies. We will also pursue the ultimate level of reality and real-time performance in applications combining images and sounds, and even tactile sensations. In this way, we hope to deliver experiences that exceed the expectations of users. Also, for the forthcoming Beyond 5G era, we hope to develop remote technology that works more closely with people to help solve various social issues.

[Reference URLs]
[1] https://www.sony.co.jp/SonyInfo/technology/activities/SonyTechnologyDay2019_demo2/
[2] https://www.sony.com/electronics/360-reality-audio
[3] https://www.youtube.com/watch?v=DMY4LB-4-24
[4] https://www.youtube.com/watch?v=VIPEckQ9wnk&feature=youtu.be
[5] https://www.sony.net/SonyInfo/design/stories/ghostbusters/?ui-ux
[6] https://doi.org/10.1002/sdtp.12923
[7] https://www.youtube.com/watch?v=Dmo5Hq4ROBk
[8] https://www.sonycsl.co.jp/project/2373/
[9] https://www.sony.co.jp/SonyInfo/News/Press/201810/18-085/
[10] https://www.youtube.com/watch?v=qE6tAoaPhyo&feature=youtu.be&list=PL7tWrqXC5RzO4yWWjd814dC7si4-rgaih&t=239
[11] https://www.sony.net/SonyInfo/design/stories/AiRhockey/?ui-ux

Field Trials of Using 5G in Video Transmission

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1. Introduction

High-speed and large-capacity communications through a 5th generation mobile communications system (referred to below as "5G") has a high affinity with the field of video transmission. It is expected to enable the transmission of high-definition video deemed difficult to achieve up to the 4G era, broaden the usage scenarios of new video technologies such as augmented reality (AR) and virtual reality (VR), and drive new developments in video technologies.

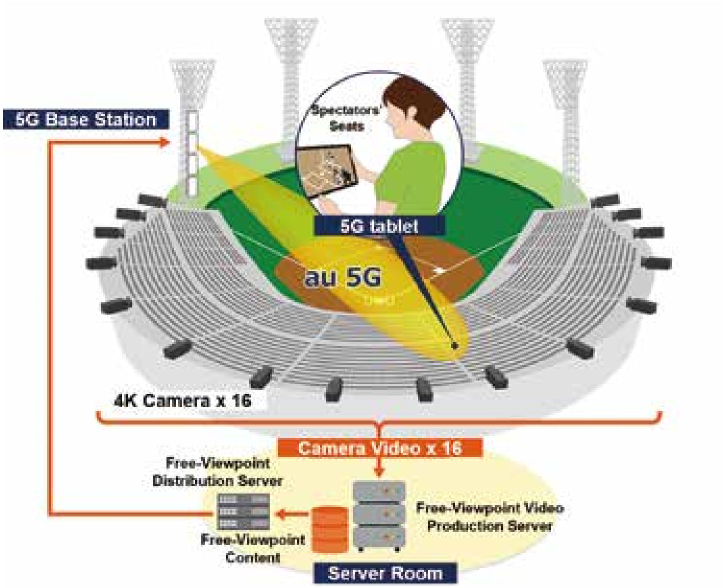
This paper introduces the results of field trials using 5G in video transmission.

2. 5G × real-time distribution of free-viewpoint video

Interest is growing in technologies that can provide users with an even higher sense of presence such as AR/VR as new video-experience technologies of the 5G era. One example of video technologies that can make such high-presence video possible is free-viewpoint video synthesis technology. In the past, it was only possible to view video shot directly by a camera, but free-

■ **Figure 1: Real-time distribution of free-viewpoint video**

■ **Figure 2: System configuration of free-viewpoint video distribution trial**



viewpoint video enables video to be appreciated from a viewpoint not shot by a camera (virtual viewpoint). As a trial combining this free-viewpoint video and 5G, we here introduce a real-time free-viewpoint video distribution trial using 10 5G tablets conducted at a Japanese professional baseball game held at Okinawa Cellular Stadium in Naha in June 2018.

In this trial, the video taken by 16 4K cameras pointed at the batter's box in the field was used as a basis for synthesizing free-viewpoint video from any angle desired by a spectator in real time and to distribute that video to the spectator's seat in the stadium in real time using the high-speed, large-capacity features of 5G in the 28 GHz band. An image of real-time distribution of free-viewpoint video is shown in Figure 1.

The configuration of the free-viewpoint video distribution system of this trial is shown in Figure 2. In this system, the video taken by 16 4K cameras oriented toward the batter's box is sent to a free-viewpoint video production server installed within the stadium to produce free-viewpoint video content in real time. This content is then sent to a free-viewpoint distribution server provided for each user 5G tablet. The users, meanwhile, input viewpoint instructions by touch operations on the screen of their 5G tablets and the system transmits that information to the free-viewpoint distribution server using 5G. This server then synthesizes the free-viewpoint video (2K, 30 fps) corresponding to the received viewpoint information in real time to for distribution to each 5G tablet.

The trial demonstrated that this configuration combined with the large-capacity and low-latency transmission capabilities of 5G enables free-viewpoint video to be displayed approximately 0.5 sec. after a viewpoint input from a 5G tablet. In other words, it showed that the time difference between what one is actually seeing with one's own eyes at a sporting event and the video displayed on the tablet is so small that the user can feel a high sense of presence through interactive viewpoint operations without feeling an uncomfortable time lag. The trial also showed that large-capacity video could be distributed simultaneously to many spectators, which is something that would be difficult for mobile communications of previous generations. A scene of this trial can be seen in a video released on YouTube.[1]

As one example of what this technology can achieve, a spectator sitting on the first-base side can view video taken from the third-base side on one's own 5G tablet and can also rotate, magnify, or reduce the video through touch operations on the tablet. It also incorporates a replay function so that a spectator can take another look at an exciting play such as a home run from various viewpoints. The technology can be applied to stadiums or various types of sporting events where cameras can be installed beforehand and suggests a new sports-viewing style using 5G.

3. 5G × drone

Today, drones are increasingly being used in videography, but the use of 5G with drones is expected to bring about major changes in aerial video applications. For example, the delivery of high-definition video from drones was first made possible by storing the video in camera recording equipment mounted on a drone and collecting the video data after bringing the drone down. However, mounting a 5G terminal on a drone will enable the video from the drone to be relayed in real time. This will enable real-time delivery of high-definition video from angles never thought of before, which should find use in events demanding a high sense of presence. The following introduces two field trials of real-time video transmission from drones using 5G.

