Technical Committee Meeting

28.10.2023 - 13:30-17:00 & 29.10.2023 - 9:00-17:00

ABU 2023 SEOUL

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ABU Technical Department

REPORT OF TOPIC CHAIRMAN
DISTRIBUTION TOPIC AREA

Topic Chairman	**:**	**Yuji Nagata (NHK)**
Period of Report	**:**	**December 2022 to October 2023**
Date of Report	**:**	**28 October 2023**

Introduction

Distribution topic area comprises four projects. The matters concerning digital terrestrial television broadcasting, digital satellite broadcasting, digital sound broadcasting and these frequency planning are studied or investigated by these projects. This topic area also covers research on IBB and OTT, including platforms and standards, etc.
This document has been submitted for this Technical Committee Annual meeting.

1. Next Generation Terrestrial Broadcasting (D/NGTB)

Project Manager: **Mr. Akihiko Sato** (NHK, Japan)
Co-project Manager: **Dr. Jeon Sungho** (KBS, Korea)
Mr. Chen Delin (ABS, China)
Mr. Halil Us (TRT, Turkey)
Mr. D.P. Singh (India)
Mr. Rajesh Meena(India)
Mr. A K Mangalgi(DDI, India)
Mr. Zhang Yu (ABS/China)
Mrs. Xiao Jingting (ABS, China)

Reports from the project managers and the contributor are as follows.

1.1 Investigate efforts toward the realization of next-generation terrestrial broadcasting in Japan
1.2 Development of ATSC 3.0 & 5G-Broadcbast Transmission Techniques in the Republic of Korea

The reports for D/NGTB are attached as Annex 1.

2. Integrated Broadcast-Broadband and OTT (D/IBBOTT)

Project Manager: **Dr. Go Ohtake** (NHK, Japan)
Co-project Manager: **Mr. A. K. Mangalgi** (DDI, India)
Mr. R.P. Joshi
Ms. Momoko Suyama (NHK, Japan)
Dr. Shinya Abe (NHK, Japan)
Mrs. Zhang Dingjing(ABS, China)
Zhang Yu(ABS, China)
Zhang Wei(ABS, China)
He Jing(ABS, China)
Wang Lei(ABS, China)

Reports from the project managers and the contributor are as follows.

2.1 Standardization of Integrated Broadcast-Broadband System in Japan
2.2 Studies in ITU-R
2.3 Studies in ITU-T
2.4 Cyber Security in Ireland

The reports for D/IBBOTT are attached as Annex 2

Project: Integrated Broadcast-Broadband and OTT (D/IBBOTT)

Project Manager: **Dr. Go OHTAKE** (NHK, Japan)
Co-project Manager: **Mr. A. K. Mangalgi** (DDI, India)
Mr. R.P. Joshi
Ms. Momoko Suyama (NHK, Japan)
Dr. Shinya Abe (NHK, Japan)
Mrs. Zhang Dingjing (ABS, China)
Zhang Yu (ABS, China)
Zhang Wei (ABS, China)
He Jing (ABS, China)
Wang Lei (ABS, China)

2. Status report

This clause describes recent updates on IBB and OTT standards and related technologies identified and studied by this project. And it describes also recent update on standards and technologies of information security for broadcasting services and cyber security in broadcasting industry for protecting the broadcasting systems.

2.1 Standardization of Integrated Broadcast-Broadband System in Japan

IPTV Forum Japan standardizes specifications of Hybridcast in Japan. Technical specification of Hybridcast is composed of two technical standards and an operational guideline listed below and the latest versions are published in January 2022.

- IPTVFJ STD-0010 'Integrated Broadcast-Broadband System Specification', version 2.4
- IPTVFJ STD-0011 'HTML5 Browser Specification', version 2.7
- IPTVFJ STD-0013 'Hybridcast Operational Guideline', version 2.10

In the revision in November 2020 several new features were added to the Hybridcast technical specifications. Major updates are as follows:

- Addition of the new application type named "Broadcast-independent managed application"
  An application of this type runs in the state that no broadcast channel is being tuned so that service providers can offer application services regardless of their broadcasting area.
- Enhancement to the streaming video playback function
  The CMAF[*1] is added as a supported container format of streaming video, including low-latency playback features. Support for stream event delivery mechanisms

such as an ‘event message’ (emsg) box and an ‘Event’ XML element of MPEG DASH*2 are also added.

- Enhancement to the companion device function
  UHDTV broadcasting services, i.e. 4K and 8K satellite broadcasting in Japan, are added to the available channels for tuning from a companion device.
- Addition of the three-dimensional audio codec support
  The enhanced AC-3*3 is added to the available audio codecs for video streaming.

*1 ISO/IEC 23000-19 “Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media”.
*2 ISO/IEC 23009-1 “Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats”.
*3 ETSI TS 102 366 “Digital Audio Compression (AC-3, Enhanced AC-3) Standard”.

<u>In the revision in January 2022, several features related to terminated VOD services were deleted from the Hybridcast technical specifications.</u>

2.2 Studies in ITU-R

ITU-R WP6B is working for the study on IBB systems. The working party is now studying on harmonization of IBB systems by making comparison of Hybridcast (Japan), HbbTV2.0 (Europe), TOPSmedia (South Korea) and Ginga (Brazil).
At the meeting held in April 2019 in Geneva, the working party developed the comparison of application life-cycle and application transition of the IBB systems, and revised Report ITU-R BT.2267 “Integrated broadcast-broadband systems” to add a new part on the harmonization of Integrated Broadcast-Broadband (IBB) systems’ applications. To allow the exchange of services covered by the IBB systems and to deploy these services in an area where other systems are used, it is important to harmonize the IBB systems, to ensure compatibility with the IBB applications and interoperability across systems.
At the meeting, the working party revised Report ITU-R BT.2342 to replace information on TTML Text and Image Profiles for Internet Media Subtitles and Captions 1.0 (IMSC1.0) with the updated IMSC1.1 and to update a list of current EBU specifications pertinent to the content of the Report.

At the meeting held in July 2019 in Geneva, the working party revised Report BT.2267 to add the companion application to execute the application on a receiver. The working party also developed the new use cases of IBB system which provides object-based sound services via MPEG-DASH streams.
The working party also developed the global platform. The working party revised Report ITU-R BT.2400 “Usage scenarios, requirements and technical elements of a global platform for the broadcasting service” to add the specific reference to the ATSC 3.0 standard and some examples to show its Internet Protocol-based capabilities to integrate broadcast and broadband services. New digital terrestrial transmission standards such as the ATSC 3.0 system can help effectuate a converged broadcast and broadband platform, which is an important aspect of a global platform for broadcasting services.

At the meeting held in October 2020, the working party revised Recommendation ITU-R BT.2075 “Integrated broadcast-broadband system” to update an application execution mechanism of Hybridcast, with which a companion device sends a command to a receiver to tune to a designated channel and launch a Hybridcast application.

At the meeting held in March 2021, the working party prepared a revised draft report of Recommendation BT.2075 by adding information regarding commonality among IBB systems and equivalency of their functions as described in Report BT.2267 Part 3. The working party also prepared a draft revision to report BT.2267 on IBB systems to align with Recommendation ITU-T J.208 on harmonization of applications between IBB systems.

At the meeting held in September 2022, the working party revised Recommendation ITU-R BT.2075 “Integrated broadcast-broadband system” and Report BT.2267 “Integrated broadcast-broadband systems” to add a Broadcast-independent managed application, that is an application launched when broadcast services are not selected but still authenticated by broadcasters.

2.3 Studies in ITU-T

ITU-T SG9 is also working for the study on IBB system applied to Cable Digital TV. At the meeting held in November 2018 in Bogota, Colombia, the Study Group started the work to revise IBB system Recommendation (ITU-T Recommendation J.207 “Specification for integrated broadcast and broadband digital television application control framework”) to add the function of device collaboration with companion devices in Hybridcast. Recommendation J.207 is a twin of IBB system Recommendations in ITU; Recommendation ITU-R BT.2075 is another twin on this topic. So, the Study Group continue to work to revise the Recommendation according to revision of Recommendation ITU-R BT.2075. The Study Group is studying the work of smart TV operating system for hybrid cable Digital TV services including IBB DTV service provided by cable television operators and third-party providers. At the Bogota meeting, the study group make progress the work of the architecture of smart TV operating system. The study group consent the Recommendation of “The functional requirements of smart TV operating system” as ITU-T Recommendation J.1201.

At the meeting held in June 2019 in Geneve, the study group consent Recommendation J.207 to add the function of device collaboration in Hybridcast. The study group also make progress the work of drafting new Recommendation “Harmonization of Integrated Broadcast-Broadband DTV application control framework”. As for the smart TV operating system, the study group consent the Recommendation of “The architecture of smart TV operating system” as ITU-T Recommendation J.1202. In addition, making a new Recommendation for the specification of smart TV operating system was started in the study group.

At the meeting held in July 2020, the study group reached the AAP consent for the draft new Recommendation ITU-T J.1204. It is now approved and is part of a set of already approved Recommendations as follows:

- J.1201: Functional requirements of a smart TV operating system
- J.1202: The architecture of a smart TV operating system
- J.1203: The specification of a smart TV operating system
- J.1204: The security framework of a smart TV operating system

The group also consent new Recommendation ITU-T J.208 "Harmonization of Integrated Broadcast-Broadband DTV application control framework" at its November 2020 meeting. The recommendation is created based on Report ITU-R BT.2067 which defines the methods to harmonize IBB systems by identifying commonalities across the IBB systems.

2.4 Cyber Security in Ireland

On February 2023, Virgin Media television, one of Ireland’s most popular TV broadcasts, has suffered what it has deemed an “unauthorised attempt” to access its systems, taking down several of its TV channels in Ireland. The company has 3.4 million customers, including more than a million in Ireland. The attack affected numerous services. These include recorded programming on Virgin Media Three, Four, More and VMTV. Virgin Media said that “Our ongoing security monitoring system has identified an unauthorised attempt to access our systems in recent days. Due to the precautions, we have implemented there will be temporary effects to the broadcasting of some of our recorded programming on Virgin Media Three, Four, More and VMTV Player.” Virgin Media later confirmed that the breach had been, “fully contained, isolated terminated”. After that, Virgin Media has said that a cyber attack that affected programming on some of its channels was not a ransomware attack.

Source:

https://techmonitor.ai/technology/cybersecurity/virgin-media-television-suffers-major-hack

https://www.businesspost.ie/news/virgin-media-television-says-major-hack-was-not-ransomware/

https://www.siliconrepublic.com/enterprise/virgin-media-television-tv-hack-cyberattack-breach
https://www.rte.ie/news/2023/0220/1357832-virgin-media-hack/

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3. Satellite Broadcasting (D/SB)

Project Manager: **Dr. Masashi Kamei** (NHK, Japan)
Co-project Manager: **TBD**

Reports from the project managers and the contributor are as follows.

3.1 ITU-R documents related to satellite broadcasting systems
3.2 Latest topics on satellite broadcasting

The reports for D/SB are attached as Annex 3.

Annex 1

Project: Next Generation Terrestrial Broadcasting (T/NGTB)

Project Manager: **Mr. Akihiko Sato** (NHK, Japan)

Co-project Manager: **Dr. Jeon Sungho** (KBS, Korea)
Mr. Chen Delin (SARFT, China)
Mr. Halil US (TRT, Turkey)
Mr. D.P. Singh (India)
Mr. Rajesh Meena (India)
Mr. A K Mangalgi (India)
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1.1 Investigate efforts toward the realization of next-generation terrestrial broadcasting in Japan

1.1.1. Introduction

Next-generation digital terrestrial television broadcasting will be dominated by UHDTV applications. UHDTV broadcasts consist of a huge amount of data and therefore require large-capacity transmission paths.

Japan has been conducting research and development on an advanced DTTB system. The objective of the advancement is to provide improved transmission performance compared with ISDB-T in terms of increased transmission capacity and reduced *C/N* required. The advanced system has been designed to provide UHDTV services for fixed reception together with HDTV services for mobile reception simultaneously. R&D projects on the advanced DTTB system have been conducted in three phases.

– Phase 1: R&D project on basic technologies for a next-generation DTTB system (2013-2016)
– Phase 2: R&D project on the advanced DTTB system (2016-2018)
– Phase 3: Technical verification of new DTTB systems (2019-2022)

During technical verification phase, trials were conducted to verify the transmission performance and feasibility of new DTTB systems. Additional features were also demonstrated. The trials conducted during the technical verification phase are detailed in § 1.1.3.

1.1.2. Overview of advanced DTTB system specification and evaluation of its transmission characteristic

With the aim of improving the quality and expanding the functions of digital terrestrial television broadcasting services, advanced transmission systems have been developed that inherit the key functions of integrated services digital broadcast-terrestrial (ISDB-T) systems, which employs hierarchical transmission based on frequency division multiplexing (FDM) and a segment structure. The advanced DTTB system has a new signal frame structure that enables bandwidth to be flexibly allocated to multiple services for different reception scenarios, such as fixed reception and mobile reception, compared with ISDB-T. In order to expand transmission capacity, adoption of new transmission technologies such as higher order modulation (256QAM, 1024QAM, and 4096QAM), non-uniform constellations (NUCs), low density parity check (LDPC) code, dual-polarized multiple-input multiple-output (MIMO) and Channel Bonding have been studied. Currently, verification of the transmission technologies are in progress.

The following are documents to help you get more information about the advanced DTTB system:

[1] A Study on the Transmission System of an Advanced ISDB-T
https://ieeexplore.ieee.org/document/8971915
This report describes an overview of the transmission system for a next-generation DTTB called the advanced ISDB-T and its basic transmission performance.

[2] Transmission System Design of UHD-1/4K and UHD-2/8K Terrestrial Television Broadcasting and its Performance Proof by Large-Scaled Field Experiments
https://ieeexplore.ieee.org/document/9136826
This paper presents the concept and specifications of the proposed system. The verification results of a computer simulation, and laboratory and large-scale field experiments are also described.

[3] Fixed Reception Performance of FDM-based Transmission System for Advanced ISDB-T
https://www.set.org.br/ijbe/ed6/Artigo1.pdf
This paper provides a BICM selection guideline based on the simulation results for fixed reception scenarios toward the practical application of advanced ISDB-T.

1.1.3 End-to-end demonstration in technical verification phase (2019-2022)

To conclude the verification phase, end-to-end technical demonstrations were conducted in four metropolitan areas in Japan. Objectives of the field experiments were to verify the interconnectivity of all layers of the prototype equipment and the feasibility of the next-generation DTTB systems. Two new DTTB systems were verified. One system, the advanced DTTB system (i.e. advanced ISDB-T), adopts various advanced transmission technologies for improved transmission performance that will enable delivery of new services in one RF channel. Another system, the compatible DTTB system using LDM, transmits the new and current services simultaneously using layered division multiplexing (LDM) in one RF channel. End-to-end technical demonstrations were conducted and were on-aired from large-scale experimental stations in four metropolitan cities in Japan from November 2022 to January 2023.

1.1.3.1 Overview of Advanced DTTB system (advanced ISDB-T)

The objective of the advanced DTTB system is to provide improved transmission performance compared with ISDB-T in terms of increased transmission capacity and reduced *C/N* required in order to deliver new services in one RF channel. The advanced system has been designed to inherit the features of ISDB-T; i.e. it aims to provide a 4K or 8K UHDTV services for fixed reception and an HDTV service for mobile reception simultaneously by frequency division multiplexing (FDM) within a single RF channel. It also uses a frequency-segmented structure that allows partial reception. The bandwidth per segment is reduced to increase the number of segments from 13 (for ISDB-T) to 35, allowing flexible bitrate distribution between layers such as the mobile reception layer and fixed reception layer. Depending on the upgraded BICM technologies used, frequency utilization improves by 1.7 times in comparison with ISDB-T at the same required *C/N*. R&D continues with the goal of making further improvements to the performance and provide additional features including hybrid FDM/TDM, LDM, channel bonding, and low-delay transmission.

