6-4 Real-Time 3D High-Definition Image Transmission Experiment for Cardiac Surgery by NICT and URCF

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NICT and Ultra-Realistic Communications Forum (URCF) have conducted joint experiment of real-time 3D High-definition image transmission for cardiac surgery on January 30, 2010. The 3D images of two cardiac surgical operations conducted at the Yamato-Seiwa hospital in Kanagawa prefecture are transmitted to the site of the international medical meeting "CCT2010 Surgical" held at the Kobe International Exhibition Hall, via experimental internet satellite "WINDS". Very clear high-definition 3D images of the operations by skillful surgeons can be observed in real time by many experts at the conference site.

Keywords
3D image, High-definition image, IP transmission, Satellite communication, Cardiac surgery operation

1 Introduction

3D technology has rapidly developed over the past few years resulting in the sale of 3D televisions for home use. Consequently, various formats of 3D transmission technology are continuing to be developed.

Looking back to the year 2007, low cost compact high-definition cameras were advancing and live-action 3D images were beginning to become comparatively easier to capture. Furthermore, in the area of display devices, 3D televisions enabling stereovision were first put on the market and 3D broadcasts commenced through the Nippon BS Broadcasting Corporation. Conversely, in regard to transmission technology for 3D high-definition images, although technology to compress such images by the Side By Side format utilized by the BS broadcast and broadcast them using the same signal format as high-definition images was already established, technology to transmit 2 channel HDTV format independent high-definition images was not available.

Therefore, NICT and Ultra-Realistic Communications Forum (URCF) 3D Image Transmission Working Group took the initiative to perform research and development on a transmission system that transmits high-definition 3D images to households in real time utilizing next-generation transmission technology and conduct transmission experiments to verify and validate its practical use.

Three years of research and development accumulated in the world first experiment of real-time 3D high-definition image transmission for cardiac surgery IP transmission experiment at the "CCT2010 Surgical" held at the Kobe International Exhibition Hall via the internet satellite "WINDS" on January 30, 2010.

Some have said that the fate of patients undergoing cardiac surgery is in the hands of the intuition of accumulated experience of a skilled surgeon. This technology may be capable of enabling isolated surgeons in distant locations or developing countries to learn the latest techniques for particularly difficult cardiac surgery and widely raise the standard of medical treatment by transmitting operations by highly skilled medical practitioners in real time.

It is essential that skills are passed on and experience shared not through prerecorded video but in “real time”. In comparison to conventional 2D images, 3D images can convey an extensively larger volume of information in minute detail. It is therefore also necessary to develop technology that transmits such 3D information to the actual location where medical procedures are being performed in real time.

In light of this necessity, we conducted an experiment of transmitting the images of an actual operation theater to an international conference attended by a large number of experienced cardiac surgeons for the purpose of receiving the expert evaluations of effectiveness of this technology.

In this paper, we will provide an outline of the URCF in section **2** and an introduction of the activities of the 3D Image Transmission Working Group in section **3**. Then in section **4**, we will provide an outline and structure of the experiment of real-time 3D high-definition image transmission for cardiac surgery, discuss the transmission network utilizing WINDS in section **5**, explain the details of the 3D high-definition transmission technology in section **6**, report status of the experiment in section **7** and provide some considerations from a medical perspective in section **8**.

2 Overview of the Ultra-Realistic Communications Forum

The Ultra-Realistic Communication Forum (URCF)[1] was established in March, 2007, in cooperation with NICT, corporations in related fields, interested persons and the Ministry of Internal Affairs and Communications, for the purpose of accelerating the research and development of matters such as super-high-resolu-

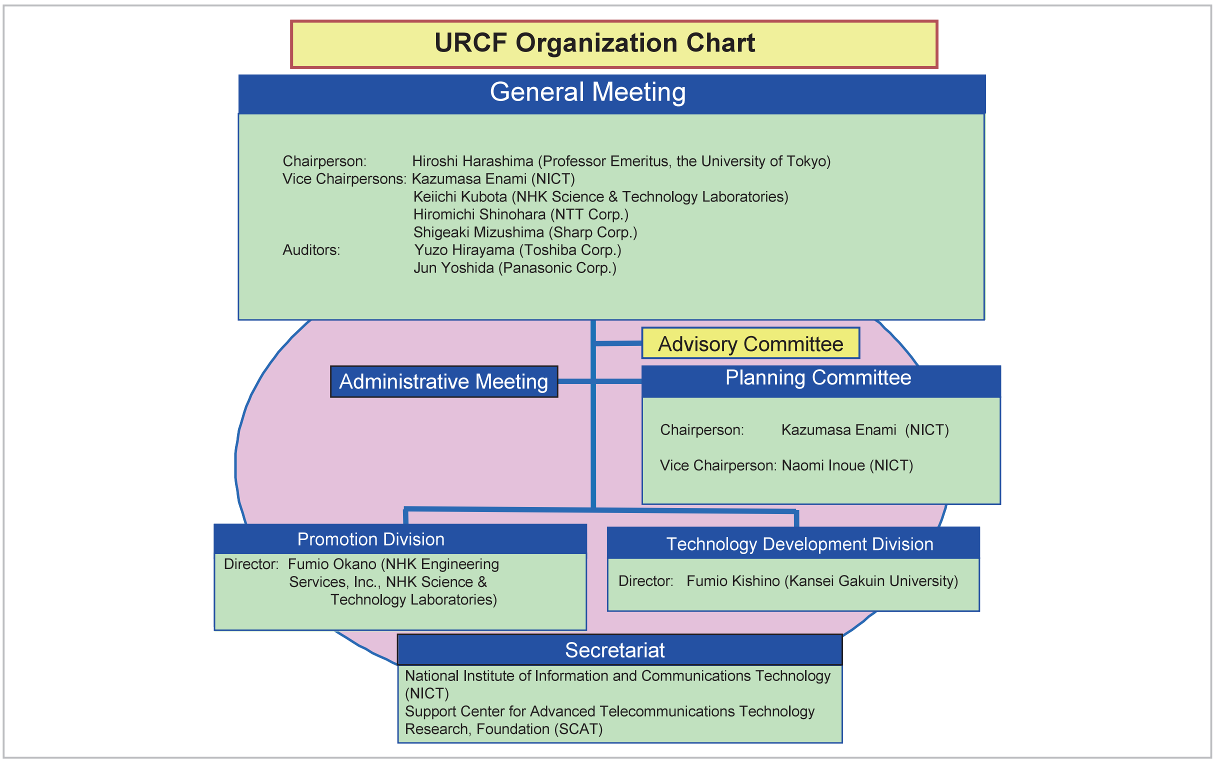

Fig.1 *Ultra-Realistic Communications Forum Organization Chart*

tion and 3D images, ultra-realistic sound reproduction and full-sensory communications. The URCF aims to conduct experiments, standardization activities, symposia and exhibitions, etc., and actively implement the research results to society in order to strategically promote research and development for ultra-realistic communications technology that displays the sensation which enables the transmission of full sensory information such as images, sound and touch which enables users in distant location to feel as though they are actually at the location.