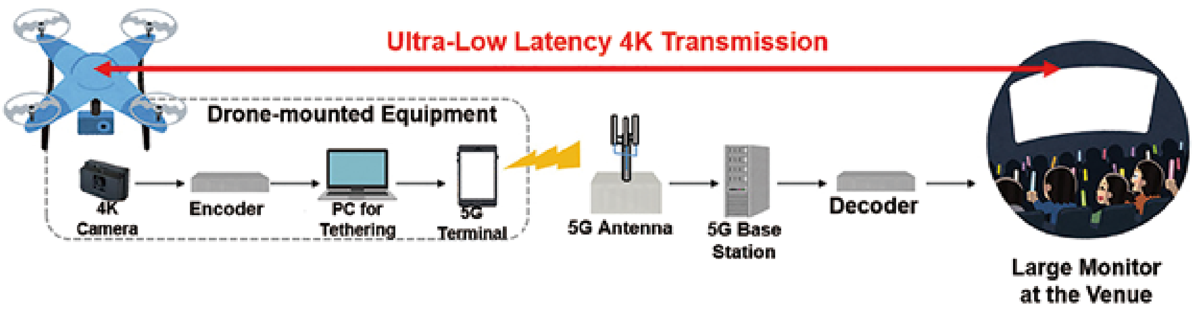
3.1 Real-time ultra-low-latency transmission of high-definition video from drone

This section introduces an example of using 5G-based video transmission from a drone at an event, which was demonstrated at FAI Drone Tokyo 2019 Racing and Conference (DTRC2019), an international drone racing and conference event held at Tokyo Motor Show 2019 in November of that year. In this event, a drone equipped with a 5G terminal and 4K camera was used to capture the scene of a drone race final with 4K, 60 fps aerial video, which was then relayed in real time to a large monitor at the venue using an ultra-low-latency transmission system and 5G in the 28 GHz band. A view of the drone shooting video of the race is shown in Figure 3.

In this event, delay in video transmission could create an out-of-sync feeling between the real movement of subjects and the video displayed on the venue's large monitor. To therefore eliminate this feeling as much as possible, it was necessary to shorten the end-to-end delay from transmitting the video taken by the camera to displaying it on the monitor. In 4K video transmission using conventional encoder/decoder equipment, the delay from video capture to monitor display is long resulting in a delay of several hundred milliseconds due to a compression process. Thus, even if low-latency communications can be

■ Figure 3: View of drone shooting video of race

Figure 4: System configuration of low-latency 4K video transmission from drone



achieved through 5G, the processing time in encoder/decoder equipment is longer than communication time by an order of magnitude thereby making it dominant, which makes it difficult to achieve low-latency video transmission on an end-to-end basis.

With this in mind, all of the processes from camera input to video output in the ultra-low-latency 4K video transmission system used in this trial were reviewed to reduce the latency, the large-capacity capabilities of 5G were exploited, and video-compression and distribution parameters were optimized such as reducing the compression rate. In this way, the latency from camera capture to video display on the large monitor at the venue was reduced to less than 100 milliseconds and a high-reality video viewing experience of the drone race from above was achieved.

Figure 5: Scene from trial of 8K video transmission from drone

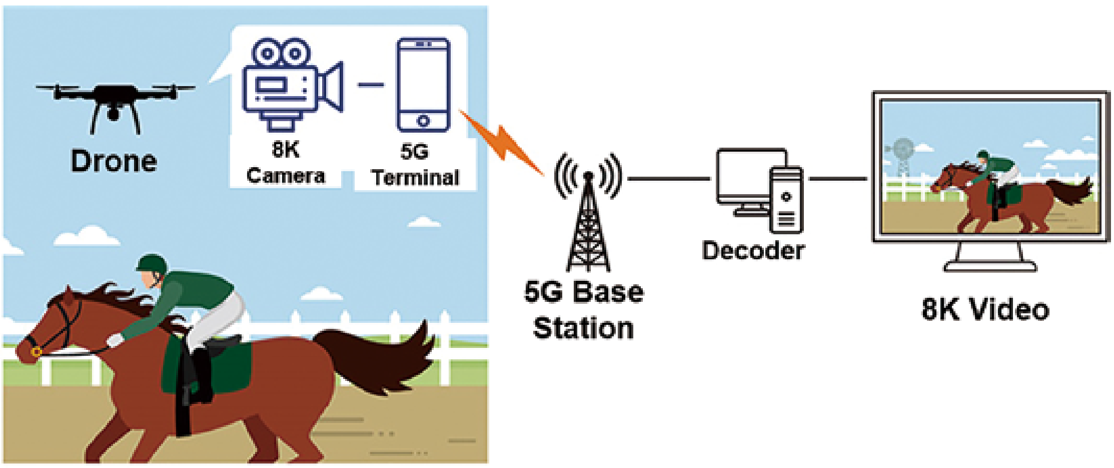
The system configuration of low-latency 4K video transmission from a drone is shown in Figure 4.

The combination of 5G and drones is expected to achieve real-time distribution of exciting video previously unseen, such as video from viewpoints that follow an object moving at high speed or video from inaccessible locations such as overhead points. Additionally, the future spread of drones equipped with a 5G terminal should enable even more users to become video distributors and bring even minor sporting events or activities under the spotlight.

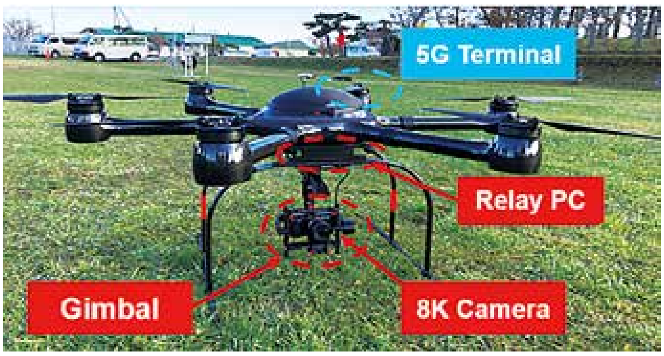
3.2 Real-time transmission of 8K video from drone

The following introduces a trial of transmitting 8K ultra-high-definition video in real time using 5G to observe and monitor a racehorse on a training course from remote locations as a means of supporting racehorse training. This trial was conducted in November 2019 in cooperation with the Hidaka Race Horse Cooperative Upbringing Center in Niikappu, Hokkaido. The trial envisioned a number of uses for this capability. For example, it could satisfy the needs of horse owners, producers, etc. that would like to check on the growth of their ponies entrusted to a cooperative without having to actually go there. It could also be used to convey the charm of horse pastures to people living overseas and to the horse-riding population, to promote tourism to or employment at such pastures, and to even increase the sale of horse-racing betting tickets. This trial was conducted as part of the 5G System Trials by the Ministry of Internal Affairs and

Figure 6: System configuration of 8K real-time video transmission trial



■ **Figure 7: Devices mounted on drone**



Communications (MIC). A typical scene from the trial is shown in Figure 5.

The system configuration of this trial is shown in Figure 6. The 5G system covers the drone flight airspace above the training course at the racehorse training facilities in the 28 GHz band. The drone used for shooting the video mounts an 8K camera, a computer for video relay, and a 5G terminal as shown in Figure 7. The ultra-high-definition video (30 fps) from the 8K camera is delivered via 5G at a transmission rate of approximately 100 Mbps and displayed in real time on an 8K monitor installed within an office. This system can provide vivid views of a racehorse in training through ultra-high-definition video. It can also be used to broadcast high-presence video from a drone of racehorses running at full speed to tourist facilities, transportation hubs, and other sites to generate interest in racehorses and promote tourism, and it could even be used for actual races. A scene of this trial can be seen in a video released on YouTube.[2]

3.3 Summary

As described above, the real-time transmission of high-definition video from a drone by 5G enables distribution of aerial video with a high sense of presence, which was difficult to achieve in previous mobile systems. In addition, we can envision how such a system can be used for live events that require real-time characteristics or for remote piloting of drones by leveraging the low-latency feature of 5G.