1.1.3.2 Overview of Compatible DTTB system

The objective of the compatible DTTB system is to deliver new DTTB services together with existing services in the same RF channel as used for the current DTTB services during the transitional period The system has backward compatibility with ISDB-T, i.e. the system inherits the physical layer protocol of ISDB-T, so that existing commercial ISDB-T receivers can detect and demodulate the signal for existing services. This method is assumed to be used in circumstances where a vacant channel cannot be identified or created to introduce a new DTTB service. The compatible DTTB system multiplexes an existing DTTB signal and a new DTTB signal in the physical layer with Layered Division Multiplexing (LDM). Figures 1.1.1 and 1.1.2 show a brief block diagram and the signal structure of the system, respectively. The signal for the new service is modulated with the bit-interleaved coded modulation (BICM) technologies of the advanced DTTB system, i.e. higher-order modulations, NUCs and LDPC code, and the other blocks are the same as in ISDB-T. The injection level is defined as the power ratio between the existing ISDB-T signal and the signal for the new service. Carrier power of the signal for the new service is set much lower than the carrier power of the ISDB-T signal.

The transmission capacity and the service areas of the existing service and new service are in a trade-off. If the transmission capacity of the existing service is maintained, the service area of the existing service will be reduced due to interference from the signal of the new service. If the service area of existing service is to be retained, the transmission capacity of the existing service needs to be reduced to improve robustness against interference. To reduce the interference to the existing service, the transmission power of the new service needs to be decreased, i.e. injection level needs to be increased, thereby reducing the service area of the new service. In the case where a higher-order modulation scheme (e.g., 64-QAM-7/8) is used for the existing service and/or under an SFN environment, the injection level may need to be increased. On the other hand, in the case where the existing service uses a lower-order modulation scheme (e.g. 16-QAM-2/3), the injection level may be reduced. To achieve the same service area for the new service as the existing service even with the reduced transmission power, transmission parameters offering higher robustness must be employed, which reduces the transmission capacity. If a narrow service area is acceptable for the new service, transmission parameters offering higher transmission capacity can be used to deliver UHDTV.

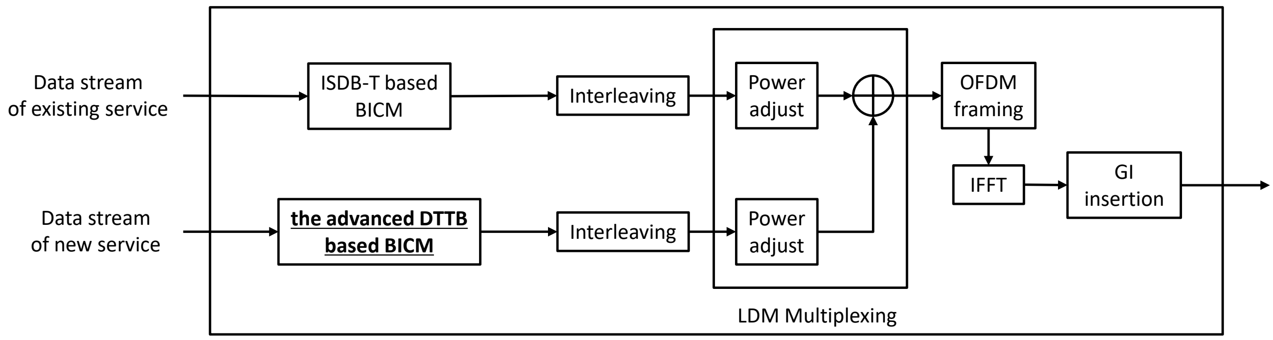
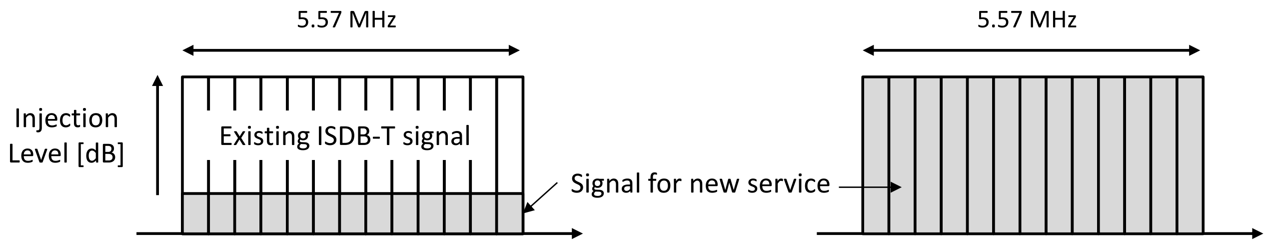


FIGURE 1.1.1 Compatible DTTB system using LDM



a) During transition b) After transition

FIGURE 1.1.2 Signal structure of compatible DTTB system using LDM

1.1.3.3 Transmission parameters

A prototype modulator and demodulator were developed for the two systems and their performances were confirmed in laboratory experiments. The feasibility of the systems was verified through large-scale field trials in four metropolitan cities in Japan.

The parameters listed in Table 1.1.1 were used in the field experiments of the advanced DTTB system. The occupied bandwidth was expanded by about 5% compared with that of ISDB-T to increase transmission capacity. 26 and 9 segments out of 35 segments were assigned for UHDTV (fixed reception) and HDTV (mobile reception) services, respectively. As for error-correcting code and carrier modulation, low density parity check (LDPC) code and NUCs were used for the UHDTV and HDTV services to enhance transmission robustness. Real-time encoder and decoders implementing Versatile Video Coding (VVC) and MPEG-H 3D Audio were used.

TABLE 1.1.1 Parameters for field experiments of the advanced DTTB system

Modulation method	OFDM	
Occupied bandwidth	5.83 MHz	
Multiplexing system	FDM	
Reception scenario	Fixed (Rooftop)	Mobile (Car-mounted)
Number of segments	26	9
Carrier modulation	1 024 NUC QAM	16 NUC QAM
FFT size (number of radiated carriers)	16k (15,121)	
OFDM symbol duration	2 592 μs	
Guard interval ratio (guard interval duration)	800/16 384 (126 μs)	
Error-correcting code	Inner: LDPC, code rate = 9/16 Outer: BCH	Inner: LDPC, code rate = 7/16 Outer: BCH
Transmission capacity	21.5 Mbit/s	2.2 Mbit/s
Video coding	VVC Main10	
Video format	3 840 × 2 160/60/P (4K)	1 920 × 1 080/60/P (2K)
Video bit rate	9.0 Mbit/s (4K) * 2	0.7 Mbit/s (2K) * 2
Audio coding	MPEG-H 3D Audio Baseline Profile	
Audio bit rate	704 kbit/s (22.2ch + 4 objects)	96 kbit/s (2ch + 2 objects)

The parameters listed in Table 1.1.2 and Table 1.1.3 were used in the field experiments of the compatible DTTB. Two parameter sets were verified: one for during the transition and the other for after the transition. The occupied bandwidth and the OFDM signal structure were the same as in ISDB-T. The parameter set for during the transition is for transmitting both the existing and new services in one RF channel using LDM. 12 segments and 1 segment were assigned out of 13 segments to the existing HDTV (fixed reception) and SDTV (mobile reception) services, respectively, and 13 segments were assigned to the new service (fixed reception). As for the error-correcting code and carrier modulation, LDPC code and NUCs were used in the new service layer. The injection level was set to 21 dB. As for the required C/N, the fixed layers of the existing service and new service are approximately 20 dB, which is the same as the current link budget in Japan. The parameter set for after the transition is to transmit new services in one RF channel. 13 segments were assigned to the new service, and LDPC code and NUCs were also used. 256 NUC QAM with a code rate of 11/16 for the LDPC code was used.

TABLE 1.1.2 Parameters for field experiments of compatible DTTB system using LDM (during the transition)

Modulation method	OFDM		
Occupied bandwidth	5.57 MHz		
Multiplexing system	LDM		
Injection Level	21 dB		
Service	New service	Existing service	
Reception scenario	Fixed (Rooftop)		Mobile (Car-mounted)
Number of segments	13	12	1
Carrier modulation	QPSK	64-QAM	QPSK
FFT size (number of radiated carriers)	8k (5 617)		
OFDM symbol duration	1 008 μs		
Guard interval ratio (guard interval duration)	1/8 (126 μs)		
Error-correcting code	Inner: LDPC code rate = 4/16 Outer: BCH	Inner: Convolutional Code, code rate = 2/3 Outer: Reed-Solomon	Inner: Convolutional Code, code rate = 2/3 Outer: Reed-Solomon
Transmission capacity	2.17 Mbit/s	14.9 Mbit/s	416 kbit/s
Video coding	HEVC	MPEG-2	H.264
Video format	1 920 × 1 080/60/P	1 440 × 1 080/60/I (2K)	320×240/15/I (QVGA)
Video bit rate	1.6 Mbit/s*	12.5 Mbit/s	220 kbit/s
Audio coding	MPEG-2 AAC	MPEG-2 AAC	
Audio bit rate	201 kbit/s	201 kbit/s	51 kbit/s

* Offline encoding.

TABLE 1.1.3 Parameters for field experiments of compatible DTTB system using LDM (after the transition)

Modulation method	OFDM
Occupied bandwidth	5.57 MHz
Service	New service
Reception scenario	Fixed (Rooftop)
Number of segments	13
Carrier modulation	256 NUC QAM
FFT size (number of radiated carriers)	8k (5 617)
OFDM symbol duration	1 008 μs
Guard interval ratio (guard interval duration)	1/8 (126 μs)
Error-correcting code	Inner: LDPC : code rate = 11/16 Outer: BCH
Transmission capacity	24.1 Mbps

Video coding	HEVC
Video format	3 840 × 2 160/60/P (4K)
Video bit rate	16.5 Mbit/s *
Audio coding	MPEG-2 AAC
Audio bit rate	201 kbit/s

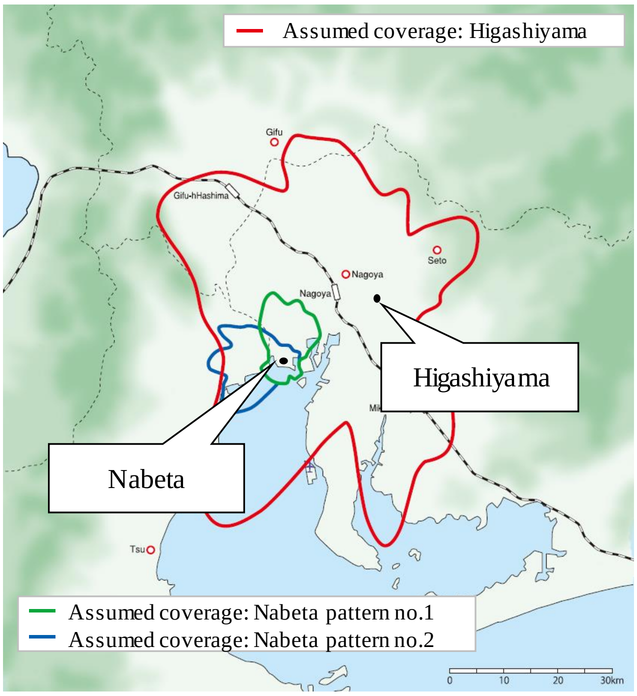
* Offline encoding.

1.1.3.4 Field trials

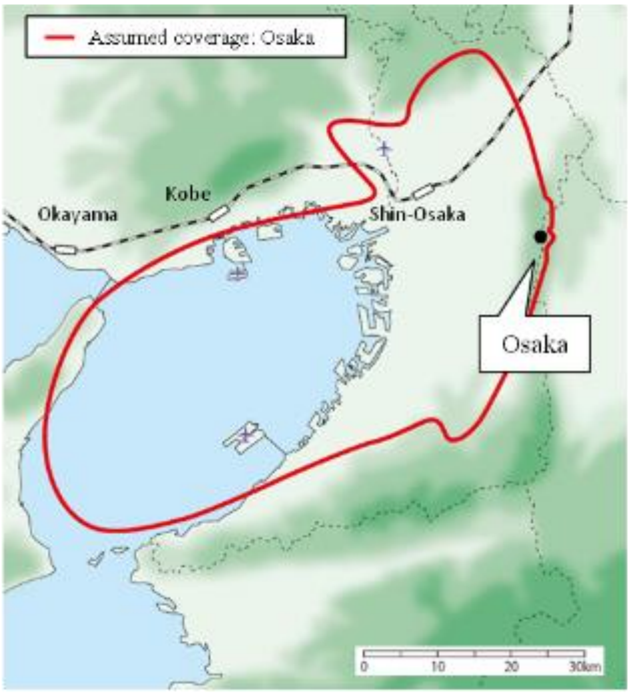
1.1.3.4.1 Experimental environment

Large-scale experiments were conducted to evaluate the performance of the new DTTB systems in different propagation environments in four metropolitan cities, Tokyo, Nagoya, Osaka and Fukuoka. Figure 1.1.3 shows the transmitter sites and assumed coverage areas for the experimental parameters in Tables 1.1. to 1.1.3. Table 1.1.4 lists the specifications of the transmission stations. These coverage areas were on the same scale as those of currently used main DTTB stations. Although each transmission station is equipped for MIMO with two transmitters and two antennas for horizontally and vertically polarized waves, the end-to-end demonstrations used the SISO system with horizontal polarization. Figures 1.1.4 to 1.1.7 show the locations of the transmitting and receiving sites in the four areas.

a) Tokyo area



b) Nagoya area



c) Osaka area

d) Fukuoka area

FIGURE 1.1.3 Experimental environments

TABLE 1.1.4 Transmission parameters

	Tokyo area	**Nagoya area**	**Osaka area**	**Fukuoka area**
Transmitter site	Shiba (Tokyo)	Higashiyama (Nagoya City, Aichi)	Osaka (Higashi Osaka City, Osaka)	Fukuoka (Fukuoka City, Fukuoka)
Transmission frequency	563.143 MHz UHF 28ch	605.143 MHz UHF 35ch	509.143 MHz UHF 19ch	701.143 MHz UHF 51ch
Polarization	Horizontal, Vertical			
Transmission power	Horizontal: 1 kW, Vertical: 1 kW			
e.r.p.	Horizontal: 2.1 kW Vertical: 2.1 kW	Horizontal: 980 W Vertical: 980 W	Horizontal: 4.6 kW Vertical: 4.6 kW	Horizontal: 1.5 W Vertical: 1.5 W
Transmitting antenna height	280 m above sea level	203 m above sea level	570 m above sea level	218 m above sea level