The organization chart of the URCF is shown in Fig. 1. The chairperson is Hiroshi Harashima, a professor emeritus at the University of Tokyo and the chairperson of the Planning and Promotion Committee that implements operational planning for the entire organization is NICT's Vice-President Enami. As of August 24, 2010, the forum comprised of ninety three regular members (manufactures, broadcasters and various organizations, etc), one hundred and one special members (interested persons such as university professors), totaling two hundred and four committee members.

The URCF has two divisions. The Promotion Division conducts experiments, standardization, application development and awareness activities related to the promotion of ultra-realistic communications and the Technology Development Division conducts activities to promote research and development regarding the psychophysical effects of full-sensory communications (including super-high-resolution images, 3D images, ultra-realistic sound reproduction, touch and smell).

Under the Planning Committee and the two divisions, there are sections and working groups that implement specific activities. The composition of the divisions and working groups are shown in Fig. 2.

3 Activities of the URCF 3D Image Transmission Working Group

As shown in Fig. 2(b), the URCF 3D Image Transmission Working Group belongs to the Verification Experiment Planning Section of the Promotion Division. Launched in June, 2007, this Working Group was established for the purpose of implementing 3D live transmission experiments with the NICT's JGN2plus connected with 3D monitors and promoting such technology to the general public. In addition, the Working Group conducts both the development of image transmission devices via a high-definition 3D network and research and development for its practical use. The members of this Working Group are ten organizations

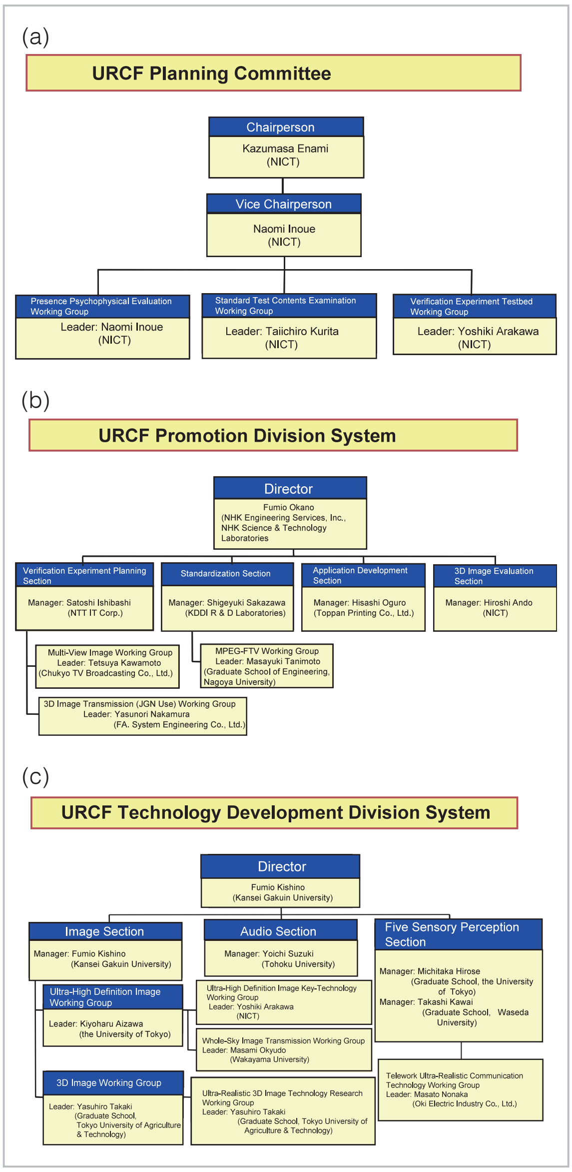

Fig.2 *Composition of Divisions and Working Groups*

(a) Planning Committee, (b) Promotion Division, (c) Technology Development Division

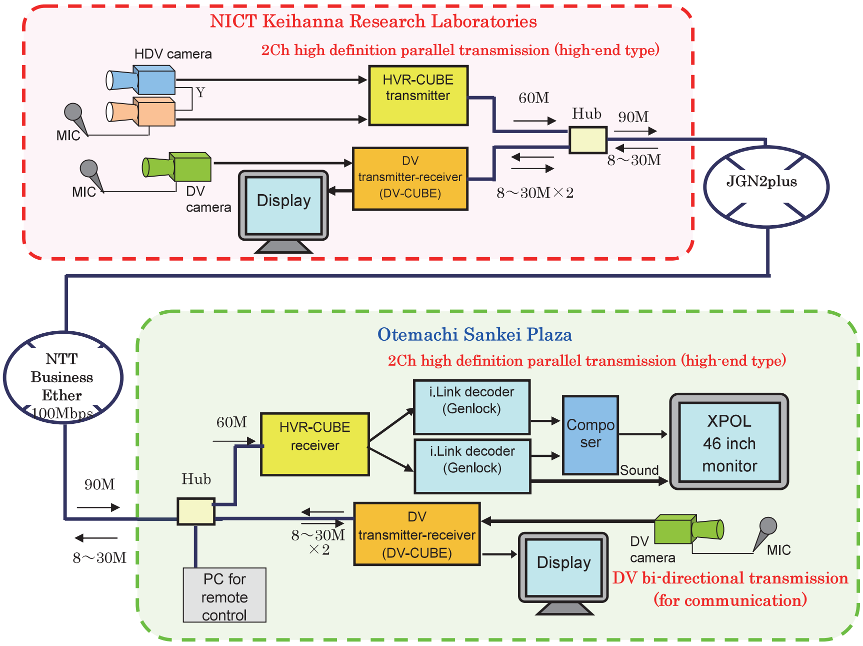

Fig.3 *Composition of URCF regular general meeting demonstration system*

<Sankei Hall Exhibition>
3D TV live broadcast

<NICT Keihanna Research Laboratories>
Live filming of robot with 3D camera

Fig.4 *Photographs of both points at URCF regular general meeting demonstration*

(including the four organizations of the authors). The three core companies, FA System Engineering, NHK Media Technology, Inc and ASUNA Corp each develop transmission devices, cameras and related devices and 3D monitors and NICT is responsible for transmission lines.

In the first fiscal year, a 3D transmission device was developed and the following three experiments were conducted.

(1) November 2007

A 3D camera was installed on the KDDI Otemachi Building and this was connected to an Ehime University 3D television via JGN2plus. The content was the buildings in Otemachi.