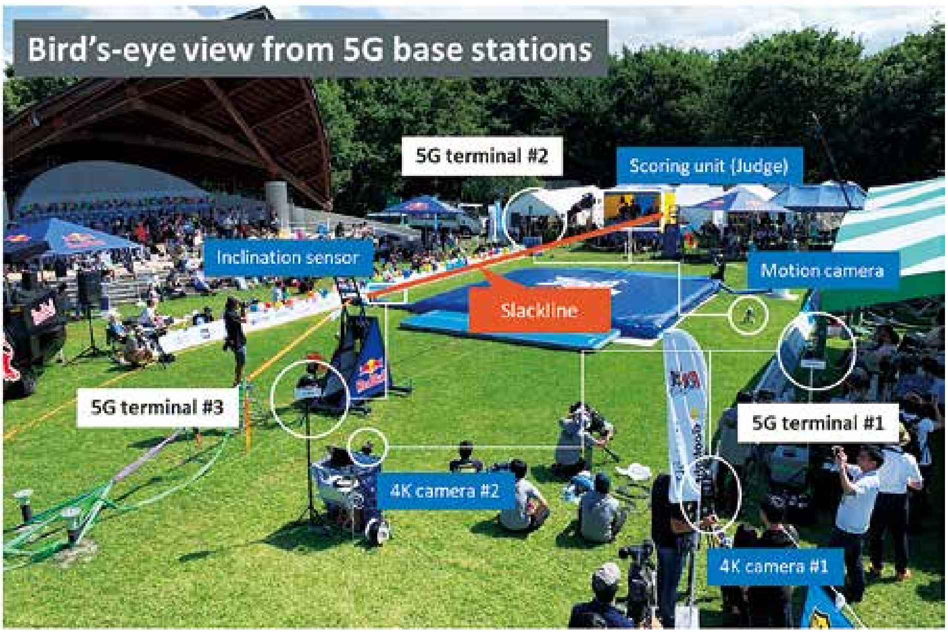
As examples of using 8K or other high-quality video transmitted from a drone, we can consider the transmission of high-definition video of sports scenes with a high “you are there” feeling and the use of high-quality video in the maintenance of infrastructure facilities such as bridges that are difficult for people to access. In the latter case, the use of a drone would enable immediate and detailed checking through live distribution of high-definition video without having to send people directly to the target site thereby improving work efficiency.

4. 5G × promotion of new sporting events and enhancement of sense of presence for spectators

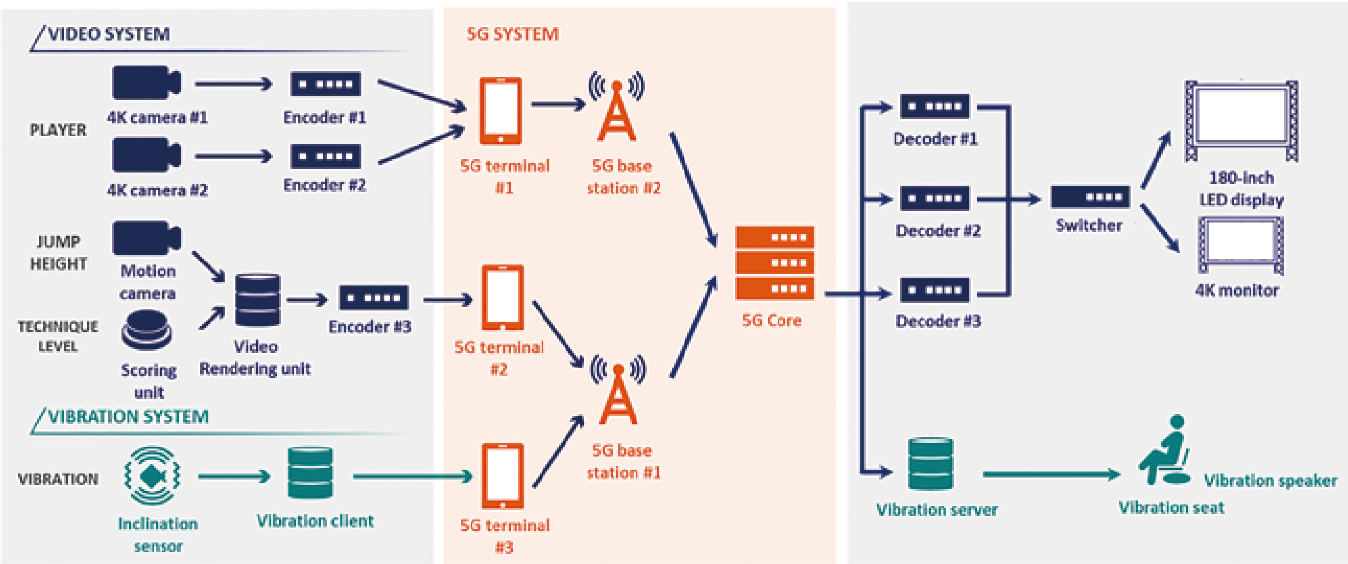
5G is expected to be used in sporting events. A new competitive sport called “slacklining” is now being promoted, but problems remain such as insufficient understanding of the rules of the game and the inability of conveying the appeal of the sport. With the aim of solving these problems, a trial was conducted at the 2019 Slackline World Cup Japan FULL COMBO held at Obuse Park in Nagano prefecture in September 2019 using the ultra-high-speed and low-latency features of 5G to provide spectators with a new viewing experience. This trial was conducted as part of the 5G System Trials by MIC.

This trial aimed to make slacklining easy to understand by automatically measuring the height of a slackline player’s jump and displaying that information on the event video even for spectators unfamiliar with the sport. Furthermore, to achieve highly entertaining sports viewing that creates a feeling of oneness with the players, the trial used high-definition video, added production effects to the video, and shared information on a player’s physical sensations (vibration) with spectators in real time

■ **Figure 8: Layout of equipment at Slackline World Cup Japan venue**



■ Figure 9: System configuration of video and vibration-information transmission test



using 5G. In this way, spectators could experience the excitement of the competition. The layout of the equipment used in this trial is shown in Figure 8 and the configuration of the video and vibration-information transmission test is shown in Figure 9. Here, the automatic measurement of the height of a jump was accomplished through the use of a motion camera installed in front of the slackline used in the competition. Moreover, in addition to the height of a jump automatically determined from the video of the motion camera, information such as the level of a certain technique as determined by the judge, the number of consecutive jumps, etc. were visualized and transmitted by 5G in the 28 GHz band together with video of the competition captured by 4K cameras (60 fps) and finally displayed in real time on the venue's large monitor. Here, two cameras were installed to capture a player so that angles could be switched flexibly during a performance to provide video viewing from different viewpoints. The end-to-end delay from shooting the video to its output on the large monitor was approximately 300 milliseconds, but since spectators would tend to turn toward the monitor after watching a player's performance, there was no sense of mismatch.