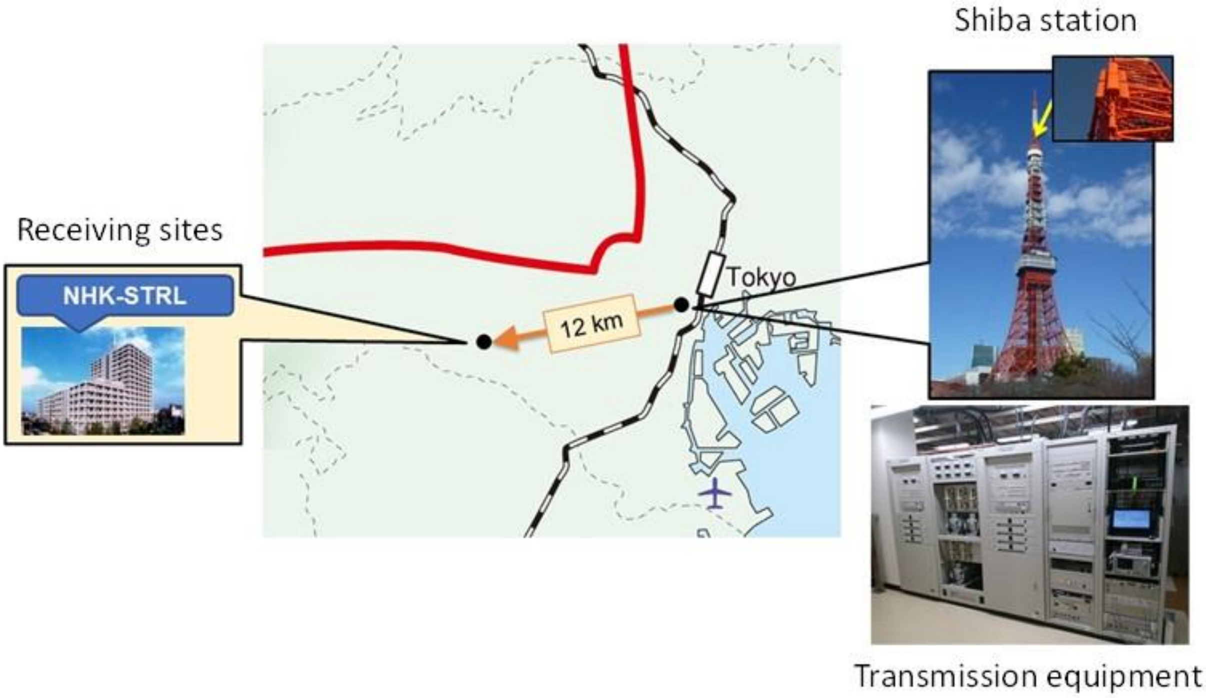


FIGURE 1.1.4 Locations of transmitting and receiving sites in Tokyo

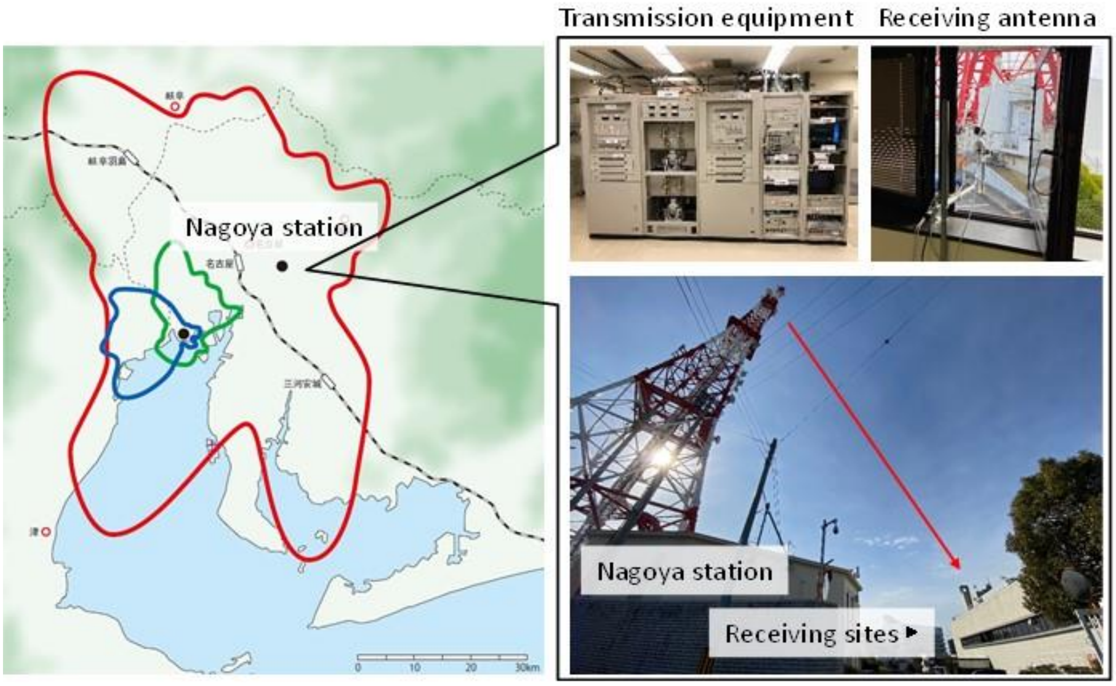


FIGURE 1.1.5 Locations of transmitting and receiving sites in Nagoya

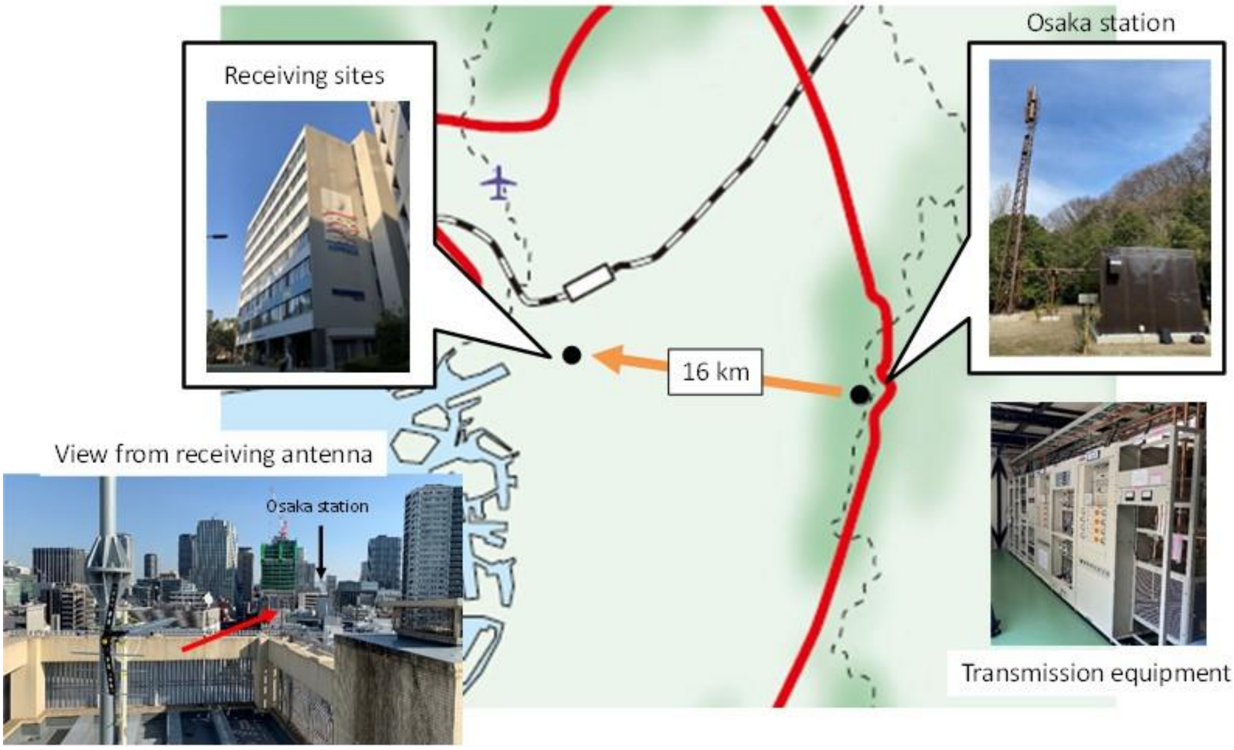


FIGURE 1.1.6 Locations of transmitting and receiving sites in Osaka

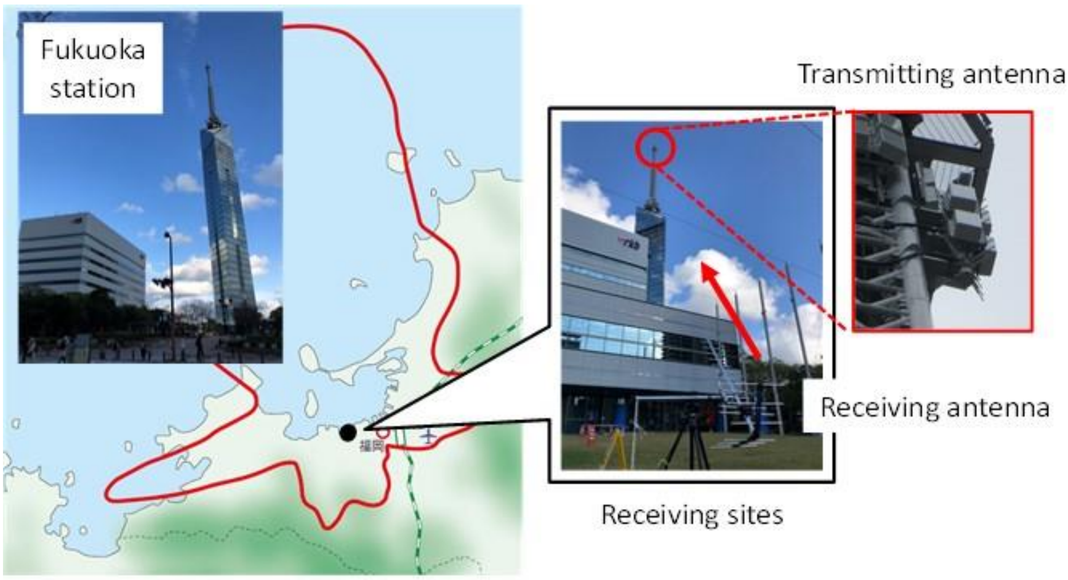


FIGURE 1.1.7 Locations of transmitting and receiving sites in Fukuoka

1.1.3.4.2 Trials of the advanced DTTB system

The demonstration of the advanced DTTB system involved field trials of hierarchical transmission of two UHDTV (fixed reception) and one HDTV (mobile reception) signal. The block diagrams of the transmitting and receiving systems are shown in Figures 1.1.8. Figure 1.1.9 shows the spectrum of the received signals in Tokyo. Figures 1.1.10 and 1.1.11 show the delay profile and constellation of the received signal. As for the delay profile, there were almost no reflected waves (Fig. 1.1.10). The end-to-end connection using the real-time VVC/MPEG-H 3DA encoder/decoder, re-multiplexer and modulator/demodulator of the advanced DTTB system was successfully demonstrated in all four areas.

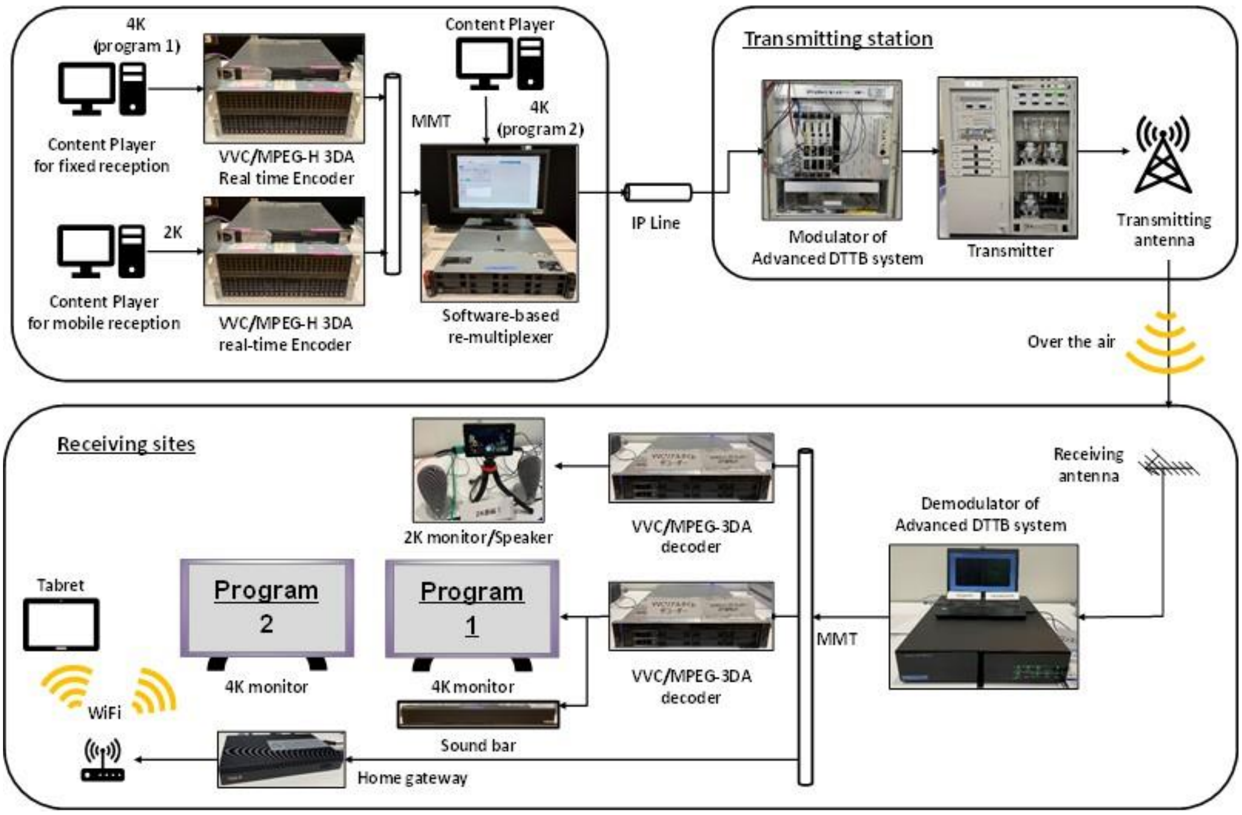


FIGURE 1.1.8 Block diagram of transmitting and receiving systems of the advanced DTTB system

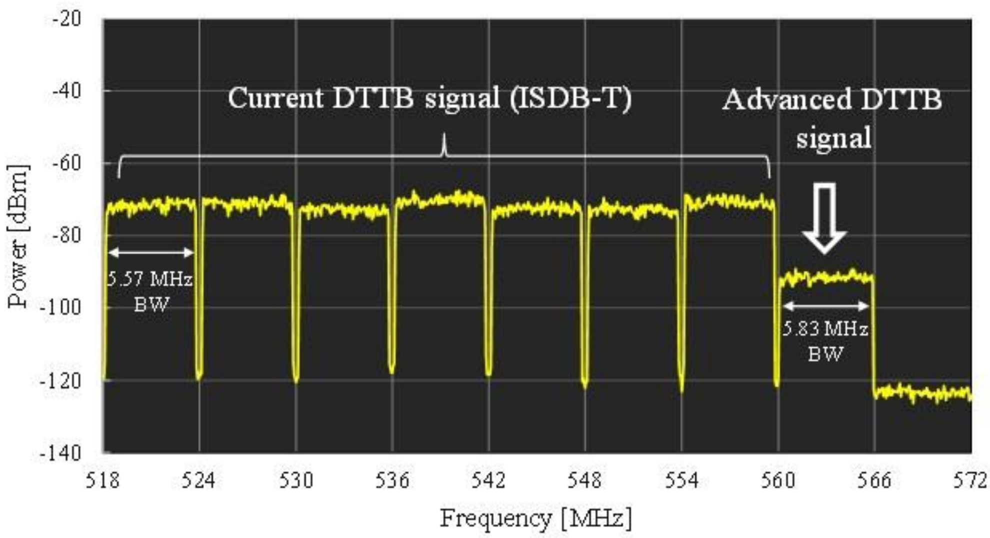


FIGURE 1.1.9 Spectrum of received signal

Note: This figure shows the receiving signal in Tokyo. The advanced DTTB signal was allocated upper-adjacently to the current DTTB signals. The difference in received power between the advanced DTTB signal and the current DTTB signals is due to the different transmitting powers and transmitting points.