(2) In February, 2008, a 3D camera was installed on the Shinagawa KEIO building and a 3D display was installed NICT located at Koganei via JGN2plus. The content was the trains

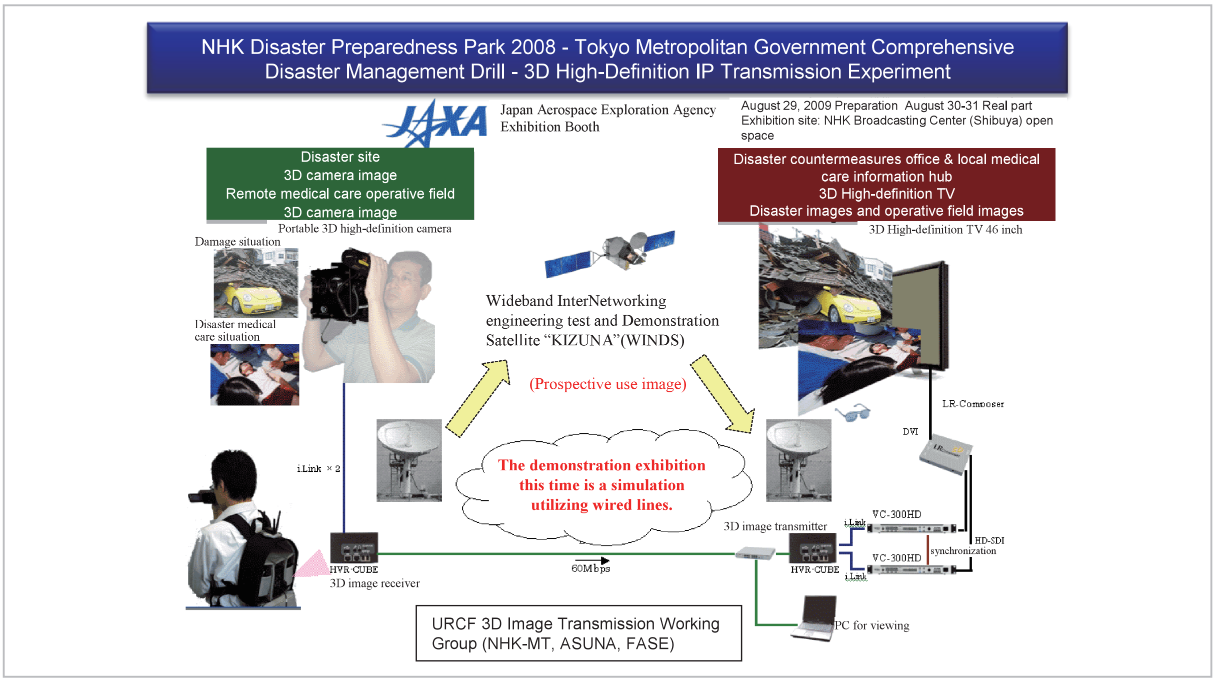

Fig.5 *Experiment composition of Tokyo Metropolitan Government Comprehensive Disaster Management Drill*

at Shinagawa station.

(3) June 2008

The Otemachi Sankei Plaza 4fl and NICT Keihanna Research Laboratory were connected via JGN2plus at the URCF general meeting. The content was robots (Infanoid and Keepon developed by NICT).

The network structure of this experiment is shown in Fig. 3 and photographs of the two locations connected by the telecommunications line is shown in Fig. 4. In addition, a technical explanation of Fig. 3 is provided in section **6**.

In the second year, five experiments were conducted for the purpose of conducting promotional activities and its application through a 3D high-definition network.

(4) July 2008

Keihanna Research Laboratory and the headquarters were connected via JGN2plus at the NICT headquarters general exhibition. The content was robots.

(5) August 2008

An experiment for 3D high-definition IP transmission device intended for an IP satellite was conducted as a part of the Tokyo Metropolitan Government Comprehensive Disaster Management Drill performed at the JAXA booth during the NHK Disaster Preparedness Park 2008. The experiment tested a 3D camera used to capture disasters.

This experiment was the first application test for practical use. Although a local network was used, it was verified that the 3D camera would be effective to ascertain actual damage caused disasters. The structure of this experiment is shown in Figure 5 and photographs of the experiment being conducted are shown in Fig. 6.

(6) September 2008

A 3D camera was installed in Dogo Onsen Station in Matsuyama and the images were transmitted to the NICT booth at CEATEC JAPAN 2008. The content was the Botchan Train.

(7) November 2008

A 3D camera was installed at the NICT Keihanna Research Laboratory and images were transmitted to the site of the Regional ICT Future Festa 2008 in Tokushima via JGN2plus and local infrastructure. The content was robots.

(8) March 2009

Live images of the Space Whether Prediction Office of the NICT headquarters was transmitted to the VisLab OSAKA booth at the Osaka North Yard: Knowledge Capital Trial 2009.

<Back-pack storing 3D images transmitter>

<3D high-definition image filming (1)>

<3D high-definition image capture (2)>

<Exhibition booth>

Fig.6 *Photographs of Tokyo Metropolitan Government Comprehensive Disaster Management Drill*

In the third year, research on the stability from the 3D camera to the 3DTV and safety of 3D images for the purpose of practical use was conducted and as a result of this research, an experiment of real-time 3D high-definition image transmission for cardiac surgery was conducted as reported in this paper.

(9) October 2009

A 3D camera was installed on the main building of Dogo Onsen, Matsuyama and images were transmitted to the NICT booth at CEATEC JAPAN 2009. The content was the main building of Dogo Onsen, the City of "*Saka no ue no kumo*" (Clouds above the hill). In this experiment, images were re-encoded using the Side By Side format at the CEATEC site and multicast delivery at several locations around Matsuyama City were also tested.

(10) January 2010

The experiment of real-time 3D high-definition image transmission for cardiac surgery was conducted. The details are discussed in section **4**.

4 Outline and structure of the experiment of real-time 3D high-definition image transmission for cardiac surgery

The experiment of real-time 3D high-definition image transmission for cardiac surgery was conducted in time for the special session of the "CCT2010 Surgical" (Complex Cardiovascular Therapeutics 2010) internal conference for cardiovascular therapeutics specialists held at the Kobe International Exhibition Hall and the Kobe Portopia Hotel on January 28–30, 2010. At the session held on January 30, both 2D and 3D images for two types of cardiac surgery conduced in the morning and afternoon were transmitted and the commentating medical practitioners explained and discussed the operations while viewing the images. The photographs of the site in the CCT 2010 Kobe International Exhibition Hall and the session being conducted are shown in Fig. 7 and Fig. 8 respectively. The 2D images were shown on the large-scale screen in the center of the exhibition hall, next to this, another screen was used for presentation purposes and the 3D images were displayed on nine 46 inch monitors placed around the hall.

The operations were performed at the Kojinkai Yamato Seiwa Hospital[2] in Kanagawa Prefecture. This hospital is a specialist cardiac surgery facility that performed 278 coronary bypass operations in 2008, the highest number in Japan (624 artery operations and the second highest number of cardiac valve operations). With the cooperation of the patients on the day, a coronary bypass (off-pump CABG) operation was performed in the morning by Dr Hiroshi Okuyama and mitral valve plasty operation was performed by Dr Atsushi Kurata in the afternoon. Both operations are regularly carried out at medical facilities around Japan.