Additionally, as an activity leveraging the low-latency feature of 5G, we conducted a test on delivering the vibration felt by a player when making contact with the slackline to a spectator's seat instantaneously without delay so as to provide a feeling of oneness with that athlete. In more detail, an inclination sensor was installed on the slackline to detect the instantaneous vibration that occurs when the player makes contact with the slackline. The output from this sensor would then be converted to vibration information and transmitted by 5G to a speaker installed on a spectator's vibration seat. This vibration information was delivered in about 40 – 50 milliseconds thereby providing a spectator with a viewing experience having both a feeling of oneness and a sense of presence with the player at the event. A scene of this trial can be seen in a video released on YouTube.[3]

As described above, the large-capacity, low-latency features of 5G were used to help popularize a new competitive sport. In particular, adding information on a player's performance to video promoted understanding of the techniques involved, and conveying information on a player's physical sensations in addition to video helped to provide a new exciting experience. As demonstrated by this trial, we can expect 5G to contribute to the revitalization of regional communities and development of sports by invigorating sporting events rooted in regions or even new sporting events.

5. Conclusion

This paper introduced field trials of applying 5G to various applications using video transmission. The high-speed, large-capacity, and low-latency features of 5G will first and foremost enable the transmission of high-definition video by easing some of the technical constraints that had previously been placed on video transmission. In addition, they can be expected to create new applications and novel user experiences by combining more fully with new technologies.

References
[1] Real-time free-viewpoint public trial at a professional baseball game using au 5G (released 2018/06/27)
https://www.youtube.com/watch?v=eeZ9NJEKFT8
[2] World's first transmission of 8K live video from 5G drone; racehorse training support (released 2020/04/16)
https://www.youtube.com/watch?v=WtvhSTebvLw
[3] Excitement of Slackline World Cup Japan using 5G and Regional Revitalization (released 2020/04/16)
https://www.youtube.com/watch?v=S_mOloyQk6s

5G-AV-QoS Technology

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1. Introduction

The fifth-generation mobile communications system (5G) features high speed and large capacity, low latency, and massive connectivity. A high-speed and large-capacity transmission path will enable real-time transmission of 4K or 8K high-definition video, while low latency is expected to enable bidirectional communications via videophones or other devices using high-definition video.

This paper introduces the development of high-definition video transmission technology at Panasonic Corporation.

2. 5G-AV-QoS Technology

Panasonic's 5G-AV-QoS technology[1] transmits video and audio data in real time while maintaining high-quality video and audio over a packet network.

Problems in real-time transmission when using a packet network originate in the fact that a communications path cannot be exclusively occupied in contrast to a conventional circuit switched network. Since multiple connections share the packet network, congestion can occur when the communications network becomes crowded resulting in packet loss if the capacity of the network is exceeded. In addition, a delay in packet arrival can occur since a large volume of packets may be held up in router equipment.

Panasonic's video transmission technology aims to achieve high-quality video transmission in a packet network. This paper describes congestion control, dynamic sending-rate control, and sending-rate control with radio-unit assist as key functions of this technology.

2.1 Congestion control

"Congestion" is a state in which a packet network is filled with communications data. This state can cause packet loss or latency to occur. Congestion control is a function that controls the data-sending rate at the sending side to prevent a state of congestion from occurring.

The Internet and the 5G core network are typical of networks that use a packet network based on Internet Protocol (IP). In addition, data transmission using a packet network generally makes use of Transport Control Protocol (TCP) for data communications such as Hyper Transfer Protocol (HTTP) for displaying information on a browser and File Transfer Protocol (FTP) for transferring files. Here, TCP is equipped with a resend function when packet loss occurs and a congestion control function for controlling the data-sending rate when congestion occurs. This TCP congestion control function prevents a specific connection from transmitting a large volume of data that would monopolize the packet network and enables multiple connections to share the transmission bandwidth. In addition, User Datagram Protocol (UDP) has come to be used for real-time transmission as in voice communications (Voice over IP). UDP is oriented to real-time transmission since it enables data to be transmitted at a fixed rate through application-side control. Furthermore, unlike TCP, UDP does not include a congestion control function, which makes it necessary to control the data-sending rate to prevent congestion from the application side. In the case of audio data, the amount of data is relatively small, which means little impact on the communications of other users. However, video transmission, which transfers a large amount of data, can significantly affect other users making congestion control an important function. TCP Friendly Rate Control (TFRC)[2] that enables coexistence with data communications using TCP is known to be a congestion control system that can be used with UDP.

Panasonic's 5G-AV-QoS adopts a congestion control system based on TFRC, which calculates the sending rate using the Round Trip Time (RTT) value and the packet loss rate. The TFRC sending rate is calculated using Eq. (1) in Figure 1. Here, the RTT value (R in Eq. (1)) exhibits variation, so in Eq. (2), a weighted average of R is calculated between a past RTT value (Rsample) and the last RTT value (Rlast) using a filter constant q. Sending rate (X) becomes large when RTT is small. If congestion occurs, RTT increases and sending rate (X) drops. The sending rate (X) also drops when the packet loss rate (p) increases.

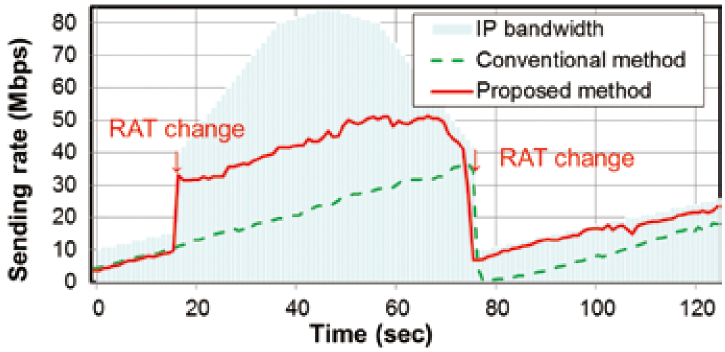
Figure 1: Sending-rate equation

$$X = \frac{s}{R\sqrt{\frac{2bp}{3}} + t_{RTO}\left(3\sqrt{\frac{3bp}{8}}\,p(1+32p^2)\right)} \quad \cdots\text{(Eq. 1)}$$

$$R = q\,R_{last} + (1-q)\,R_{sample} \quad \cdots\text{(Eq. 2)}$$

X: sending rate
s: packet size
R: Round-trip time calculated from R_{last}, R_{sample}, and q (Eq. (2))
b: max. number of packets acknowledged by a single acknowledgement
p: packet loss event rate
T_{RTO}: retransmission timeout value
R_{last}: last round-trip time
R_{sample}: past round-trip time
q: filter constant

■ Figure 2: Simulation results of sending-rate control with radio-unit assist[4]



2.2 Dynamic sending-rate control

Sending-rate control is a function that dynamically adjusts the resolution of the transmitted video and the compression ratio of the video codec in accordance with the transmission bandwidth. The bandwidth of the transmission path is calculated by the sending-rate equation described above and the resolution of the video and the compression ratio of the video codec are determined according to that sending rate.

5G-AV-QoS supports the H.265/MPEG-HHEVC and H.264/MPEG-4 AVC video codecs. Which of these codecs to use can be selected by settings made when beginning video transmission. Resolution can be changed, for example, by compressing an input 4K image to Full HD, which would considerably reduce the amount of data sent. It is also possible to make settings that fix video resolution while dynamically adjusting only the compression ratio.

2.3 Sending-rate control with radio-unit assist

The 5G system enables use of the millimeter-wave band, which means that high-speed and large-capacity data transmission can be expected. However, as frequencies become higher, the distance that electromagnetic waves can travel becomes shorter thereby reducing the cell size of radio communications. When controlling the sending rate through congestion control for user communications while moving, the sending rate can only be raised gradually, and by the time the sending rate has been sufficiently raised, the user may have already passed through a cell enabling high-speed data transmission. In other words, sending-rate control on its own may not enable effective use of the bandwidth of a high-frequency cell.