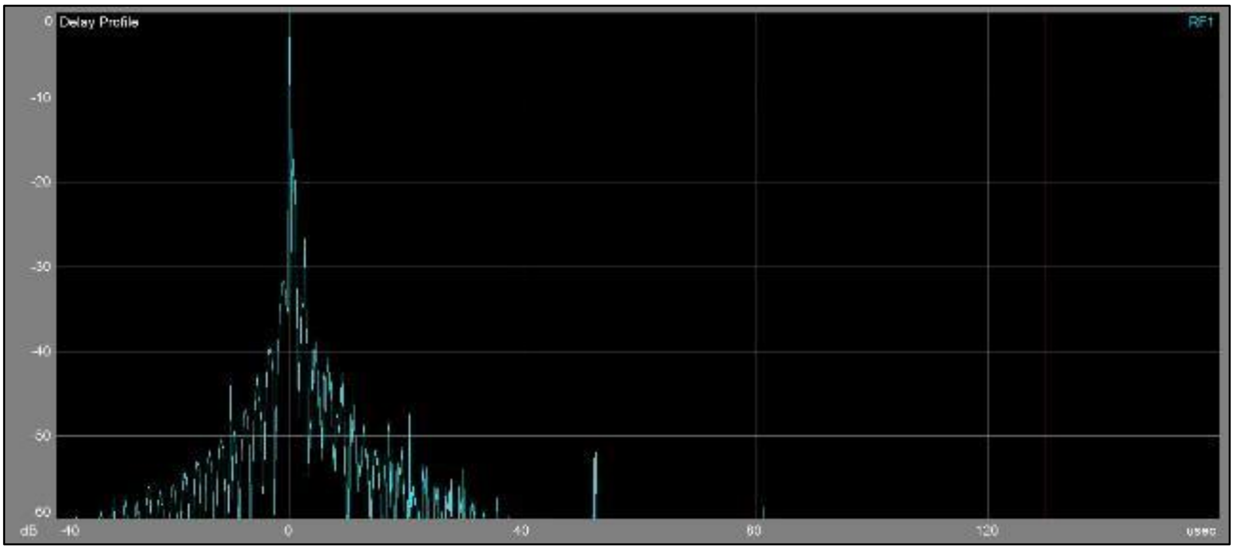
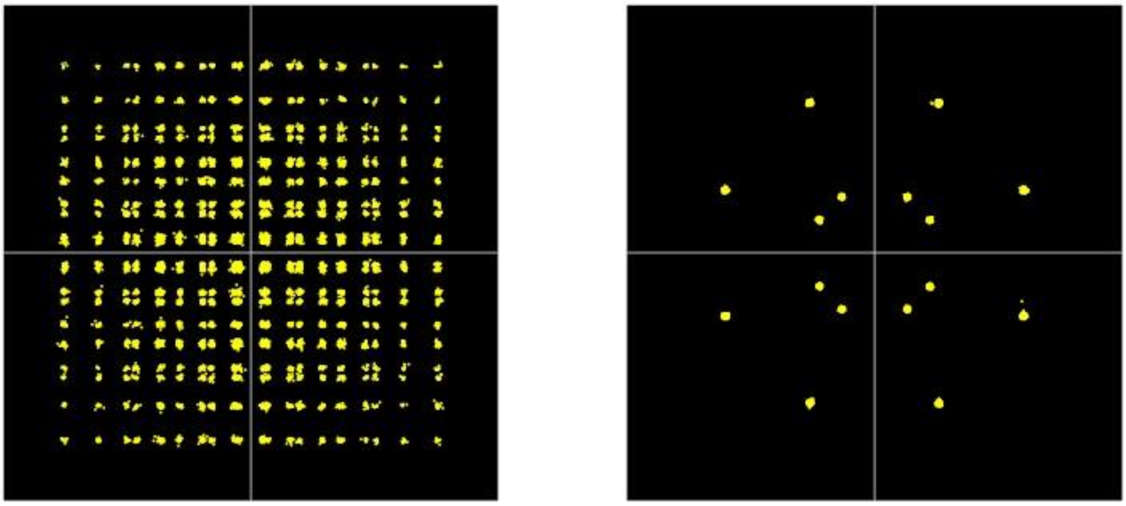


FIGURE 1.1.10 Delay profile of received signal



(a) 1024 NUC QAM for UHDTV

(b) 16 NUC QAM for HDTV

FIGURE 1.1.11 Constellations of received signal of the advanced DTTB system

1.1.3.4.3 Trials of the compatible DTTB system

The demonstration of the compatible DTTB system aimed to show feasibility of the two transmission modes for during and after the transition. The block diagram of the transmitting and receiving systems is shown in Figure 1.1.12.

Figure 1.1.13 shows the spectrum of the received signals in Tokyo. Figures 1.1.14 and 1.1.15 show the constellation of the received signals for during the transition and for after the transition. In the constellation for during the transition (Fig. 1.1.14), both the mobile and fixed layers of the existing service signals were multiplexed with the QPSK modulated signals for new service. This demonstrated that, using the compatible DTTB system, a new service can be received by new receivers while existing commercial ISDB-T receivers can receive the existing service.

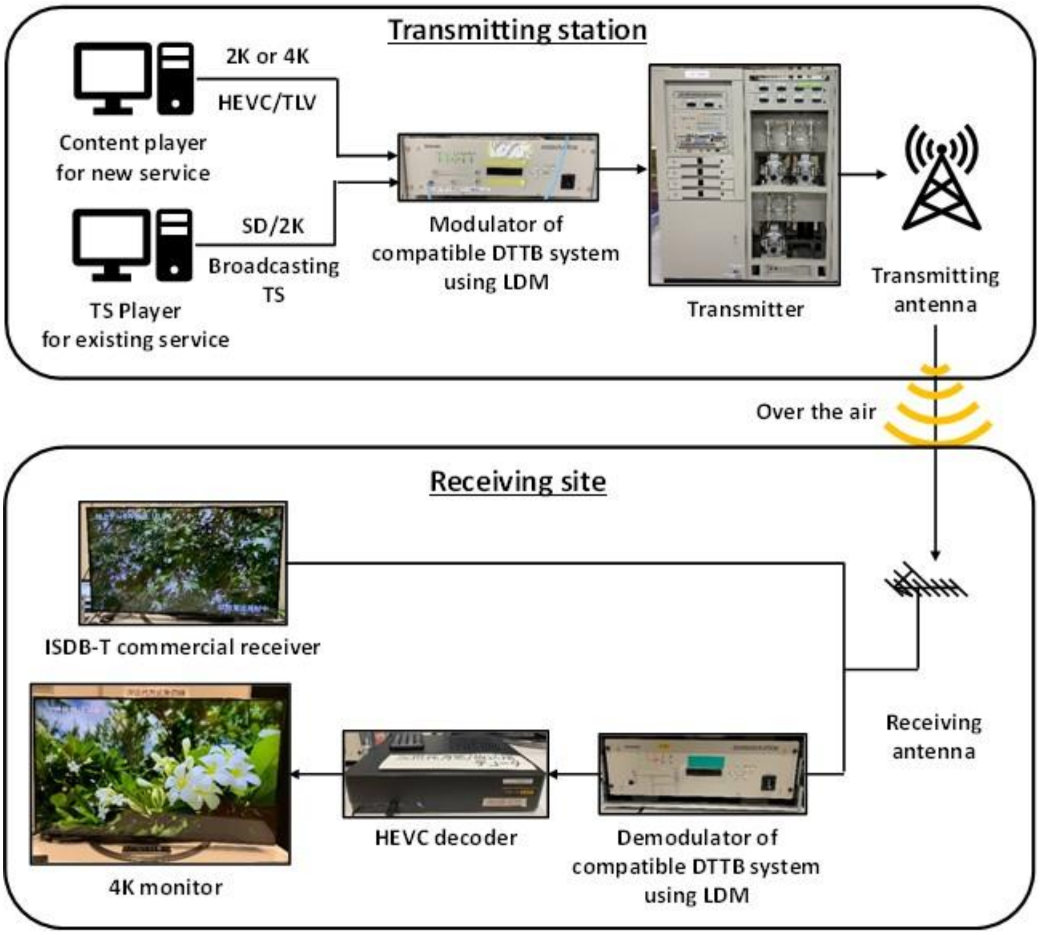


FIGURE 1.1.12 Block diagram of transmitting and receiving system of compatible DTTB system

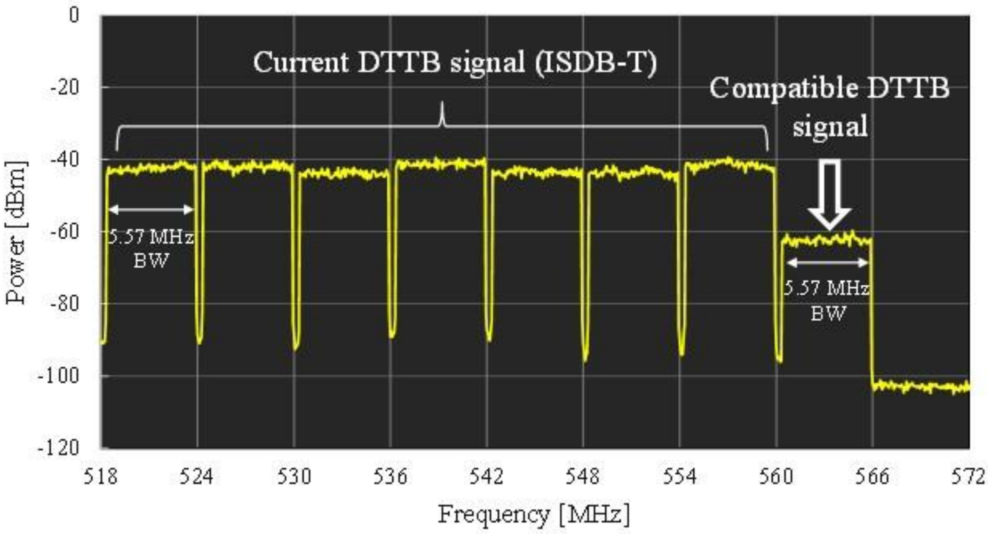
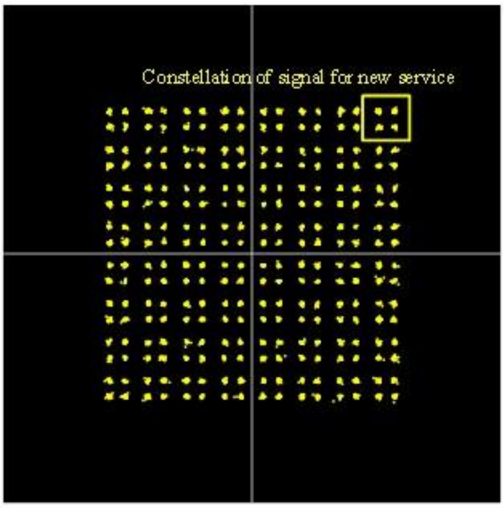
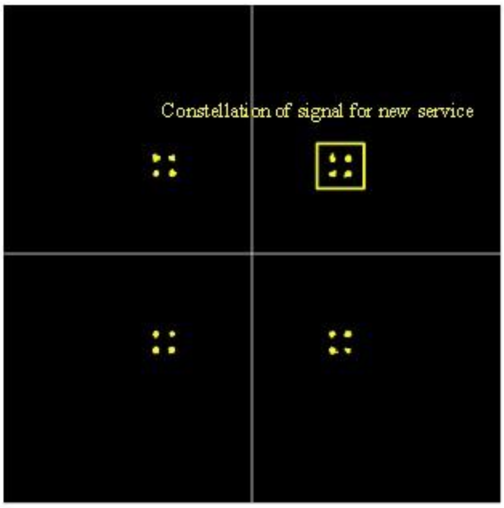


FIGURE 1.1.13 Spectrum of received signal

NOTE: This figure shows the receiving signal in Tokyo. The compatible DTTB signal was allocated upper-adjacently to the current DTTB signals. The difference in received power between the compatible DTTB signal and the current DTTB signals is due to the different transmitting powers and transmitting points.



(a) fixed layer of ISDB-T
existing service 64-QAM for HDTV + new service QPSK for HDTV
with injection level of 21 dB



(b) mobile layer of ISDB-T
existing service QPSK for SDTV + new service QPSK for HDTV
with injection level of 21 dB

FIGURE 1.1.14 Constellations of received signal
(Compatible DTTB system with parameters set for during the transition)

256 NUC QAM for UHDTV

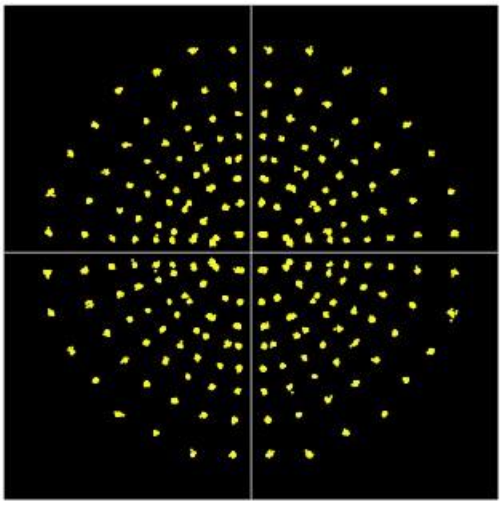


FIGURE 1.1.15 Constellations of received signal
(Compatible DTTB system with parameters set for after the transition)

1.1.4 8K-UHDTV field experiments with channel bonding

Channel bonding technologies use two or more radio frequency (RF) channels to transmit data from a single physical layer pipe (PLP) that exceeds the capacity of a single RF channel. These multiple RF channels may be located at any channel frequency and may not necessarily be adjacent to each other. To verify the channel bonding technology, an 8K-UHDTV field experiment of the channel bonding was conducted using two RF channels.

1.1.4.1 Transmission parameter and equipment

A field experiment was conducted with channel bonding using two RF channels based on the advanced system described in § 1.1.2. The transmission parameters are presented in Table 1.1.5. Each transmitting station for the two individual RF channels was composed of two transmitters for horizontal and vertical polarized waves. A dual-polarized dipole antenna was used for transmitting antennas. Simultaneous transmission of a UHDTV service for fixed reception and an HDTV service for mobile reception was assumed using FDM. A block diagram of the transmitting side is presented in Fig. 1.1.15.