Although transmission experiments up until now have utilized above terrestrial channels, it has become apparent the last one mile high-speed network environment is now even weaker and communication connection for the high-speed network between the two bases incurs much effort and cost. Consequently, in a new test, we decided to use WINDS, a high-

Fig.7 CCT 2010 site

Fig.8 Special session site

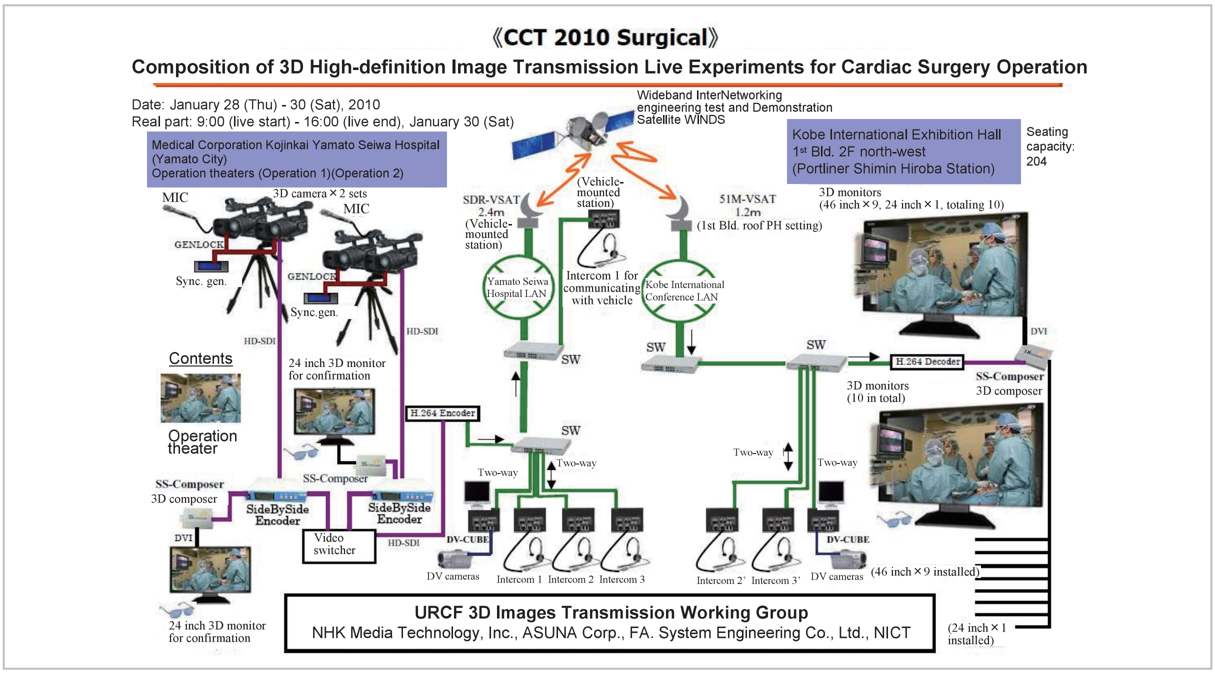

Fig.9 Composition of 3D high-definition image transmission live experiments for cardiac surgery

speed satellite internet connection that enables communication lines to be opened by merely installing a portable earth station and vehicle-mounted station, to conduct the world's first 3D high-definition transmission of a surgical operation using satellite communications in real-time.

The composition of the experiment of 3D high-definition image transmission for cardiac surgery is shown in Fig. 9. Since the operations were performed in two different operating theaters, one 3D camera was installed in each theater. A photograph of a 3D camera in one of the operating theaters is shown in Fig. 10. Each 3D camera consists of a high-definition camera with highly accurate synchronization for the left and right eyes. After combining the left and right images in real-time using a Side by Side Encoder, the images from one of the operation theaters was selected using a video switcher and then encoded by a H.264 encoder. After the IP formatted data was sent to the Kobe Exhibition Hall via WINDS, the data was decoded by a H.264 decoder, transformed to comply with the monitor input interface standards by the 3D SS-Composer and outputted to nine 46 inch monitors and one 24 inch monitor. The intercom and DV camera were used to contact another site and confirm the status between the both sites.

The details of the transmission network via WINDS are discussed in section **5** and the details of 3D high-definition transmission technology are discussed in section **6**.

Fig.10 *Operation theater with a camera installed*

5 Transmission network utilizing WINDS

Wideband InterNetworking engineering test and Demonstration Satellite "KIZUNA" (WINDS) is a satellite developed in order to conduct experiments of technology regarding the construction of the high speed satellite communications system utilizing the Ka-band frequency as a part of the research and development regarding the design of the advanced information telecommunications network for the e-Japan Priority Policy Program initiated by the government IT Strategy Headquarters.

The Multi-Port Amplifier (MPA), Active Phased Array Antenna (APAA) and ATM Baseband Switch (ABS) were developed to install in WINDS. The satellite was a joint development by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT) and NICT was put in charge of the development of the ABS.

WINDS was launched by the H-IIA rocket from the Tanegashima Space Center on February 23, 2008. After initial check-out of the functions, the satellite development institutions NICT and JAXA commenced basic experiments from July 2008 and since October 2008 utilization experiments have been conducted by public tenders from the Ministry of Internal Affairs and Communications.

5.1 Overview of the Wideband InterNetworking engineering test and Demonstration Satellite "KIZUNA" (WINDS)[3]

WINDS is a technology experimental satellite jointly developed by JAXA and NICT. It was launched by the H-IIA rocket from the Tanegashima Space Center on February 23, 2008. A photograph and details of WINDS is shown in Fig. 11.

WINDS is deployed into a geostationary orbit at 143 degree of east longitude with a design lifespan of five years. The communications ex-