At Panasonic, in addition to sending-rate control through congestion control as described above, we have been studying sending-rate control with radio-unit assist that passes handover information from the radio unit to the video-transmission unit[3][4]. The results of simulating the use of this function are shown in Figure 2. When using the method based only on sending-rate control (green broken line), it can be seen that the sending rate rises only gradually in entering a 5G New Radio (5G-NR) cell. In contrast, when using sending-rate control with radio-unit assist (red solid line), the sending rate is able to suddenly jump on being notified by the radio unit that a handover to 5G-NR has occurred. It is also possible to set the sending rate lower on being notified by the radio unit that the user is leaving the 5G-NR cell.

3 Application Examples

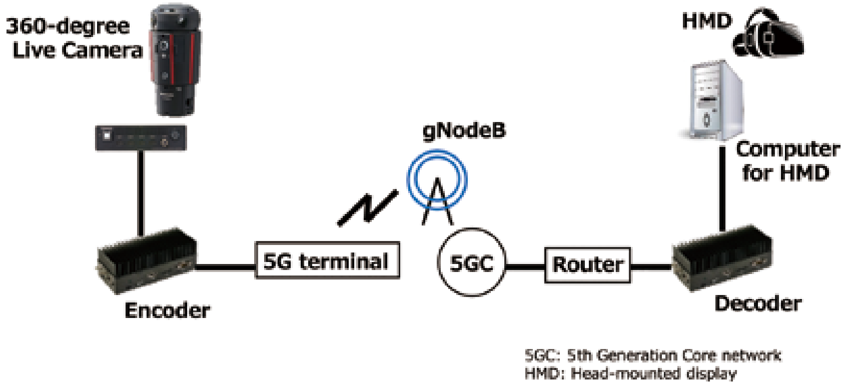
Panasonic participated in the 5G Systems Integrated Verification Trial overseen by the Ministry of Internal Affairs and Communications (MIC) and conducted verification trials on applications and services using a high-definition video transmission system[5].

Configuration of the high-definition Virtual Reality (VR) video transmission system used in the verification trial is shown in Figure 3. This system used Panasonic's 360-degree Live Camera (AW-360C10GJ/AW-360B10GJ)[6] to shoot video. The camera performs real-time stitching of video from four camera systems and outputs uncompressed 360-degree 4K/30p video (3840 x 2160) in a 2:1 equirectangular format. This data is then compressed by an encoder and transmitted in IP packets. Next, the receiver side inputs the 360-degree video output from a decoder into a personal computer for head-mounted display (HMD) use and finally outputs the video to the HMD using Panasonic-developed software. A user wearing the HMD can have a VR experience in which he or she feels present at a remote location (a site in which the 360-degree Live Camera is installed). The following introduces mobile remote conferencing, mobile remote museum, and mobile remote guidance as verification trials using this high-definition VR video transmission system.

3.1 Mobile remote conferencing

In January 2019, we conducted a verification trial of mobile remote conferencing using 5G in Kamiyama town, Tokushima prefecture. In the trial, a 5G mobile station was mounted in an automobile and a participant riding in the automobile participated in the conference while wearing a HMD. The conference room was equipped with the 360-degree Live Camera and 360-degree video of the conference room was sent to the participant riding in the automobile. A view of this conference room is shown in Figure 4. Here, the subject attending the conference from the moving automobile participated in the meeting with a sense of actually being in the conference room through VR video viewed on the HMD.

■ Figure 3: High-definition VR video transmission system



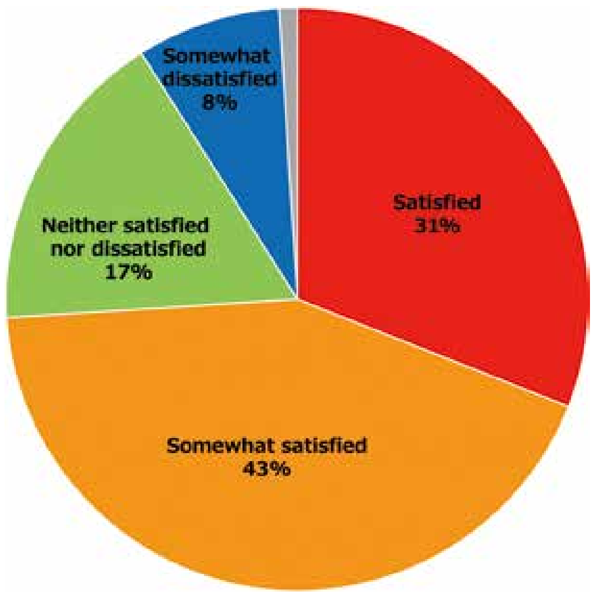
■ Figure 4: View of mobile remote conferencing with VR video transmission system

3.2 Mobile remote museum

In February 2019, we conducted a verification trial of a mobile remote museum connecting the Fukui Prefectural Dinosaur Museum and the Tokyo SKYTREE TOWN. In this trial, a 5G base station was installed within the museum and video from inside the museum was sent to Tokyo while moving a 360-degree Live Camera and 5G mobile station. On the Tokyo side, a participant wearing a HMD had a visual experience as if he or she were actually moving through the museum and experienced an even greater sense of presence at that location by actually conversing with a researcher present at the museum.

We assessed user acceptance of such a use case of a mobile remote museum by administering a questionnaire after conducting a similar trial in December 2018. In the questionnaire, a person experiencing the mobile remote museum was asked to select from "satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, dissatisfied." Results of the questionnaire are shown in Figure 5. Out of a total of 452 respondents, 74% replied "satisfied" or "somewhat satisfied." Users described their impressions with such comments as "It was nice to see things that I usually don't see." "I enjoyed viewing in real time." and "I felt as if I was actually there."

■ Figure 5: Results of questionnaire on satisfaction with mobile remote museum



3.3 Mobile remote guidance

In January 2020, we conducted a verification trial of mobile remote guidance using 5G in Eiheiji town, Fukui prefecture. In this trial, the 360-degree Live Camera was installed inside a snow-removal vehicle and a user at a remote location (control center) gave advice to the vehicle operator while examining the video from within the vehicle. A view of this verification trial is shown in Figure 6 and a view of examining the video received from the snow-removal vehicle is shown in Figure 7. In the latter figure, the video displayed on the monitor is the same video seen by the HMD wearer. Users experiencing this application gave comments such as "It was actually easy to use." and "I felt as if I was actually operating the vehicle, more than I expected." This was because describing the situation was easy even from a remote location since video was provided in addition to audio and because viewing by HMD made it possible to give direct instructions as in ordinary conversation in the manner, for example, of "Clear the snow drift on your left."

4. Conclusion

This paper introduced Panasonic's 5G-AV-QoS video transmission technology using 5G. It also presented mobile remote conferencing, mobile remote museum, and mobile remote guidance as promising services and applications using high-definition video transmission.