TABLE 1.1.5 Parameters for field experiments of channel bonding

Transmitter site	Kinuta, Tokyo		
Transmission frequency	599.143 (UHF Ch 34)	581.143 MHz (UHF Ch 31)	
Transmission power	Horizontal: 1 W, e.r.p.: 1.3 W Vertical: 1 W, e.r.p.: 1.45 W	Horizontal: 1 W, e.r.p.: 9.3 W Vertical: 1 W, e.r.p.: 9.3 W	
Transmitting antenna height	104 m above sea level (74 m above ground level)	126 m above sea level (96 m above ground level)	
Modulation method	OFDM		
Occupied bandwidth	5.57 MHz	5.57 MHz	
Reception scenario	Fixed (Rooftop)		Mobile (Car-mounted)
Number of segments	33	24	9
Carrier modulation	1024 NUC QAM		16 NUC QAM
FFT size (number of radiated carriers)	16 k (15 121)		
Guard interval ratio (guard interval duration)	800/16 384 (126 μs)		
Error-correcting code	Inner: LDPC, code rate = 9/16 Outer: BCH		Inner: LDPC, code rate = 7/16 Outer: BCH
Transmission capacity (each)	52.4 Mbit/s (MIMO)	38.0 Mbit/s (MIMO)	4.4 Mbit/s (MIMO)
Transmission capacity(total)	90.4 Mbit/s (MIMO)		
Video coding	HEVC		

Video format	7 680 × 4 320/60/P (8K)	1 920 × 1 080/60/P (2K)
Video bit rate	MIMO: 80 Mbit/s (8K)	MIMO: 4.0 Mbit/s (2K)

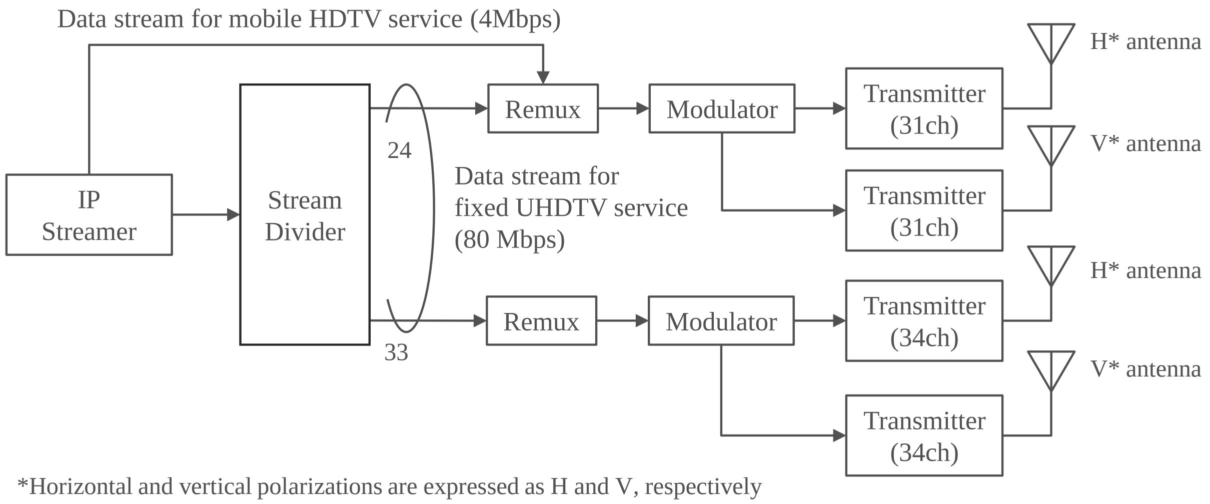


FIGURE 1.1.15 Block diagram of transmitter site

1.1.4.2 Field measurement

The transmitted signals were received at a line-of-site point located 4.5 km from the transmitter site. A block diagram of the receiving side is illustrated in Fig. 1.1.16. A dual-polarized Yagi-antenna was used to receive both the horizontal and vertical signals. Each signal transmitted in Ch 31 and Ch 34 was demodulated individually. The spectrum, constellations, and bit error rate (BER)s of the received signals are presented in figures 1.1.17, 1.1.18 and 1.1.19 respectively. The output data streams from the demodulators for the fixed reception UHDTV service were combined and fed to an MPEG media transport (MMT) /high-efficiency video encoding (HEVC) decoder, and the data stream for mobile reception HDTV service was fed to another MMT/HEVC decoder. The decoded UHDTV and HDTV images are displayed in Fig. 1.1.20.

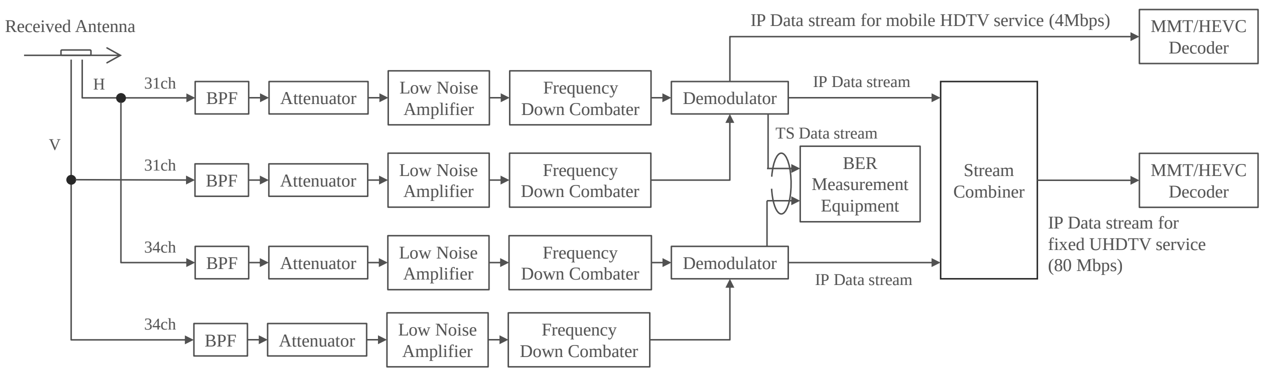


FIGURE 1.1.16 Block diagram of receiver side

(a) Horizontal (b) Vertical

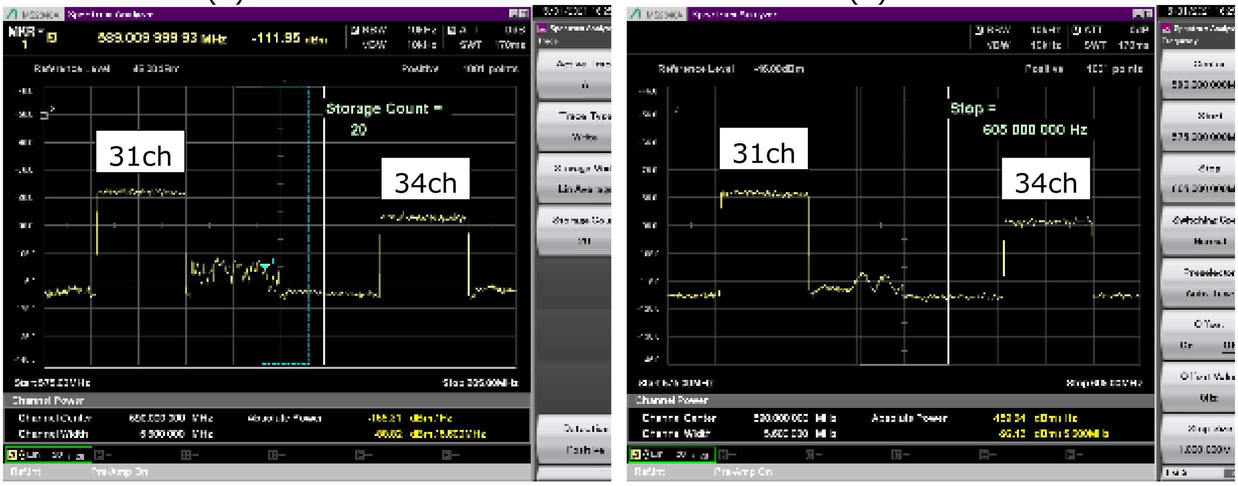
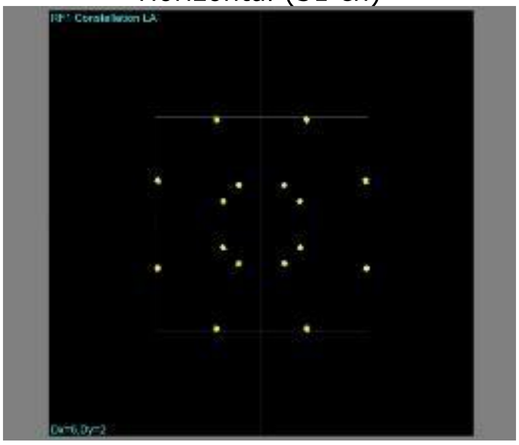


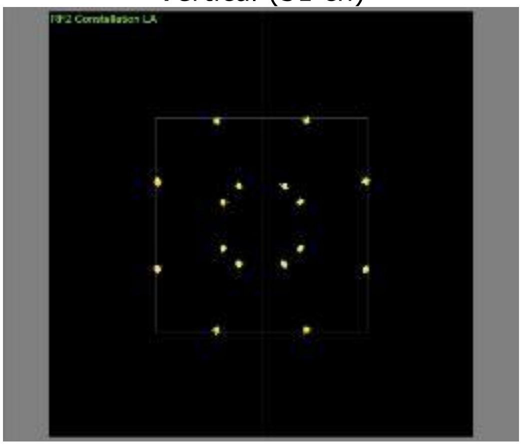
FIGURE 1.1.17 Spectrum of received signals

(a) Mobile reception layer
Horizontal (31 ch)



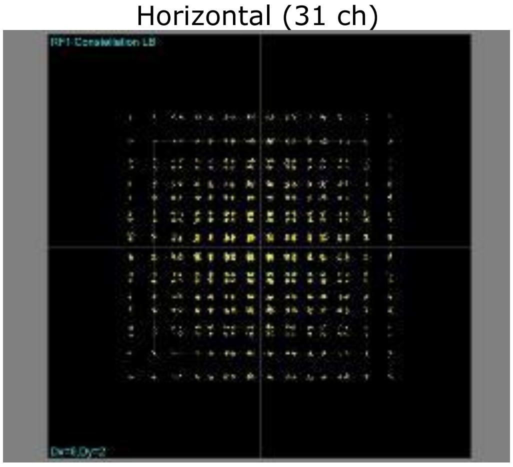
MER = 33.8 dB

(b) Mobile reception layer
Vertical (31 ch)



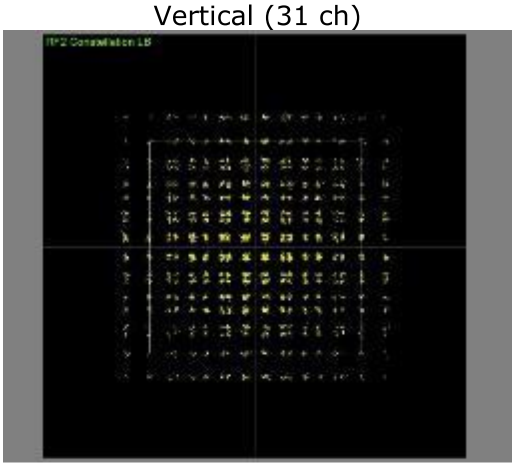
MER = 33.5 dB

(c) Fixed reception layer
Horizontal (31 ch)



MER = 34.3 dB

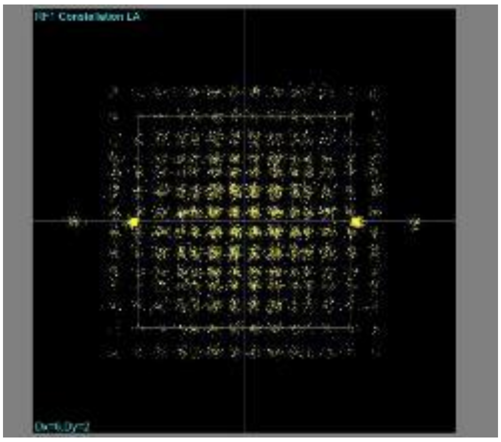
(d) Fixed reception layer
Vertical (31 ch)



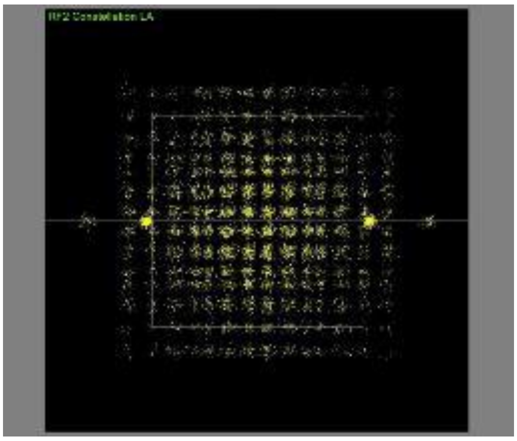
MER = 34.0 dB

(e) Fixed reception layer
Horizontal (34 ch)

(f) Fixed reception layer
Vertical (34 ch)



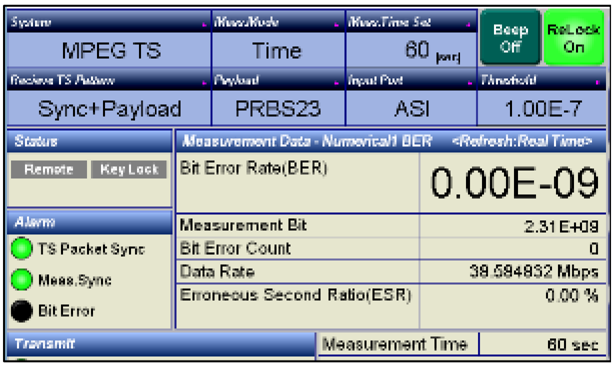
MER = 27.2 dB



MER = 27.0 dB

FIGURE 1.1.18 Constellation of received signals

(a) Fixed reception layer – 31 ch



(b) Fixed reception layer – 34 ch

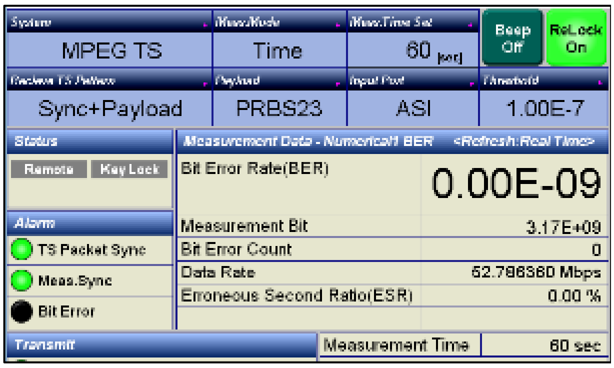


FIGURE 1.1.19 Measurement results of bit error rates

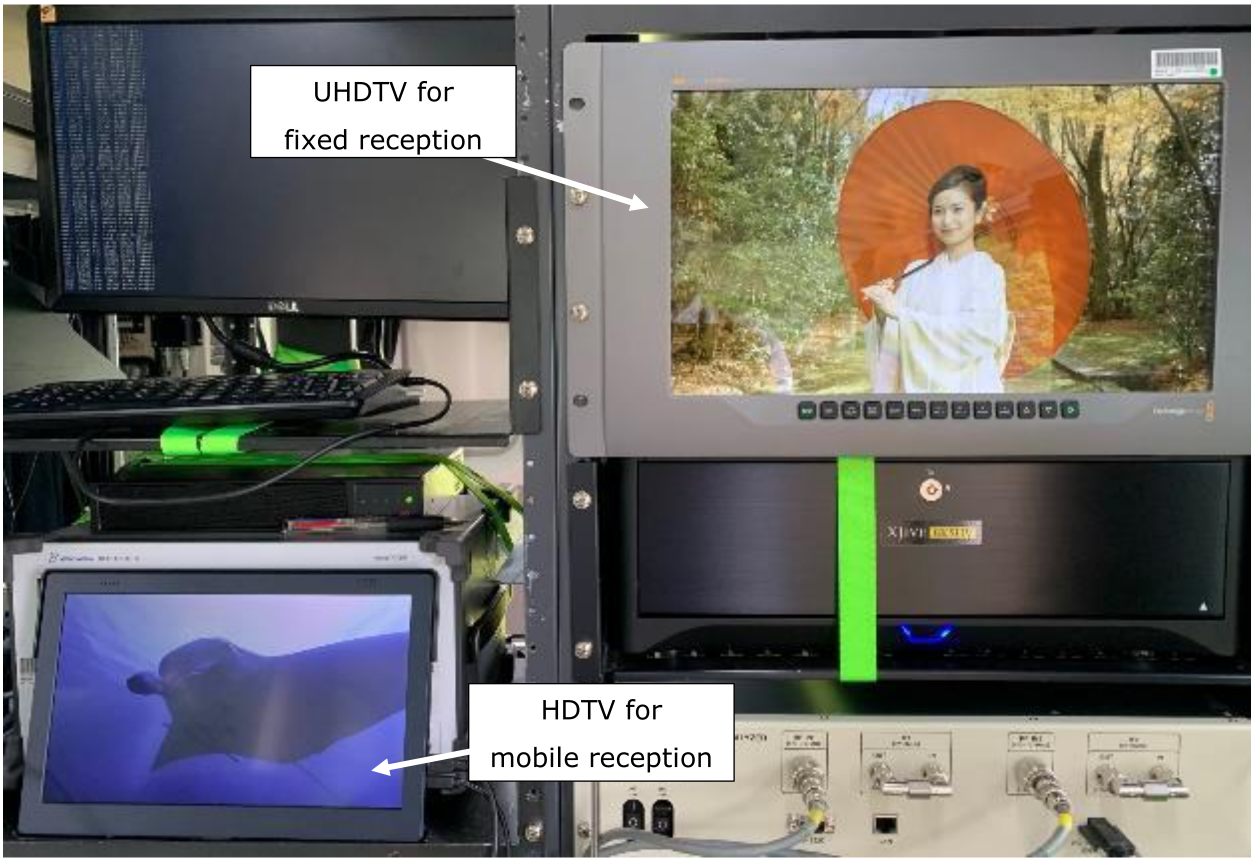


FIGURE 1.1.20 Received video of UHDTV and HDTV

1.1.5. Summary

In the field of broadcasting, UHDTV has the potential to succeed HDTV.