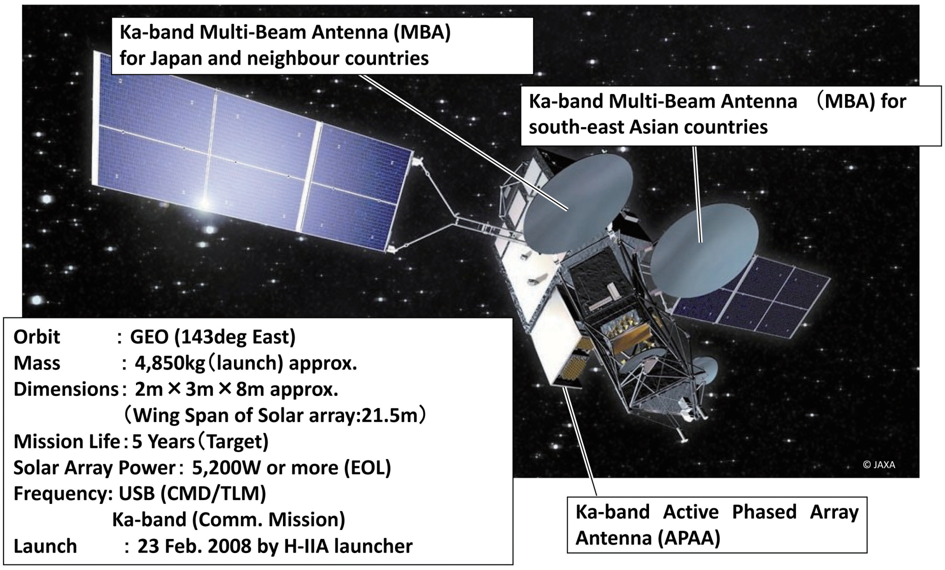

Fig.11 *Overview of WINDS and specifications*

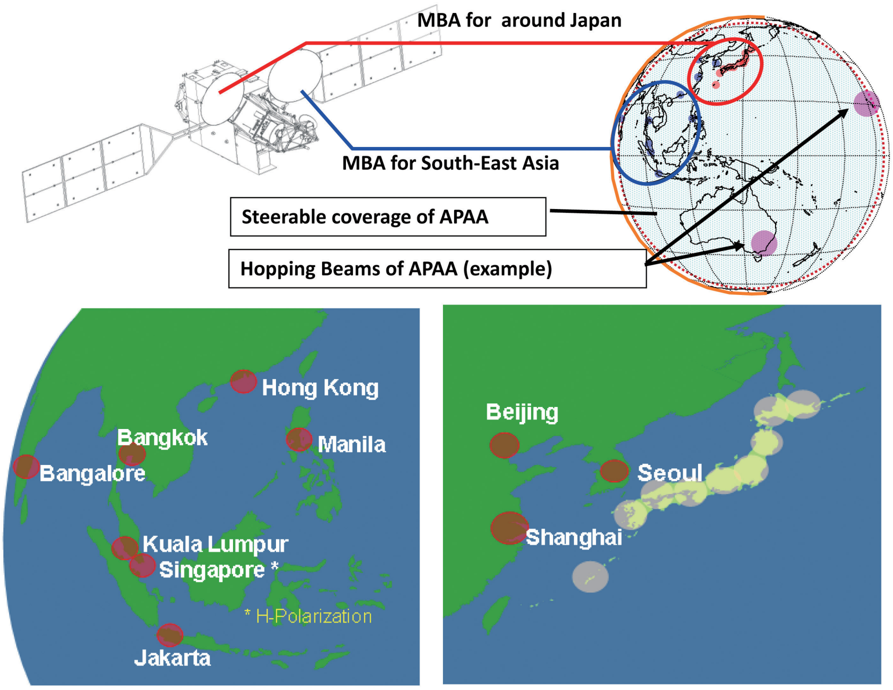

Fig.12 *WINDS service area*

periment utilizes a Ka band frequency (uplink 27.5-28.6 GHz/downlink 17.7-18.8 GHz).

Two types of antennas are attached to WINDS. One antenna is a Ka-band Multi-Beam Antenna (MBA) with two 2.4 m main reflectors, one for Japan and neighbor countries and one for South-East Asian countries. The other antenna is Ka-band Active Phased Array Antenna (APAA).

The WINDS service area is shown in Fig. 12.

The MBA for domestic use covers Japan

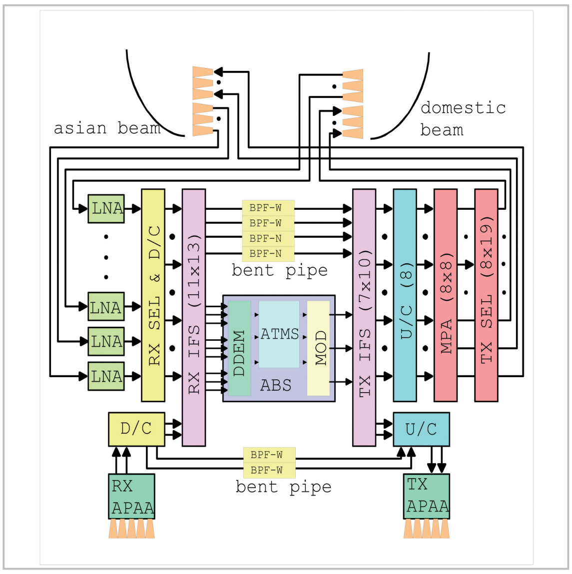

Fig.13 WINDS transponder diagram

with nine beams and also covers neighboring countries (Seoul, Shanghai and Beijing). The MBA for South-East Asia covers seven cities including Singapore.

Conversely, the APAA can scan electronically with beams and use two beams simultaneously for each transmission and reception. The APAA has a scanning scope that spans across the globe.

The WINDS transponder diagram is shown in Fig. 13.

ABS is mounted on WINDS. Uplink signals from the ground are demodulated on the demodulator (DDEM), switched between several beams on the switching equipment (ATMS) and then remodulated on the modulator (MOD) to downlink. Errors that occur during uplink are corrected by the on-board regenerative baseband switch. This also enables transmission power to be efficiently operated by multiplexing downlink signals.

The uplink signal uses the modulation formula: QPSK and error correction: Reed-Solomon Coding RS (255, 233). The transmission speed is capable of utilizing 1.5 Mbps, 6 Mbps, 24 Mbps, 51 Mbps and 155 Mbps (51Mbps×3). The downlink signal uses the modulation formula: QPSK and error correction: Reed-Solomon Coding RS (255, 233) and the transmission speed is capable of utilizing 155 Mbps only. TDMA is used as the access method, 1 time slot is 2 ms and 1 super frame has 320 slots (640 ms).

Furthermore, the transponder can be utilized as the non-regenerative repeating line by bypassing the on-board baseband switch but by using the Band Pass Filter (BPF). The transponder has a bandwidth of 1.1 GHz and is therefore capable of transmitting a maximum of 1.2 Gbps.

5.2 WINDS satellite communications experiment

On the transmission side, an ultra-high speed small-scale earth station (SDR-VSAT) was installed in the carpark of the Yamato Seiwa Hospital filming location within the Kanto beam in order to conduct the 3D high definition transmission experiment using WINDS. In addition, on the transmission receiving side, a small-scale earth station (51M-VSAT) was installed on the roof of the Kobe International Exhibition Hall within the Kinki beam in order to receive images. The earth station IDU input terminal (Ethernet: 1000 Base-T) was used for an interface with the imaging device.

The main specifications of the SDR-VSAT and 51 M-VSAT are shown in Table 1.

Installed in an experimental vehicle, the SDR-VSAT consists of an antenna with an aperture of 2.4 m and a TWTA with a saturation output of 215 W. When utilizing the on-board baseband switch, it has a maximum transmission of 155 Mbps (51 Mbps×3) and a receiving speed of 155 Mbps.