■ **Figure 6: View of verification trial of mobile remote guidance**

■ **Figure 7: View of giving guidance to snow-removal vehicle operator**

References
[1] H. Asano et al.: "A study on high quality mobile video transmission for 5G," IEICE Tech. Rep., Vol. 118, No. 474, RCS2018-327, pp. 231-236, March 2019. (in Japanese)
[2] S. Floyd et al.: RFC5348 "TCP Friendly Rate Control (TFRC): Protocol Specification."
[3] N. Shimizu et al.: "Uplink Video Transmission Control System According to Radio Connection Destination in Heterogeneous Network," Proceedings of the Society Conference of IEICE, B-5-27, 2017. (in Japanese)
[4] T. Sano et al.: "Wireless Communication Technologies for New Solution Business in the 5G World," Panasonic Technical Journal, Vol. 64, No. 2, Nov. 2018. (in Japanese)
[5] Y. Okumura et al.: "Co-creation of New Services in 5G Era and 5G System Trials," Information Processing, Vol. 61, No. 3, Mar. 2020, pp. 243-249. (in Japanese)
[6] 360-degree Live Camera AW-360C10GJ/AW-360B10GJ. https://panasonic.biz/cns/sav/products/aw-360/index.html

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Activity of Disseminating Japanese EWBS Technology

— *Emergency Warning Broadcast System* —

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Abstract

The Japanese digital terrestrial broadcasting system (ISDB-T) has been adopted by 14 countries in Latin America. DiBEG extends technical support and cooperation to help with the implementation of ISDB-T in these countries. The Emergency Warning Broadcast System (EWBS) is one of the key features of ISDB-T and is expected to be introduced as a national communication system for emergency situations. The "EWBS Superimpose Dissemination System", improved from the Japanese original version by meeting local requirements in Latin America, has successfully been developed in Japan. Taking advantage of the robustness of the ISDB-T "One-seg" technology, making maximum use of the existing broadcasting networks, this system realizes simple utilization and wide coverage with outstanding reliability. This system has already been introduced to some Latin American countries and been evaluated highly. Japan continues technical cooperation so that EWBS can contribute to disaster prevention and mitigation in these ISDB-T adopting countries.

1. Technical Requirements for EWBS in Latin American Countries

Japan's Early Warning System, quickly communicating emergency information such as tsunami and earthquake warnings to the public, has been introduced mainly by a mobile communication network and has long been available on a wide variety of mobile devices equipped with features such as area mail and SNS. On the other hand, although the EWBS using a broadcasting network has long been in operation by the most broadcasters in Japan, compatible receivers are limited and not widespread enough. In that sense EWBS is no more than a complementary measure in Japan.

In most countries in Latin America, because the mobile communication networks have not been well established with enough resilience to sudden line disconnections, the EWBS through broadcasting networks is expected to be a core system for disseminating information for national disaster prevention. In order for EWBS to play this core role, some improvements were required for it to work as a more reliable system that will not miss an alarm under any conditions. There are also many differences in broadcasting operation between Japan and Latin America. The original Japanese EWBS version could not be introduced as–is, and local requirements in Latin America had to be satisfied.

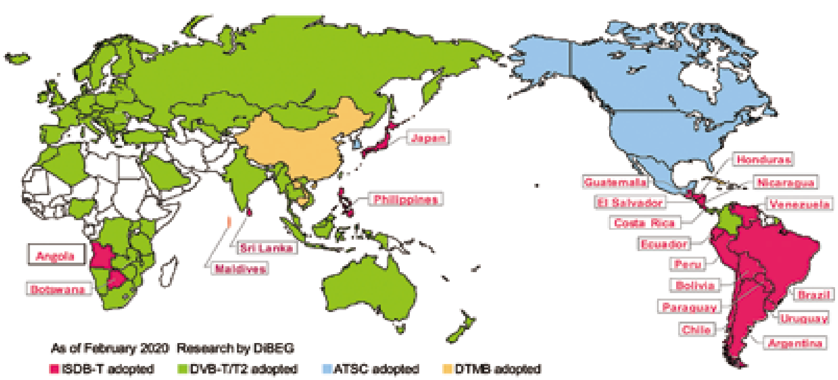
The differences in EWBS requirements are shown in Table 1 on the next page.

2. Development of the "EWBS Superimpose Dissemination System"

In collaboration with several manufacturers in Japan and Argentina, we have developed an "EWBS Superimpose Dissemination System" to better serve local requirements in Latin America. In addition to the EWBS signals originally operated in Japan, this system will also transmit character "Superimpose" signal, which will be received and displayed on various types of EWBS receivers.

The "Superimpose" function of ISDB-T transmits text information independently in the background of the broadcasting program. This function is proposed to be used in combination with

Figure 1: Countries adopting ISDB-T (in red)



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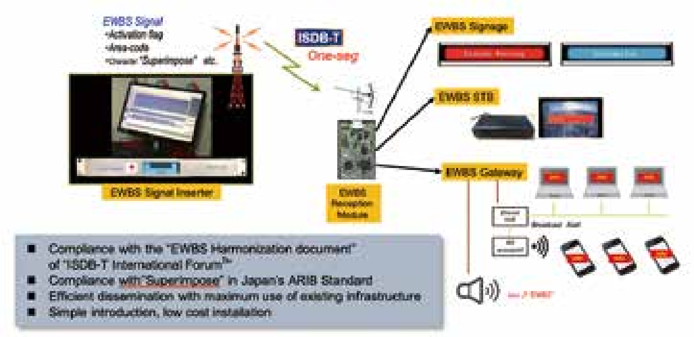
3 Seiji SAKUMA: Senior Researcher, ISDB-T Promotion Group, ARIB (Association of Radio Industries and Businesses)

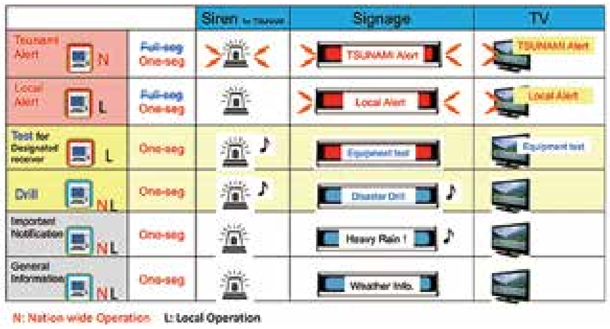
■ Table 1: Differences in requirements for EWBS

	Japan	Latin America
Main Operator	Broadcasters (all)	Government (National Organization for Disaster Prevention)
Concept of using broadcast radio waves	Means of delivering broadcasters' program content	Means of delivering "national disaster prevention information"
Target Areas	ⓐ Nationwide ⓑ Regional areas	ⓐ Nationwide, ⓑ Regional areas ⓒ Local areas
Information disseminated	ⓐ Early warning	ⓐEarly warning ⓑ Information after the occurrence (Post-event information)
Target recipient	TV Viewers in general households	Public places (offices, firefighting stations, hospitals, etc.) and general households
Type of receivers	TV receivers for home use	Various receivers for public / home use ・Public signage, sirens, etc. ・TV receivers for home use

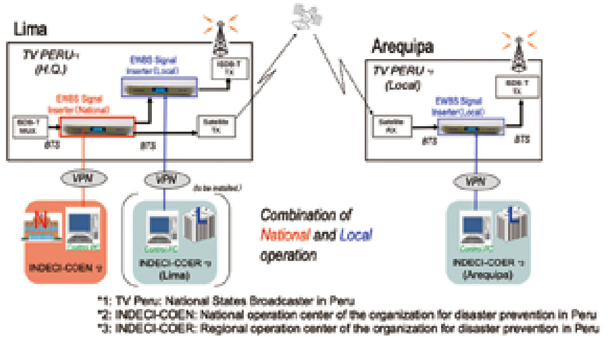
■ Figure 2: EWBS Superimpose Dissemination System for Latin American countries[4]



■ Figure 3: EWBS Latin American version – application to various operation patterns



■ Figure 4: Example of EWBS operation in Peru



EWBS in Latin America for the purpose of communicating disaster information. By using some control codes of Superimpose, we also developed a function that can identify and activate receivers to respond according to the type of alarm. We have also designed several device tests and training modes to accommodate various required operational patterns.