Japan has launched an R&D project aiming at developing an advanced DTTB system and evaluating its performance through field trials in large-scale experimental environments constructed in urban areas.

These field experiments will show the feasibility of terrestrial UHDTV transmission using several key technologies, including dual-polarized MIMO, 4096-QAM carrier modulation, LDPC code, NUC and channel bonding. The UHDTV system to be used in Japan will be selected on the basis of further consideration and examination of various technical possibilities and future trends.

More information such as transmission parameters, experimental results on R&D project phase-1 and phase-2 were described in reference documents [1]-[3] (in § 1.1.2) and the Rep. ITU-R BT.2343-8. (http://www.itu.int/pub/R-REP-BT.2343)

1.2. Development of ATSC 3.0 & 5G-Broadcbast Transmission Techniques in the Republic of Korea

South Korea was at the forefront in adopting ATSC 3.0, introducing its NextGen TV standard in 2016 and launching regular 4K ultra high definition (UHD) broadcasts in May 2017 based on the ATSC 3.0 standard. Currently, ATSC 3.0 services cover over 80% of the population. Beyond UHD, South Korean broadcasters are continuously innovating new services, aligned with the nation's ATSC 3.0 service roadmap.

In line with the South Korean government's policy, KBS expands its broadcast network based on the ATSC 3.0 standard every year. This year, we started regular broadcasting in the Jeonju and Cheongju areas. We are also preparing for regular broadcasting in the Chuncheon and Changwon areas next year. Starting with the UHD 1-channel main broadcast in the Seoul metropolitan area in May 2017, from January 2023, we are now simultaneously transmitting a fixed-reception UHD 1-channel (9-1) and a mobile-reception HD 1-channel (9-2). Furthermore, using the two-way Integrated Broadcast and Broadband (IBB) standard, we have been continuously offering the TIVIVA service since 2019.

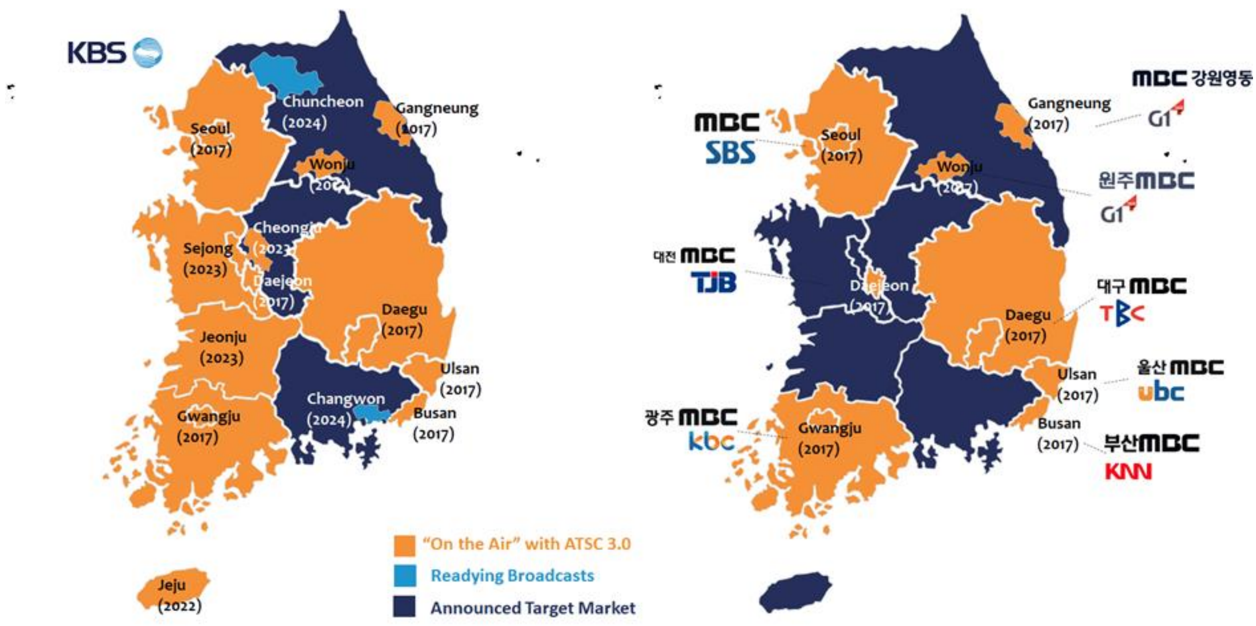


FIGURE 1.2.1 South Korea ATSC 3.0 Regular Broadcasting Service Area (Source) https://www.atsc.org/nextgen-tv/deployments/

1.2.1. Establishment of the National SFN Integrated Monitoring System for Stable SFN Operation

According to the government's policy, there is a plan to fully transition to ATSC 3.0 by 2027. For this transition, ensuring the stability of ATSC 3.0 operation is a pre-requisite. To achieve this, it's essential to establish guidelines for stable SFN broadcast network operation. Still, there's no such ATSC standard in North America. In this context, in December 2021, KBS, MBC, and SBS – leading South Korean broadcast technology teams – reflecting their over 5 years of operational experience, pioneered the establishment of the 'TTAK.KO-07.0154 Terrestrial UHD System Monitoring Guidelines' standard ahead of North America. Based on this, we have independently developed and are operating a system, as shown in Fig. 1.2.2, that can rigorously monitor the status of the national broadcasting network in real-time, with one-second intervals.

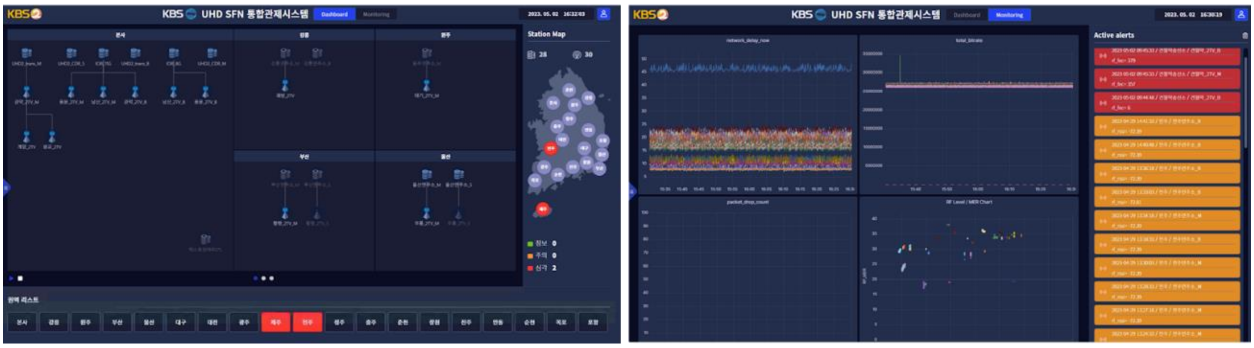


FIGURE 1.2.2 South Korea's TTA Standard-based 'National SFN Integrated Monitoring System' (Left) Network status monitoring dashboard (Right) Real-time key measurement value monitoring dashboard.

The National SFN Integrated Monitoring System, connected to the KBS control line closed network, provides both headquarters and regional operators with identical and prompt views of the nationwide situation. This not only enables immediate observation of the conditions of the organically linked SFN broadcasting network but also offers the advantage of mutually checking situations in other regions. It plays a crucial role in precisely identifying where and what kind of malfunction has occurred and in immediately taking emergency measures to resolve it.

1.2.2. Operation of the country's only Multi-channel Broadcast (MMS) channel that allows mobile viewing

On July 19, 2021, just before the opening ceremony of the Tokyo Summer Olympics, ATSC 3.0 multi-channel test broadcasting was launched. As detailed in Tab. 1.2.1, within the designated television frequency band of 6MHz, the transmission bit rate was adjusted to accommodate channels 9-2 and 9-3, both designed for mobile reception, alongside the already broadcasting UHD 9-1 channel. As of 2023, only channel 9-2, capable of simultaneous broadcasting, remains operational. Efforts are currently being made to introduce experimental multi-channel radio broadcasts at a transmission rate of 96 kbps. This initiative aims to digitize and enhance FM radios, predominantly used within vehicles.

TABLE 1.2.1 KBS Multi-Channel Broadcasting Operational Status

<table>
<tr><th colspan="2" rowspan="2">Channel</th><th rowspan="2">Reception Environment</th><th colspan="6">2021</th><th colspan="12">2022</th><th colspan="6">2023</th></tr>
<tr><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>~</th></tr>
<tr><td rowspan="4">UHF CH52 (701 MHz)</td><td>9-1 UHD</td><td>Fixed</td><td colspan="24">Regular broadcasting</td></tr>
<tr><td>9-2 HD</td><td rowspan="3">Fixed / Mobile</td><td colspan="3">Olympic Dedicated Channel</td><td colspan="15">Disaster Specialized Channel</td><td colspan="6">Simulcast (9-1 DTV)</td></tr>
<tr><td>9-3 Visual Radio</td><td colspan="18">Visual KBS1 Radio
+ KBS Panorama / Missing Child Alerts / Weather Life Information</td><td colspan="6">Discontinued</td></tr>
<tr><td>Datacasting</td><td colspan="24">Advanced Emergency Alerts</td></tr>
</table>

KBS has proactively launched a nationwide mobile channel, in line with the government's policy, which caters to viewers on the move. This initiative spurred domestic manufacturers to explore the development of in-vehicle direct-reception devices. It also facilitated diverse testing in various reception environments across the country, leading to the introduction of globally verified products with robust performance. Consequently, the roadmap for integrating ATSC 3.0 receivers into vehicles is becoming increasingly defined each year. Soon, viewers are expected to enjoy KBS content seamlessly, wherever and whenever they wish.

1.2.3. Center of Terrestrial Broadcasting New Technology Research and Development: KBS Kyunggi Gamaksan (Bukgamak) Experimental Station

In a collaborative effort, KBS and ETRI are spearheading national projects focused on 'Broadcast-Communication Convergence Technology Demonstration' and the development of '8K-UHD Broadcasting Related Technology'. To assess the large-scale impact and outcomes of these national projects, an experimental station has been established and is currently operational on Gyeonggi Gamaksan (Bukgamak), as depicted in Fig. 1.2.3. At present, not only are transmitters that adhere to the ATSC 3.0 standard installed, but also ATSC 3.0 transmitters equipped with dual-polarization MIMO antennas, and the 5G-Broadcast transmitters that meet the 3GPP Rel-16/17 standards. These transmitters marked the inaugural launch of experimental waves in South Korea. This year, there is an agenda to enhance the transmitter to support ATSC 3.0-5G Time-Division Multiplexing (TDM) transmission from a singular source. Additionally, there's a plan to construct a new Channel Bonding ATSC 3.0 transmitter, consolidating UHF CH52+CH56, two broadcasting channels.

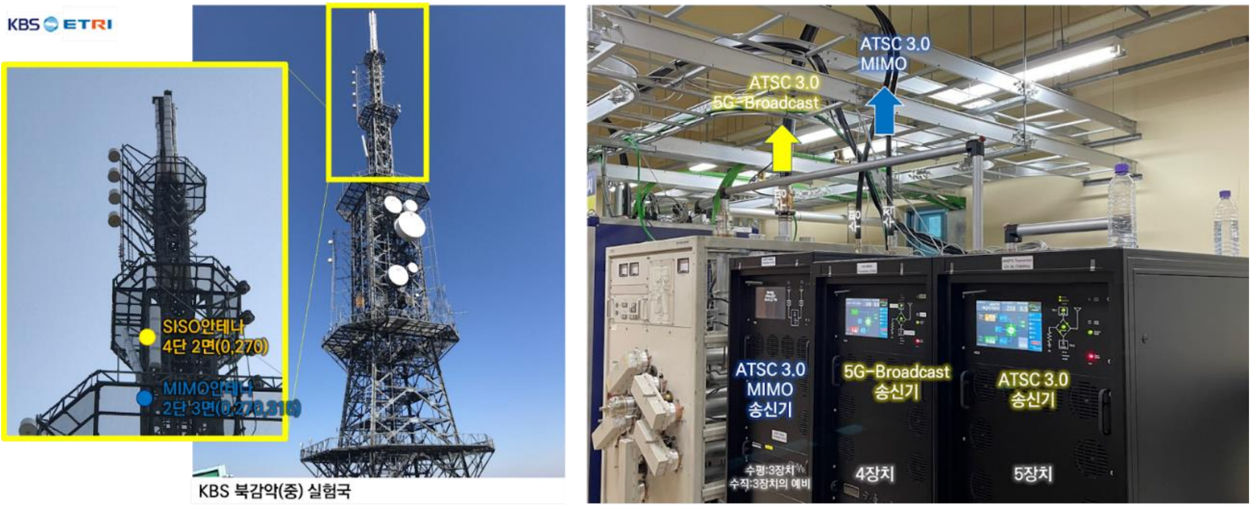


FIGURE 1.2.3 KBS Bukgamak Experimental Station (Left) 4-stacked 2-sided SISO antenna and 2-stacked 3-sided MIMO antenna installed on the transmission tower. (Right) Experimental transmitters installed in the 3rd-floor equipment room of the relay station. These devices have officially obtained South Korea's radio station permits.

TABLE 1.2.2 Status of National Projects Using KBS Gyeonggi Gamaksan Experimental Station (as of October 2023)

Project Name	Research Period	Research Objective & Details
Development of Integrated Transmission Technology for 5G and Broadcasting Network (ATSC 3.0)	April 2019 - December 2023 (45 months)	Aim to develop a technology that enables simultaneous transmission of both a fixed reception channel (adhering to the ATSC 3.0 standard) and a mobile reception channel (in line with the 5G-FeMBMS standard). This will be executed within a UHD broadcasting channel utilizing time-division multiplexing.
Development of Terrestrial 8K Media Broadcast Transmission and Reception Technology	April 2022 - December 2026 (57 months)	Focus on developing a transmission system proficient in supporting both 'channel bonding' and 'multiple antenna' technologies. This will pave the way for the delivery of 8K-UHD media over terrestrial broadcasting networks, achieving a maximum of 200Mbps.
Development of 4-Rx Diversity Mobile Reception ATSC 3.0 Chip	April 2023 - December 2026 (45 months)	Design and introduce a state-of-the-art mobile broadcasting reception chip characterized by its high performance and sensitivity. This chip will be engineered with multiple receiving antennas, all consistent with the ATSC 3.0 standard. Initiate the production and launch of a set-top box, specifically designed for vehicular use, ensuring it meets the benchmarks set by commercial product standards.

1.2.3.1. Development of Integrated Transmission Technology for 5G and Broadcasting Network (ATSC 3.0)

Currently, there's ongoing development for the technology that simultaneously transmits a fixed reception channel (compliant with the ATSC 3.0 standard) and a mobile reception channel (based on the 5G-FeMBMS standard) within a terrestrial UHD broadcasting channel using time-division multiplexing. A recent field test confirmed its successful operation.