Conversely, the 51 M-VSAT consists of an antenna with an aperture of 1.2 m and a SSPA with 40 W. When utilizing the on-board baseband switch, it has a maximum transmission of 51 Mbps and a receiving speed of 155 Mbps.

During the 3D high-definition experiment conducted in January 2010, 288 slots were allotted for the SDR-VSAT transmission at 155 Mbps (51 Mbps×3) mode and 288 slots for the 51 M-VSAT transmission at 51 Mbps mode.

Prior to the transmission of images, packet loss is measured and the quality of communication lines is verified using the network charac-

Table 1 *Specifications for SDR-VSAT and 51M-VSAT*

	SDR-VSAT	51M-VSAT
Antenna size	2.4m	1.2m
HPA	215W:TWTA	40W:SSPA
EIRP	76.0dBW and over	61.7dBw and over
G/T	24.5dB/K and over	19.0dB/K and over
TX data rate	regenerative:155Mbps bent-pipe:622Mbps	regenerative:51Mbps
RX data rate	regenerative:155Mbps bent-pipe:622Mbps	regenerative:155Mbps
photograph		

teristic tool iperf.

SDR-VSAT → 51 M-VSAT UDP 100 Mbps
Packet loss: 0 %

51 M-VSAT → SDR-VSAT UDP 30 Mbps
Packet loss: 0 %

6 3D high-definition image transmission technology details

6.1 Transmission technology developed by URCF 3D Image Transmission Working Group

The URCF 3D Transmission Working Group has developed two types of 3D high-definition Image IP transmission technology. These two types of technology transmit 3D high-definition images using an IP (internet protocol) based on IEEE1394. IEEE1394 is a standard for the high speed serial communications bus. Since this enables clock synchronized critical communications to be performed and multiple signals such as images, sounds and control signals to be transmitted simultaneously, it is widely used on both consumer and professional equipment as a multimedia connection terminal. It is one type standard connection terminal to connect digital household electrical appliances that also enables power to be supplied by a cable (bus power) and to be connected and disconnected (hot plug) during the operation of equipment. It is sometime referred to as FireWire, i.Link and a DV terminal.

Low-end types suitable to directly transmit horizontal compression two screen multiple 3D images to households, etc., using IEEE1394 through best effort communication lines (narrow middle band lines) use side-by-side compression. As shown in Fig. 14, the side-by-side compression format compresses the width of images by 1/2, aligns two images on the left and right of the screen and constructs a synthesized image. By compressing the horizontal direction to 1/2 and decreasing the horizontal resolution to 1/2, the issues such as vertically elongated two images appearing on the screens of regular televisions still remains. However, since the electric signal format is exactly the same as the signals used for regular televisions, the major merit of this technology is that 3D high-definition (stereo images) signals can be transmitted, broadcasted and recorded on regular high-definition equipment without any modifications.

The initial experimental low-end type IP transmission system is shown in Fig. 15. The 3D image streams captured on two synchro-

Fig.14 Image with Side-By-Side compression

nized HDV cameras are encoded using i.Link after encoding into two screens and are inputted into the IP transmission device. Then, the images become IP based and are transmitted via a network after synthesized into a side-by-side format. As the images are still high-vision compatible signals at this stage, they are inputted into a 3D television after i.Link decoding. The images are extended to left and right eye images from the side-by-side signals and displayed in 3D on a 3D television. The use band-