A message signal can be easily inserted into an existing terrestrial digital network, and wide coverage and robust transmission characteristics can be realized easily and at low cost by using One-segment signals. This feature enables it to be easily introduced in Latin American countries where disaster prevention information transmission systems have not been developed well yet.

1) EWBS Signal Inserter (Transmitting device)

The EWBS Signal Inserter enables insertion of an EWBS signal, such as an emergency flag, text Superimpose, or Area-code, into the Broadcast Transport Stream (BTS) as defined by ISDB-T. Inserting the EWBS signal at the BTS stage enables EWBS operation to be implemented quite easily in the Latin American countries adopting ISDB-T, where various manufacturers have supplied various ISDB-T broadcasting systems. The EWBS Signal Inserter can be installed in the master control room at a broadcast center; or at a local transmitting station to insert location-specific information into a TV program. A control terminal (PC) installed at a national organization for disaster prevention can be connected easily to the EWBS Signal Inserter through an IP network. Peru has increased the reliability and security of the entire system by establishing IP connections through a VPN configuration over a microwave link.

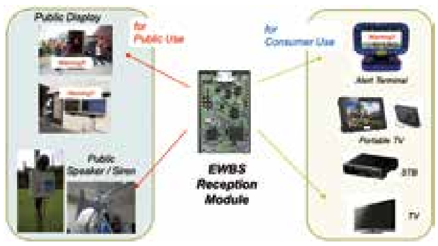
Figure 4 shows an example of operation in Peru. It ensures that national and local information can be transmitted in a flexible manner according to its specific purposes and target areas.

With the cooperation of a local manufacturer in Argentina, we have also developed an EWBS signal transmission system to optimize the DVB distribution format, which is widely used in Latin America.

2) EWBS Reception Module (Reception device)

To promote the sale and permeation of EWBS receivers in the consumer market, we have developed a basic module called "EWBS reception module" that can be deployed in various receivers. This module constantly monitors the terrestrial digital One-seg signal of a specific broadcasting station carrying the EWBS signal, and once it detects an EWBS signal, it decodes the signal and outputs an emergency flag and a text message. In Latin America, information terminals such as electronic bulletin boards and speakers can be seen around the city. Mounting this module on these exiting terminals enables them to be applied as alarm indicator devices.

■ Figure 5: Wide-ranging applications of the EWBS reception module



3) EWBS Signage (Reception device)

We have also developed text display terminals (EWBS signage) equipped with the EWBS reception module. These are

4 ISDB-T International Forum: An international group of ISDB-T adopting countries for the purpose of harmonizing the practical application of ISDB-T digital broadcasting

intended for installation in public facilities where people gather, such as government offices, fire stations and any other disaster prevention locations, as well as in shopping centers. As a notable installation location, Peru has installed terminals at radio stations in local cities and regions. When installed in a radio booth, if a warning is received, the radio announcer can read messages to the listeners as they are displayed.

The expected application of signage is for dissemination of information right after a disaster ("Post-event information" in Table 1). An example of application is to install a display in an evacuation center, providing daily lifeline information to the evacuees, such as the status of restoring lifeline services and volunteer activities.

Figure 6: EWBS signage in operation at a radio station in Lima, Peru

4) EWBS Set-top Box (Reception device)

Since an ordinary STB has only one tuner, it will receive EWBS signals while watching a broadcast channel that is operating the EWBS, but it will miss alarms while watching other broadcast channels. The STB that we have developed implements a separate, dedicated tuner that monitors EWBS 24 hours-a-day, so it can receive EWBS and not miss any EWBS messages. It also uses the HDMI-CEC function to automatically start up the TV and it has a function to switch viewing to the HDMI port.

HDMI-CEC is a function of HDMI for Consumer Electronics Control (CEC), which links operation of electronic products such as TV receivers and HDD recorders by exchanging control signals between them through an HDMI cable. This STB utilizes the one-touch display function, which is a common command function that automatically turns on a TV if it is switched off and switches the input to the EWBS channel.

There are many households in Latin American countries viewing TV programs by cable, and in such households the inability to receive EWBS signals (by way of digital terrestrial broadcasting) has been an issue. This STB can switch the HDMI port to show EWBS information even while the TV viewer is watching a cable TV program. This feature stimulated and attracted the attention to this STB product.

In order to check that the CEC function of the STB is effective and never misses an alarm, we performed EWBS reception trials in Peru and Costa Rica, in cooperation with a local electronics retailer in these two countries, using several TV receivers for sale in stores. The trials confirmed automatic startup on most of the TV receivers of major manufacturers, with only a few exceptions.

This STB can be applied in ordinary households and also in public places where a TV is normally installed, such as school classrooms, and hospital waiting areas.

Figure 7: Functions of the EWBS STB

3. Current Status of EWBS Implementation in Latin American Countries

The EWBS Superimpose Dissemination System has been supplied on an experimental basis to some of the Latin American countries adopting ISDB-T. The current status of technical cooperation from Japan and the actual implementation in these countries is described in Table 2 on the next page.

In all of these countries, the equipment has worked well. Locally in Peru, the system was evaluated very highly, and full-scale operation has already started.

We believe that the key to further system expansion is to improve the operational level. Each of the countries was required to start everything from the very beginning, including expansion of equipment maintenance, establishing an organization for system operation, and securing government budget for such purposes.

Reports with some topics on the latest implementation status in Costa Rica, Peru and Brazil are as follows:

1) Costa Rica "One-seg EWBS" Highly Appreciated

In March 2019, we performed a reception evaluation test using actual radio waves in Costa Rica. We measured reception in areas with weak field strength and mobile reception. Costa Rica is a mountainous country. But even in shadow areas where Full-seg cannot be received due to topographic conditions, One-seg signals could easily be received with a simple receiver antenna. For mobile reception, we conducted reception tests on traveling trains, vehicles and on boats with a signage receiver. We were able to verify and show very stable reception characteristics, which was greatly appreciated by local people. We were able to ensure that One-seg can be a key element for information and communications in the event of a disaster.

In Costa Rica, the feasibility of the EWBS was confirmed, and the government is studying the establishment of a new organization and securing budget for full-scale EWBS operation.