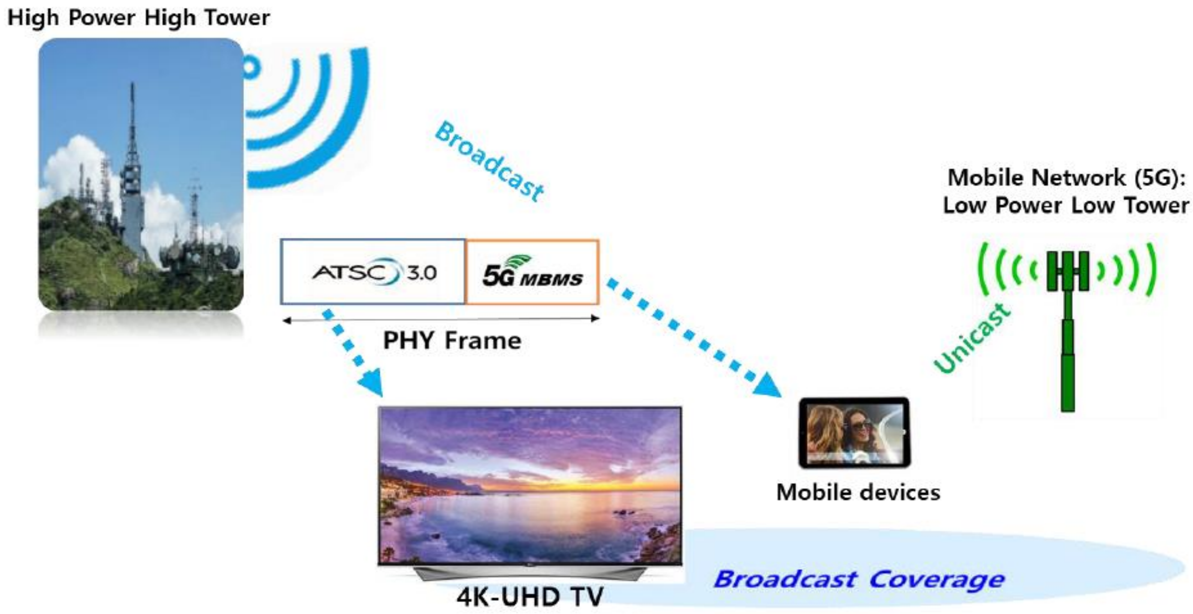


FIGURE 1.2.4 Diagram of the simultaneous transmission based on TDM (Time-Division Multiplexing) for both ATSC 3.0 and 5G Broadcast.

Through the 5G Broadcast based on 3GPP Rel-17, it's anticipated that mobile broadcast services can be provided to 5G devices within the UHD broadcasting channel without needing a separate UHD (ATSC 3.0) reception chip. This will not only expand direct reception but also extend the scope from television receivers to mobile devices, laying the foundation for technology that can be widely applied.

The computer simulation and laboratory performance comparison results between ATSC 3.0 and 5G Broadcast Physical Layer have been published in a paper [A] in IEEE Transactions on Broadcasting.

> [A] Seok-Ki Ahn, Sungjun Ahn, Jeongchang Kim, et. al., "Evaluation of ATSC 3.0 and 3GPP Rel-17 5G Broadcasting Systems for Mobile Handheld Applications," IEEE Transactions on Broadcasting, vol. 69, no. 2, pp. 338 - 356, June 2023.

Starting from July 2023, the field test for the simultaneous transmission of ATSC 3.0 – 5G Broadcast TDM has commenced and is scheduled to continue until the end of this year. In alignment with South Korea's channel bandwidth of 6MHz, four Configuration Modes have been defined to maintain a consistent transmission rate. Quantitative reception performance evaluations have been conducted through field tests for both fixed and mobile reception.

TABLE 1.2.3 Detailed settings of physical layer parameters according to four transmission rates: (Top) ATSC 3.0 (Bottom) 5G-Broadcast

Common Configuration (ATSC 3.0)		
Common parameters	FFT size	8192
	Guard interval	GI6_1536 (222.222 us)
Payload OFDM parameters	Subcarrier spacing	0.844kHz
	Pilot pattern	SP4_2
	# of payload symbols	138
	Time interleaver	CTI with a depth of 1024
	Frequency interleaver	On
Frame length		200 ms
Bandwidth		6MHz

	Configuration 0	Configuration 1	Configuration 2	Configuration 3
Outer code	5/15-LDPC (64800)	5/15-LDPC (64800)	7/15-LDPC (64800)	10/15-LDPC (64800)
Constellation	4-QAM	16-NUC	64-NUC	64-NUC
Data rate	2.73 Mbps	5.47 Mbps	11.53 Mbps	16.51 Mbps

Common Configuration (5G Broadcast)	
FFT size	12288
Guard interval	200us
Pilot pattern	SP3_2
Subcarrier spacing	1.25KHz
MCS table	Table 7.1.7.1-1 (TS 36.213) Max 64-QAM table
Bandwidth	6MHz (30RBs)

	Configuration 0	Configuration 1	Configuration 2	Configuration 3
MCS index	5	11	19	24
TBS	2664	5352	10680	16416
Code rate	0.373	0.373	0.498	0.764
Constellation	4-QAM	16-QAM	64-QAM	64-QAM
Data rate	2.60 Mbps	5.22 Mbps	10.41 Mbps	16.00 Mbps

The measurement vehicle was configured to simultaneously measure the ATSC 3.0 and 5G Broadcast signals at once. For fixed measurements, the antenna mast was raised up to a height of 9m, and for mobile measurements, it was measured at the height of the vehicle's roof (2.6m). Both fixed and mobile measurements used an Omni-Antenna.

[Fixed Reception Results]

Field tests were conducted at four different measurement points located 3.4km, 6.0km, 9.3km, and 11.7km away from the transmission point of the test station. Each location presented unique Multipath characteristics. The results were summarized in Tab. 1.2.4.

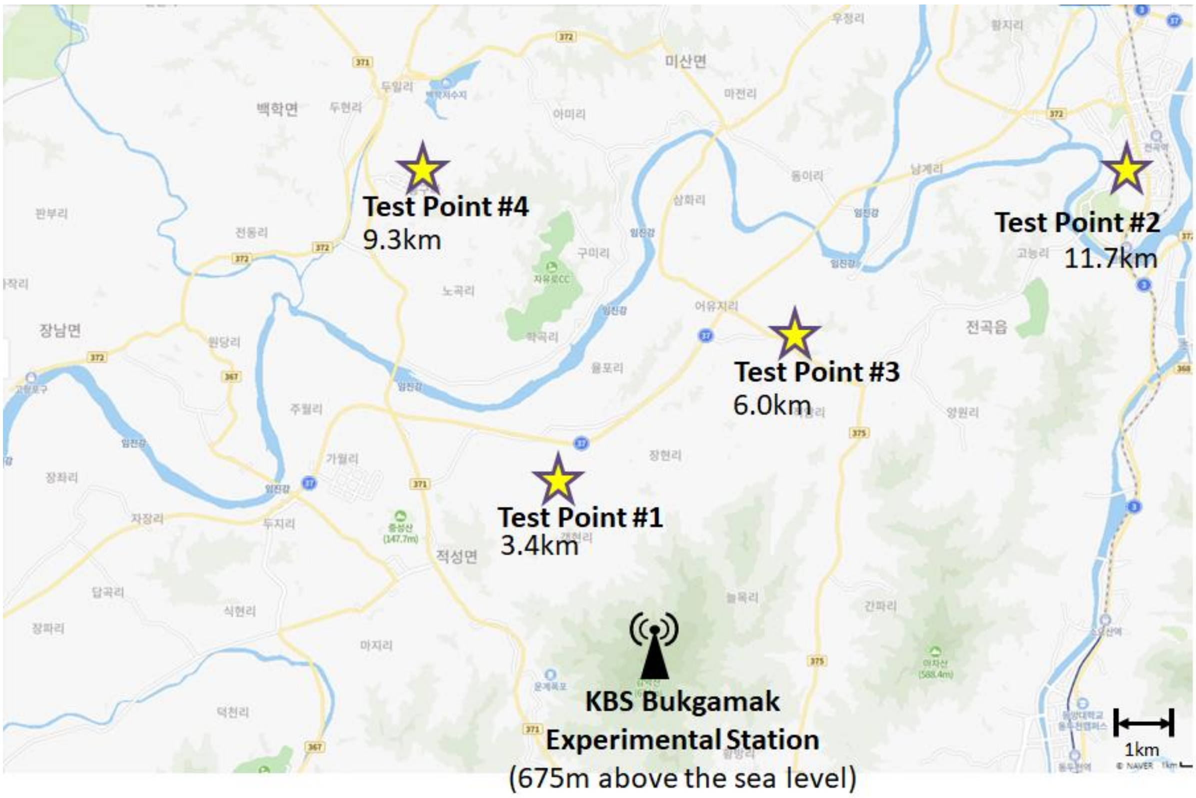


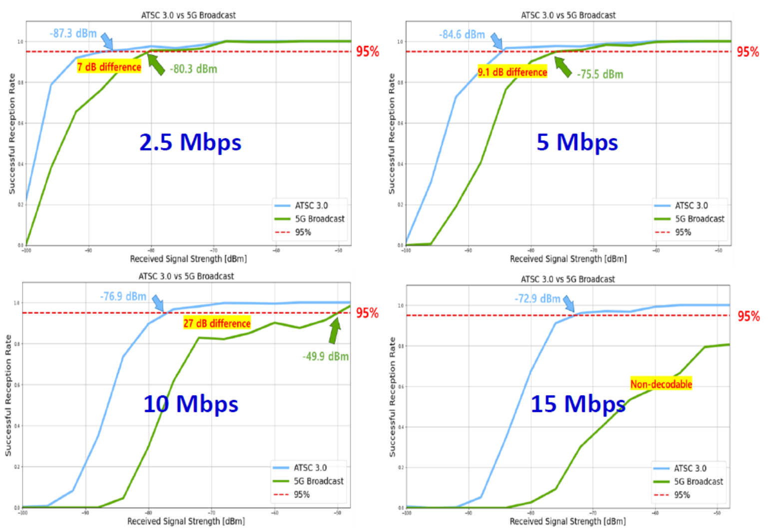
FIGURE 1.2.5 Locations of the 4 measurement points and their distances from the transmission point

TABLE 1.2.4 Comparison of ATSC 3.0 and 5G Broadcast based on ToV C/N criteria.

Config.	Reception Point	ATSC 3.0	5G Broadcast	Difference	Average Diff.
2.5 Mbps	Test Point #1	-0.32	0.31	0.63	0.8
	Test Point #2	0.18	1.33	1.15	
	Test Point #3	-0.11	0.58	0.69	
	Test Point #4	0.42	1.16	0.74	
5 Mbps	Test Point #1	3.51	4.67	1.16	1.05
	Test Point #2	4.71	5.70	0.99	
	Test Point #3	4.58	5.05	0.47	
	Test Point #4	5.05	6.62	1.57	
10 Mbps	Test Point #1	9.75	11.39	1.64	1.85 (Test point #4 excluded)
	Test Point #2	11.71	14.15	2.44	
	Test Point #3	11.93	13.41	1.48	
	Test Point #4	12.18	Non-decodable	∞	
15 Mbps	Test Point #1	14.57	18.59	4.02	3.67 (Test point #2 and #4 excluded)
	Test Point #2	15.63	Non-decodable	∞	
	Test Point #3	16.96	20.27	3.31	
	Test Point #4	Non-decodable	Non-decodable	N/A	

[Mobile Reception Results]

Within the coverage of the experimental station, mobility measurements were carried out on the same path, only varying the Configuration Mode. The mobility path had an RSSI ranging from a minimum of -99dBm to a maximum of -42dBm, with an average of about -72dBm. The measurements were carried out at an average speed of about 40km/h.



Config.	ATSC 3.0	5G Broadcast	Difference
2.5 Mbps	-87.3 dBm	-80.3 dBm	7.0 dB
5 Mbps	-84.6 dBm	-75.5 dBm	9.1 dB
10 Mbps	-76.9 dBm	-49.9 dBm	27 dB
15 Mbps	-72.9 dBm	Non-decodable	∞

[Mobile reception performance comparison results]

FIGURE 1.2.6 (Left) Successful Reception Rate Curve for ESR5 calculation (Right) Comparison of ATSC 3.0 and 5G Broadcast reception performance at the 95% location.

1.2.3.2. Development of Terrestrial 8K Media Broadcast Transmission and Reception Technology

Last year and this year, an ATSC 3.0 MIMO transmitter capable of emitting through a dual-polarization (horizontal/vertical) antenna was developed for a single transmitter. After installing it at the experimental station, field tests confirmed its ability to transmit across 4 UHD channels.

FIGURE 1.2.7 In the measurement vehicle, 4 UHD channels were successfully received at a rate of 15Mbps each, totaling 60 Mbps, using the prototype ATSC 3.0 MIMO transmitter and receiver.

By the end of 2023, an ATSC 3.0 Channel Bonding transmitter, which can double the transmission rate by bundling two terrestrial broadcast channels while still using the existing horizontal polarization transmission antenna, is planned to be fully installed. As soon as the renewal permission for the experimental station is granted, field tests for the ATSC 3.0 Channel Bonding will commence.

Ultimately, the goal is to install a transmitter that can improve the total transmission rate by four times: doubling with channel bonding technology, doubling with dual-polarization MIMO technology, and simultaneously utilizing both techniques. Verification tests will be carried out through field tests at the KBS Bukgamak experimental station.

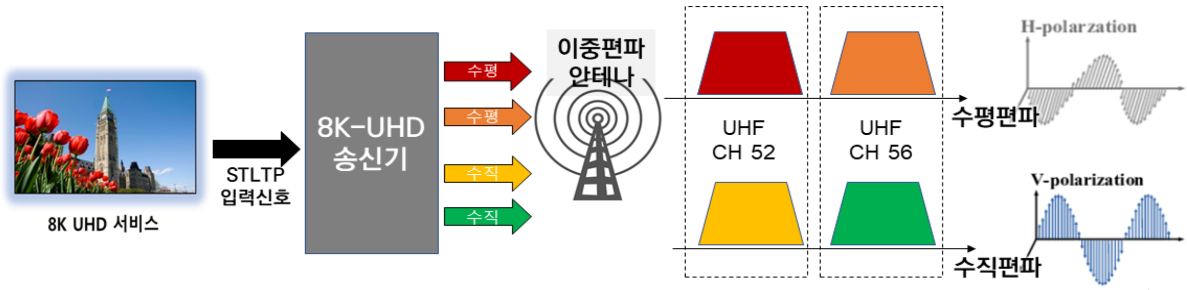


FIGURE 1.2.8 Diagram of the development plan for an 8K-UHD transmitter that utilizes both ATSC 3.0 Channel Bonding and MIMO technologies simultaneously.

1.2.3.3. Development of ATSC 3.0 Mobile Broadcasting Reception Chip

The goal is to develop a reception chip optimized for in-car mobile broadcasting, supporting 4-Rx Diversity Reception. This will significantly enhance the performance of the existing single-antenna-based TV ATSC 3.0 mobile broadcast reception chip.
Once this reception chipset is developed, it's expected to facilitate the integration of the ATSC 3.0 receiver in vehicles, as vehicle receiver manufacturers can be provided with high-performance chipsets at reasonable prices.

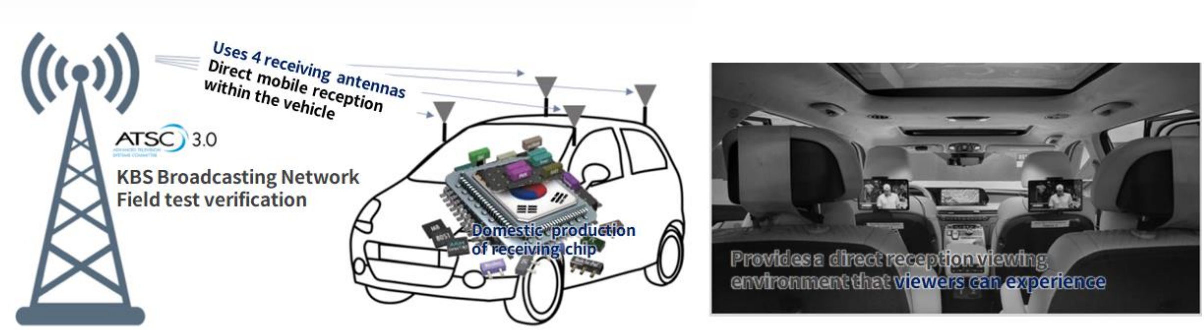


FIGURE 1.2.9 Diagram of the ATSC 3.0 vehicular reception chip supporting 4-Rx Diversity functionality.