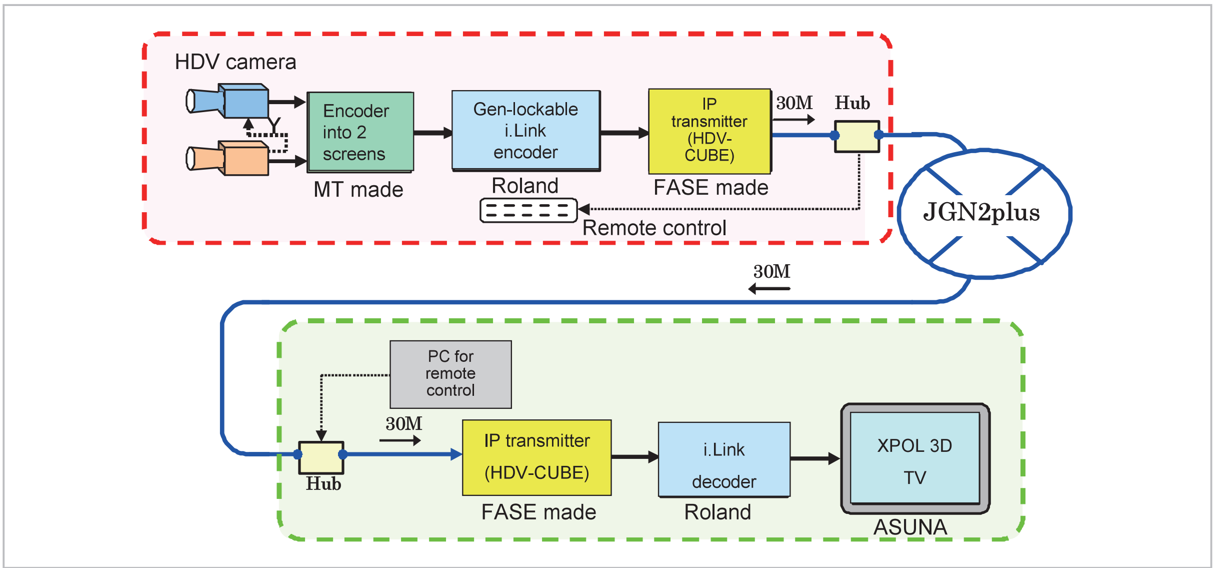

Fig.15 Composition of initial low-end type

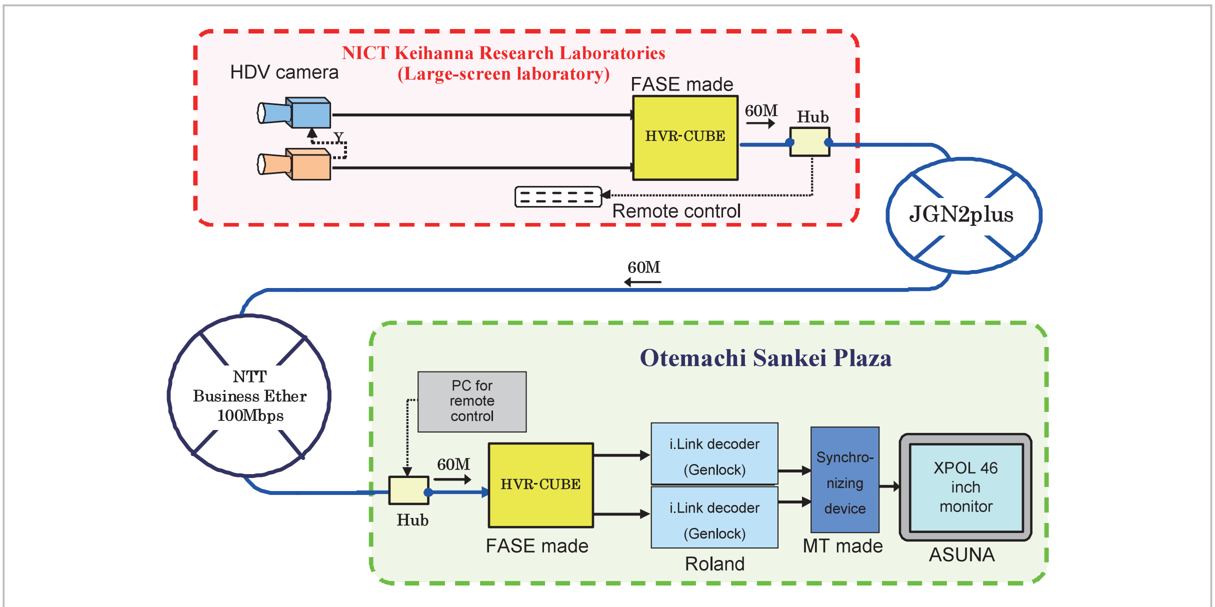

Fig.16 Composition of high-end type

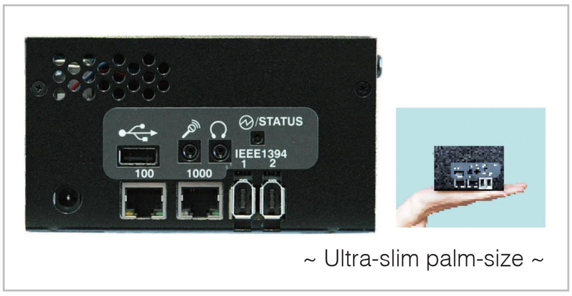

Fig.17 *3D high-definition IP transmitter HVR-CUBE*

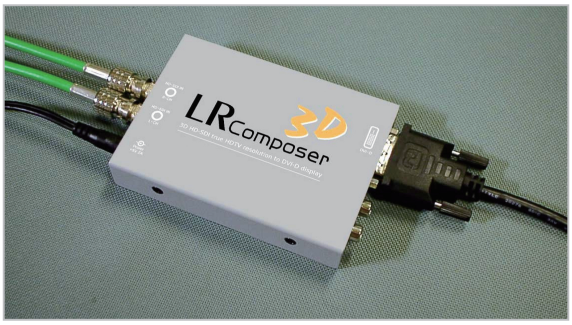

Fig.18 *3D image composer*

width is approximately 30 Mbps.

The high-end type is suitable for broadband communication lines such as JGN2plus and high-definition 3D images are transmitted as independent 2 channel HDV standard high-definition images. The experimental high-end IP transmission system is shown in Fig. 16. The 3D image stream captured on two synchronized HDV cameras is inputted to a 2 channel transmission device (HVR-CUBE) to become IP based via IEEE1394, and transmitted to a receiving point via a JGN2plus communication line. Since the two streams are maintained even on the IP transmission route and transmitted in a synchronized state, very clear 3D high-definition images can be acquired without any decrease in the HDV quality. Jitters and packet loss which occurs during transmission is absorbed by the strong error correction circuit in the transmission device. After decoding by synchronized i.Link, 2 stream images are inputted into a 3D television via an ultra-compact 2 channel 3D image composer without decreasing the image quality. The used bandwidth is approximately 60 Mbps. The 3D high-definition IP transmission device is shown in Fig. 17 and the 3D composer is shown in Fig. 18.

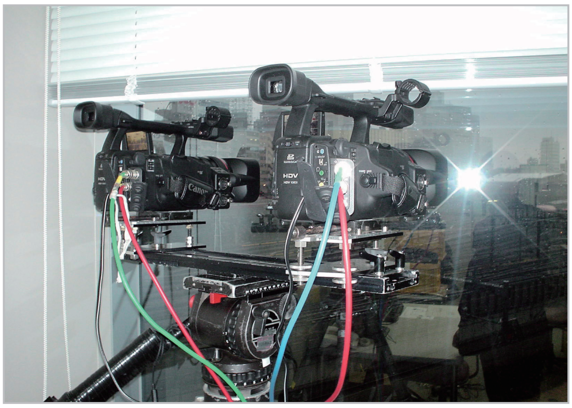

Fig.19 *3D high-definition camera*

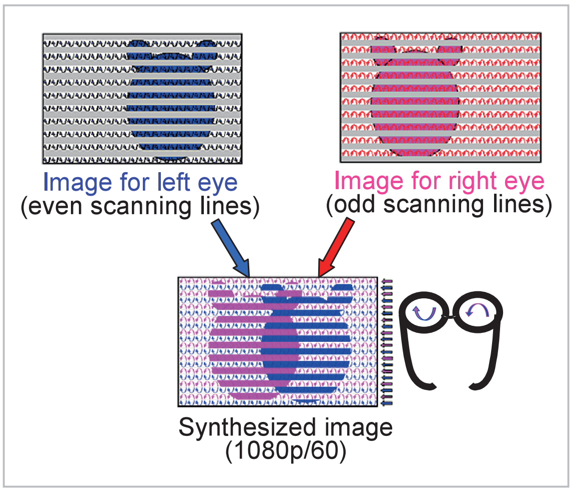

Fig.20 *XPOL-type fundaments*

The composition of the demonstration system shown in Fig. 3 is the high-end type with the 2D transmission system for bi-directional communicaiton.

6.2 Captureing and display technology

In addition to the development of the transmission system, a 3D high-definition camera and XPOL-type 3D monitor was also developed. The overview of the 3D high-definition camera is shown in Fig. 19. The XPOL-type 3D monitor is a high-definition monitor containing filter with a phase difference film with different characteristics placed on every second scanning line. The fundaments are shown in Fig. 20. Since the user can simultaneously see both the split left and right images with both the left and right eyes respectively when viewing these images, each of which is framed onto every second scanning line, while wearing polarized glasses, this display has the characteristic of displaying ideal 3D images without making the user feel tired. This display can also be used as a regular high-definition television when regular high-definition broadcasts are transmitted and the user takes off the polarized glasses.