2) Peru: Utilization in large scale evacuation drills on World Tsunami Awareness Day

Peru is the country where EWBS operation is the most advanced. Peru has a large land area and a variety of natural disasters such as wide-area tsunamis on the coast, heavy rain and landslides in the Andes areas, flooding of the Amazon River, and cold-weather damage in the high mountain areas. It is thus necessary to design and implement EWBS operations in due consideration of these various disasters. It is also important for the EWBS to establish operational rules and standardization, including nationwide and local operations and region code allocations. As the digital terrestrial network expands nationwide in the future, the EWBS operation will also have to develop and expand nationwide. We have improved the software of

Table 2: Status of EWBS implementation with support from Japan (in Latin America)

Country	Current Status
Nicaragua	3/2018 Field trial of hardware
El Salvador	10/2018 Field trial of hardware 10/2019 Start of trial operation by national organization for disaster prevention, and support for reception tests
Costa Rica	10/2018 Field trial of hardware 3/2019 Start of trial operation by national organization for disaster prevention, and support for reception tests
Peru	1/2019 Field trial of hardware 3/2019 Start of support for operation training 11/2019 Tested in a large-scale evacuation test on World Tsunami Awareness Day (Nov. 5, 2019) --- National organization for disaster prevention announced official adoption of EWBS
Brazil	12/2019 Field trial of hardware

EWBS operations in order to meet these future requirements in Peru, and the system has achieved a high level of operational performance. We expect that the permeation of receivers will naturally expand as the operational level of EWBS advances.

On November 5, 2019 commemorating World Tsunami Awareness Day, extensive evacuation drills were conducted in Peru, and EWBS played an important role for these drills. A message transmitted via EWBS was displayed on a large screen outside the shopping center at the main venue. An EWBS signage was also used in a disaster ministerial meeting.

At a symposium the following day, INDECI, the national organization for disaster prevention, announced a budget plan for the adoption and nationwide deployment of EWBS in Peru.

Figure 8: Field Survey of EWBS Reception In San Jose, Costa Rica (March 2019)

Figure 9: EWBS utilized in an event on World Tsunami Awareness Day, November 2019 in Lima, Peru

3) Brazil: Key country for diffusion of unified EWBS throughout Latin America

In Brazil there has been a growing interest in EWBS recently and they have already taken their first steps with some field trials. Brazil is rather different from other ISDB-T adopting countries in the sense that the EWBS is to be deployed for all types of critical situation, such as the collapse of a dam or a nuclear power plant, and not only for natural disasters.

Brazil was the first country outside Japan to adopt ISDB-T in 2006. DiBEG and SBTVD-Forum, the Brazilian counterpart, have long been working together on implementation of ISDB-T. We established the "EWBS rapporteur group" particularly to study unified EWBS technical standards and operations throughout Latin America. In December 2019, cooperating between Japan and Brazil, we conducted pilot tests of EWBS in its capital city of Brasilia and could show its advantages for many stakeholders. The significance of Brazil's adoption of EWBS is not limited to Brazil. The transmission and reception equipment and systems for ISDB-T digital terrestrial broadcasting in Latin America have been developed and marketed with close reference to the Brazilian digital TV standards. Broad deployment of EWBS in Brazil will lead to the spread of EWBS throughout Latin America, with unified EWBS operation and equipment.

Conclusion

The EWBS in these Latin American countries operates differently than in Japan. For this reason, we have worked on technical development of an EWBS Superimpose Dissemination System to satisfy numerous local requirements. The system we have developed is being gradually implemented and verified in Peru and other Latin American countries adopting ISDB-T, and we are continuing technical support and cooperation for stable and reliable system operation.

We are confident that collaboration between Japan and Latin American countries will standardize and unify the most suitable systems in the near future, and that devices will be launched and developed in the market, leading to broad adoption of EWBS and contributing to disaster prevention and mitigation.

Acknowledgments

We would like to express great appreciation to the Ministry of Internal Affairs and Communication of Japan for its exceptional support for our activities.

We would also like to thank several manufacturers that have provided us with technical support for the development of EWBS devices. These are TANABIKI Inc., CENTURY CORPORATION, NORITAKE ITRON CORPORATION and MASPRO DENKOH CORP. from Japan as well as VideoSwitch from Argentina.

We also thank Mr. Cesar Gallegos, from Peru, and Mr. Frank Coloma, from Costa Rica, who have been working as local coordinators for these activities.

We are grateful to the SBTVD-Forum in Brazil, for cooperative study as well as many others in Latin American countries adopting ISDB-T, who have generously extended understanding and cooperation to us in these activities

= A Serial Introduction Part 5 = Winners of ITU-AJ Encouragement Awards 2019

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.

Zeus, Inc.

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Fields of activity: ITU-D

Developing ICT Personnel in Myanmar

I would like to take this opportunity to express sincere thanks upon receiving the prestigious ITU Association of Japan Encouragement Award. Thanks to all those at ITU-AJ, those at the Pacific Telecommunications Council Japan who recommended us, and all of those in Japan and Myanmar that have supported us.

I would like to introduce the work of our company, developing ICT Personnel in Myanmar.

The reason we are working with Myanmar to begin with is that the country was designated as a "Least Developed Country" (LDC) by the United Nations, and is in particular need of support.

However, when we visited the region, even more than the spirit of this support, what we felt was a strong impetus for development within Myanmar.

We recognized this in the strong, forward-looking attitudes of the local people that could not be overcome by the environment, saying things like, "Now we're growing," "Things will change quickly now," and "We can change our country."

Thus, there was a strong sense that at the present time, they have aspirations but not the circumstances, so we might be able to get involved in building part of the nation.

As one of the Least Developed Countries, Myanmar has far too few people with the advanced education necessary to support industry. As such, we want to help produce enough human resources to support the new era in Myanmar.

We are a Japanese ICT enterprise. As such, we are providing education in Japanese language and ICT. Our primary goal is to educate SEs that can speak Japanese, so that they can work off-shore for us, or they can come work in Japan. They will learn Japanese ICT system-building technologies, and when they return to Myanmar, they will become leaders supporting ICT in their country. This is the future we would like to create with our students studying in Myanmar.

TANABIKI Inc.

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Fields of activity: Digital Terrestrial Television Broadcasting

Initiatives Spreading EWBS in Countries using ISDB-T

Upon receiving the ITU Association of Japan Encouragement Award, we would like to express sincere thanks to everyone at the ITU-AJ.

We are a fabless industrial electronics device manufacturer, mainly developing and designing devices for television broadcasting. Our products include broadcasting TS transmission equipment, and we became involved in the Emergency Warning Broadcast System (EWBS) through our consultations with Mr. Sakaguchi, who is a member of the Digital Broadcasting Experts Group (DiBEG).

The EWBS is a system for issuing emergency warnings using digital terrestrial television broadcasts and is a feature of the ISDB-T format. It is able to transmit information to entire regions where television signals can be received.

Our first initiatives were to incorporate a function for adding EWBS into broadcast TS transmission equipment, and to develop an EWBS receiver module. Using the EWBS receiver module, warnings can be output from devices other than television receivers, such as outdoor sign boards or public disaster warning speakers. One company we are collaborating with has also manufactured signage equipment incorporating the module.

Through the efforts of many from the Ministry of Internal Affairs and Communications and others, we were able to introduce the system to various countries, and received positive responses. However, it was difficult to reach the point where they adopted the technology. It has been extremely important to adapt the system to local conditions and to collaborate in building operations systems in each country.

The system is currently installed in Peru, El Salvador, Costa Rica, and Brazil. In the future, we will continue to work, supporting effective use of the system in these countries, and promoting its adoption in others.

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The ITU Association of Japan