6.3 Transmission technology for the experiment of real-time 3D high-definition image transmission for cardiac surgery

Although the high-end type discussed in **6.1** is capable of transmitting full high-definition resolution, the composition on the receiving end is complex due to synchronization on the receiving side. Furthermore, it is essential to have an IP network that has a guaranteed bandwidth of 60 Mbps or more. Since the bandwidth margin is small, reliability was made a priority and the structure of the transmission receiving side was made simpler in order to display images on ten monitors, the system used in the experiment was constructed using the same side-by-side format as the low-end type, even though the image quality slightly degraded. As shown in Fig. 9, the newly developed 3D Side By Side Encoder (Fig. 21) and 3D SS-Composer (Fig. 22) made the system much easier to use than the initial low-end type. On the transmitting side, the HD-SDI signal, the standard output format, is directly sent to the 3D Side By Side Encoder from the two cameras synchronized by GenLock and therein the Side By Side image is directly synthesized. Since these images use the signal format compatible with regular high-definition images, the widely popular compression technology H.264 can be used for transmission. Since the left and

Fig.21 3D Side By Side Encoder

Fig.22 3D SS-Composer

Fig.23 Yamato Seiwa Hospital operating room broadcasted in 3D using satellite link

right eye images are unified, there is no need to be concerned with synchronization on the transmission route. On the receiving side, 3D images are displayed on the monitor by merely transforming the Side By Side image signal to the monitor input standard DVI signal by the 3 DSS-Composer after decompressing the H.264 compression.

7 The experiment circumstances

This experiment performed a successful satellite transmission of live 3D high-definition images for more than six hours without interruption. This successful high-definition 3D transmission of a real “3D live cardiac surgical operation” enabled the participants in the operating theater and exhibition hall to share an impressive three dimensional experience. Discussions concerning matters such delicate procedures involving veins were conducted between the instructional surgeons in the exhibition hall and operating surgeons in the operating theaters without stress and the specialists confirmed that this technology could greatly enhance all skills through the conveyance of skills to surgeons in distant locations and the mutual evaluations of the specialists.

A photograph of the experiment being performed in the operating theater is shown in Fig. 23. The angle of the camera installed above the patient was adjusted as the operation progressed. Fig. 24 shows the discussions being performed in the Kobe International Exhibition Hall. The moderator, Professor Toru Asai of Shiga University of Medical Science and the commentator, Dr. Masashi Komeda of the Nagoya Heart Center, discussed matters such as the progress of operations and quality of the images while viewing the 3D monitor with 3D glasses. An example of the broadcasted live images is shown in Fig. 25. Although the 3D monitor displayed two layered images if watched with the naked eye, the participants were able to view very clear images when wearing the 3D glasses.

Fig.24 Discussions at the Kobe site

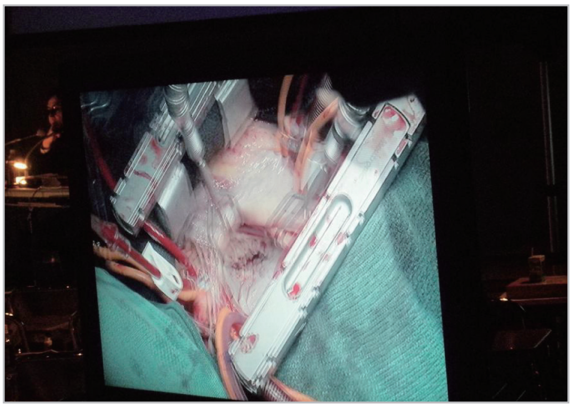

Fig.25 Live-broadcasted image

8 Observations from a medical perspective

The Director of Yamato Seiwa Hospital and the host of the surgical experiment, Akihiro Nabuchi discussed the surgeries while looking at the images at the Kobe site on the day of the experiment. The following extract of an article written in a medical magazine[4] by Director Nabuchi summarizes the medical observations.

[The live broadcast of a cardiac surgical operation was a remarkable world first that recorded images of historical significance. It vividly conveyed the brilliance of 3D technology and the even more powerful strength of human life. Viewed with the naked eye, the display merely looks like a blurred unclear image. However, when wearing the special glasses, startling 3D images that cannot be described merely as “extraordinarily real” jumped out in front of our faces. These were best quality images of any live operation video that the doctors had seen, both in Japan and aboard. Since 1996, medical practitioners have gathered at academic meetings in numerous locations to view live broadcasts of surgical operations, even in the field of cardiac surgery. Although such live videos have been continuously shown at CCT for eight years, this was the first time video has been available in 3D. The expression "ultra-realistic" properly describes these 3D images. Many of the participants claimed that the images were clearer than watching the actual operation with their own eyes.

Cardiac surgery involves an extreme sense of tension where the slightest mistake can result in the death of the patient who puts their trust in the surgeons. Everyday surgeons are moved by the beauty and resilience of the pumping hearts they see before them during surgery. Sometimes said to be the "field of the gods", the divinity of the heart, which can be described as the body and soul of a person, is displayed numerous times more vividly in 3D. Images that normally cannot be seen are clearly shown in 3D. The presence that exceeds reality, in other words, "ultra-realism" made the cardiac surgeons in the exhibition hall and myself included feel as though we were looking a heart that we hadn't seen before.

Referred to as the "depth of field", the depth of a focus point viewed with the naked eye of an ordinary person is not very deep. In addition, the eyes of humans select the information they require to be sent to the brain and then the brain discriminates such information as visual information. However, the binocular camera used produced a clarity that exceeds the quality of the naked eye and a depth that almost completely covers the depth of field. It constructed a 3D world, as far as my analysis is concerned, which exceeded human brain's bandwidth and accordingly happened to make us observe that the 3D images were deeper than in reality.]

Furthermore, Dr. Nabuchi evaluated 3D high-definition images in the medical field to be highly significant by noting that [this 3D technology will certainly assist the technical training, education and recording of surgical operations. 3D image information adds much more information to that acquired from the eyes of surgeons and will likely enable higher quality operations.]

9 Conclusions

The experiment successfully transmitted high-definition 3D images of cardiac surgery in real-time via WINDS. As a result of this success, large developments in high-level medical technology have become apparent in the near future through the use of ultra-realistic medical 3D high-definition images which have been limited to 2D until now. This has enabled very realistic 3D images to be shared between the operating theater and academic meeting hall, resulting in attention being gained from the medical community. Furthermore, this technology has enabled medical treatment and technology to be conveyed over distances in the future.

In addition, this experiment validated the transmission of live 3D images using the ultra-high speed internet communication line, WINDS (KIZUNA) as a communications infrastructure on the transmission technology side. The experiment also succeeded in providing a stable 100 Mbps transmission of high-definition images from SDR-VSAT.

Equipped with APAA, WINDS has made it possible to establish a satellite communications line across Asia and Pacific region. The success of this experiment has also shown the possibilities for the performance of experiments and use of high speed satellite communication in the region for this very high level medication application.

Acknowledgements

We would like to thank the two patients and all the staff at the Yamato Daiwa Hospital including Dr. Akihiro Nabuchi for their participation in the transmission of the surgical images, and everyone who participated in the discussions at the Kobe International Exhibition Hall.

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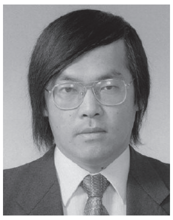
(Accepted Sept. 9, 2010)



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