1.2.4. KOBA Show 2023 Exhibition and Busan Global DTT Workshop

The achievements of the research and development were showcased at the KOBA SHOW 2023 held in Seoul COEX in June 2023, promoting to the public.

FIGURE 1.2.10 Displayed at the KBS booth during the KOBA Show

Displayed at the KBS booth during the KOBA Show were exhibits that highlighted ATSC 3.0 multi-channel, mobile, bidirectional, and radio demonstrations (Fig. 1.2.10). One of the significant features was the UHD 4-channel simultaneous transmission leveraging ATSC 3.0 MIMO technology, alongside the 5G Broadcast transmission and reception rooted in 3GPP Rel-17.

Additionally, global broadcasting technology experts from around the world were invited to Busan for the Global DTT Workshop. Insights and outcomes were disseminated through hands-on demonstrations and presentations of relevant content. Details of the event schedule and presentation materials can be accessed through the links provided:

- Workshop agenda: https://sites.google.com/view/globaldtt/schedule
- Presentation materials: https://drive.google.com/drive/folders/1Mn2Emy394ONWKH7oty4lNqiMprDvd3nK?usp=shari

<table>
<tr><th>Time</th><th>ATSC 3.0 Now
(19th July)</th><th>ATSC 3.0 Moving Forward
(20th July)</th><th colspan="2">Global DTT Trends
(21st July)</th></tr>
<tr><td>08:30 ~ 09:00</td><td rowspan="2">Registration & Technical Demos</td><td>Technical Demos</td><td colspan="2">Technical Demos</td></tr>
<tr><td>09:00 ~ 11:30</td><td>Session 3: New Developments</td><td colspan="2">Session 6: Global DTT Status</td></tr>
<tr><td>11:30 ~ 12:40</td><td>Sponsored Meal & Demos</td><td>Sponsored Meal & Demos</td><td colspan="2">Sponsored Meal</td></tr>
<tr><td rowspan="4">12:40 ~ 18:00</td><td>Opening Address & MOU</td><td rowspan="2">Session 4: New Diverse & Business Cases (1)</td><td rowspan="4">Social Networking</td><td rowspan="4">BK21: CLMC Performance Sharing Event</td></tr>
<tr><td>Session 1: ATSC 3.0 History from Inception to D2M & D2V</td></tr>
<tr><td>Coffee Break & Demos</td><td>Coffee Break & Demos</td></tr>
<tr><td>Session 2: Current & Future</td><td>Session 5: New Diverse & Business Cases (2)</td></tr>
<tr><td>19:00 ~ 21:00</td><td>Welcome Reception</td><td>Banquet</td><td colspan="2"></td></tr>
</table>

FIGURE 1.2.11 Program booklet of the Global DTT Workshop, group photo of all attendees, and an outline of the workshop schedule.

Annex 2

Project: Integrated Broadcast-Broadband and OTT (D/IBBOTT)

Project Manager: **Dr. Go OHTAKE** (NHK, Japan)

Co-project Manager: **Mr. A. K. Mangalgi** (DDI, India)

Mr. R.P. Joshi

Ms. Momoko Suyama (NHK, Japan)

Dr. Shinya Abe (NHK, Japan)

Mrs. Zhang Dingjing (ABS, China)

Zhang Yu (ABS, China)

Zhang Wei (ABS, China)

He Jing (ABS, China)

Wang Lei (ABS, China)

2. Status report

This clause describes recent updates on IBB and OTT standards and related technologies identified and studied by this project. And it describes also recent update on standards and technologies of information security for broadcasting services and cyber security in broadcasting industry for protecting the broadcasting systems.

2.1 Standardization of Integrated Broadcast-Broadband System in Japan

IPTV Forum Japan standardizes specifications of Hybridcast in Japan. Technical specification of Hybridcast is composed of two technical standards and an operational guideline listed below and the latest versions are published in January 2022.

- IPTVFJ STD-0010 'Integrated Broadcast-Broadband System Specification', version 2.4
- IPTVFJ STD-0011 'HTML5 Browser Specification', version 2.7
- IPTVFJ STD-0013 'Hybridcast Operational Guideline', version 2.10

In the revision in November 2020 several new features were added to the Hybridcast technical specifications. Major updates are as follows:

- Addition of the new application type named "Broadcast-independent managed application"
  An application of this type runs in the state that no broadcast channel is being tuned so that service providers can offer application services regardless of their broadcasting area.
- Enhancement to the streaming video playback function
  The CMAF[*1] is added as a supported container format of streaming video, including low-latency playback features. Support for stream event delivery mechanisms such as an 'event message' (emsg) box and an 'Event' XML element of MPEG DASH[*2] are also added.

- Enhancement to the companion device function
  UHDTV broadcasting services, i.e. 4K and 8K satellite broadcasting in Japan, are added to the available channels for tuning from a companion device.
- Addition of the three-dimensional audio codec support
  The enhanced AC-3[*3] is added to the available audio codecs for video streaming.

*1 ISO/IEC 23000-19 "Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media".
*2 ISO/IEC 23009-1 "Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats".
*3 ETSI TS 102 366 "Digital Audio Compression (AC-3, Enhanced AC-3) Standard".

<u>In the revision in January 2022, several features related to terminated VOD services were deleted from the Hybridcast technical specifications.</u>

2.2 Studies in ITU-R

ITU-R WP6B is working for the study on IBB systems. The working party is now studying on harmonization of IBB systems by making comparison of Hybridcast (Japan), HbbTV2.0 (Europe), TOPSmedia (South Korea) and Ginga (Brazil).
At the meeting held in April 2019 in Geneva, the working party developed the comparison of application life-cycle and application transition of the IBB systems, and revised Report ITU-R BT.2267 "Integrated broadcast-broadband systems" to add a new part on the harmonization of Integrated Broadcast-Broadband (IBB) systems' applications. To allow the exchange of services covered by the IBB systems and to deploy these services in an area where other systems are used, it is important to harmonize the IBB systems, to ensure compatibility with the IBB applications and interoperability across systems.
At the meeting, the working party revised Report ITU-R BT.2342 to replace information on TTML Text and Image Profiles for Internet Media Subtitles and Captions 1.0 (IMSC1.0) with the updated IMSC1.1 and to update a list of current EBU specifications pertinent to the content of the Report.

At the meeting held in July 2019 in Geneva, the working party revised Report BT.2267 to add the companion application to execute the application on a receiver. The working party also developed the new use cases of IBB system which provides object-based sound services via MPEG-DASH streams.
The working party also developed the global platform. The working party revised Report ITU-R BT.2400 "Usage scenarios, requirements and technical elements of a global platform for the broadcasting service" to add the specific reference to the ATSC 3.0 standard and some examples to show its Internet Protocol-based capabilities to integrate broadcast and broadband services. New digital terrestrial transmission standards such as

the ATSC 3.0 system can help effectuate a converged broadcast and broadband platform, which is an important aspect of a global platform for broadcasting services.

At the meeting held in October 2020, the working party revised Recommendation ITU-R BT.2075 "Integrated broadcast-broadband system" to update an application execution mechanism of Hybridcast, with which a companion device sends a command to a receiver to tune to a designated channel and launch a Hybridcast application.

At the meeting held in March 2021, the working party prepared a revised draft report of Recommendation BT.2075 by adding information regarding commonality among IBB systems and equivalency of their functions as described in Report BT.2267 Part 3. The working party also prepared a draft revision to report BT.2267 on IBB systems to align with Recommendation ITU-T J.208 on harmonization of applications between IBB systems.

At the meeting held in September 2022, the working party revised Recommendation ITU-R BT.2075 "Integrated broadcast-broadband system" and Report BT.2267 "Integrated broadcast-broadband systems" to add a Broadcast-independent managed application, that is an application launched when broadcast services are not selected but still authenticated by broadcasters.

2.3 Studies in ITU-T

ITU-T SG9 is also working for the study on IBB system applied to Cable Digital TV. At the meeting held in November 2018 in Bogota, Colombia, the Study Group started the work to revise IBB system Recommendation (ITU-T Recommendation J.207 "Specification for integrated broadcast and broadband digital television application control framework") to add the function of device collaboration with companion devices in Hybridcast. Recommendation J.207 is a twin of IBB system Recommendations in ITU; Recommendation ITU-R BT.2075 is another twin on this topic. So, the Study Group continue to work to revise the Recommendation according to revision of Recommendation ITU-R BT.2075. The Study Group is studying the work of smart TV operating system for hybrid cable Digital TV services including IBB DTV service provided by cable television operators and third-party providers. At the Bogota meeting, the study group make progress the work of the architecture of smart TV operating system. The study group consent the Recommendation of "The functional requirements of smart TV operating system" as ITU-T Recommendation J.1201.

At the meeting held in June 2019 in Geneve, the study group consent Recommendation J.207 to add the function of device collaboration in Hybridcast. The study group also make progress the work of drafting new Recommendation "Harmonization of Integrated Broadcast-Broadband DTV application control framework". As for the smart TV operating system, the study group consent the Recommendation of "The architecture of smart TV operating system" as ITU-T Recommendation J.1202. In addition, making a new Recommendation for the specification of smart TV operating system was started in the study group.

At the meeting held in July 2020, the study group reached the AAP consent for the draft new Recommendation ITU-T J.1204. It is now approved and is part of a set of already approved Recommendations as follows:

- J.1201: Functional requirements of a smart TV operating system
- J.1202: The architecture of a smart TV operating system
- J.1203: The specification of a smart TV operating system
- J.1204: The security framework of a smart TV operating system

The group also consent new Recommendation ITU-T J.208 "Harmonization of Integrated Broadcast-Broadband DTV application control framework" at its November 2020 meeting. The recommendation is created based on Report ITU-R BT.2067 which defines the methods to harmonize IBB systems by identifying commonalities across the IBB systems.

2.4 Cyber Security in Ireland

On February 2023, Virgin Media television, one of Ireland's most popular TV broadcasts, has suffered what it has deemed an "unauthorised attempt" to access its systems, taking down several of its TV channels in Ireland. The company has 3.4 million customers, including more than a million in Ireland. The attack affected numerous services. These include recorded programming on Virgin Media Three, Four, More and VMTV. Virgin Media said that "Our ongoing security monitoring system has identified an unauthorised attempt to access our systems in recent days. Due to the precautions, we have implemented there will be temporary effects to the broadcasting of some of our recorded programming on Virgin Media Three, Four, More and VMTV Player." Virgin Media later confirmed that the breach had been, "fully contained, isolated terminated". After that, Virgin Media has said that a cyber attack that affected programming on some of its channels was not a ransomware attack.

Source:
https://techmonitor.ai/technology/cybersecurity/virgin-media-television-suffers-major-hack
https://www.businesspost.ie/news/virgin-media-television-says-major-hack-was-not-ransomware/
https://www.siliconrepublic.com/enterprise/virgin-media-television-tv-hack-cyberattack-breach
https://www.rte.ie/news/2023/0220/1357832-virgin-media-hack/

Annex 3

Project: Satellite Broadcasting (T/SB)

Project Manager: **Mr. Masashi KAMEI** (NHK, Japan)
Co-project Manager: **TBD**

3.0 Objectives

This clause describes technologies on the latest satellite systems for UHDTV broadcasting and specifications of the latest satellite broadcasting systems. And it describes also the latest topics on advanced satellite broadcasting technologies using Ka-band, etc.

3.1 ITU-R Documents Related to Satellite Broadcasting Systems

3.1.1 Radio Regulations

ARTICLE 23 Section 2 "Broadcasting-satellite services"

APPENDIX 30 "Provisions for all services and associated Plans and List for the broadcasting-satellite service in the frequency bands 11.7-12.2 GHz (in Region 3), 11.7-12.5GHz (in Region 1) and 12.2-12.7 GHz (in Region 2)

APPENDIX 30A "Provisions and associated Plans and List for feeder links for the broadcasting-satellite service (11.7-12.5GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz in Region 3) in the frequency bands 14.5-14.8 GHz and 17.3-18.1 GHz in Regions 1 and 3, and 17.3-17.8 GHz in Region 2

RESOLUTION 506 "Use by space stations in the broadcasting-satellite service operating in the 12 GHz frequency bands allocated to the broadcasting-satellite service of the geostationary-satellite orbit and no other"

RESOLUTION 507 "Establishment of agreements and associated plans for the broadcasting-satellite service"

RESOLUTION 528 "Introduction of the broadcasting-satellite service (sound) systems and complementary terrestrial broadcasting in the frequency bands allocated to these services within the range 1-3 GHz."

RESOLUTION 536 "Operation of broadcasting satellites serving other countries."

RESOLUTION 548 "Application of the grouping concept in Appendices 30 and 30A in Regions 1 and 3"

RESOLUTION 552 "Long-term access to and development in the frequency band 21.4-22 GHz in Regions 1 and 3"

RESOLUTION 553 "Additional regulatory measures for broadcasting-satellite networks in the frequency band and 21.4-22 GHz in Regions 1 and 3 for the enhancement of equitable access to this frequency band"

RESOLUTION 554 "Application of pfd masks to coordination under No. 9.7 for broadcasting-satellite service networks in the band 21.4-22 GHz in Regions 1 and 3”

RESOLUTION 555 “Additional regulatory provisions for broadcasting-satellite service networks in the frequency band 21.4-22 GHz in Regions 1 and 3 for the enhancement of equitable access to this frequency band”

RESOLUTION 557 “Consideration of possible revision of Annex 7 to Appendix 30 of the Radio Regulations”

3.1.2 Recommendations (https://www.itu.int/rec/R-REC-BO/en)

BO.1213 “Reference receiving Earth station antenna pattern for the broadcasting-satellite service in the 11.7-12.75 GHz band”

BO.1408 “Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel”

BO.1443“Reference BSS earth station antenna patterns for use in interference assessment involving non-GSO satellites in frequency bands covered by RR Appendix 30”

BO.1516 “Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range”

BO.1659 “Mitigation techniques for rain attenuation for broadcasting-satellite service systems in frequency bands between 17.3 GHz and 42.5 GHz”

BO.1696 “Methodologies for determining the availability performance for digital multi-programme BSS systems, and their associated feeder links operating in the planned bands”

BO.1724 “Interactive satellite broadcasting systems (television, sound and data)”

BO.1774 “Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief”

BO.1784 “Digital satellite broadcasting system with flexible configuration (television, sound and data)”

BO.1900 “Reference receive earth station antenna pattern for the broadcasting-satellite service in the band 21.4-22 GHz in Regions 1 and 3”

BO.2063 “Alternative BSS earth station antenna radiation pattern for 12 GHz BSS bands with effective apertures in the range 55-75 cm”

BO.2098 “Transmission system for UHDTV satellite broadcasting”

3.1.2 Reports (https://www.itu.int/pub/R-REP-BO/en)

BO.2007 “Considerations for the introduction of broadcasting-satellite service of high-definition television and ultra-high-definition television systems in the band 21.4-22 GHz”

BO.2071 “Broadcasting-satellite service system parameters between 17.3 GHz and 42.5 GHz and associated feeder links”

BO.2101 “Digital satellite broadcasting system (television, sound and data) with flexible configuration"

BO.2102 "Multiple-feed BSS receiving antennas"

BO.2397 "Satellite transmission for UHDTV satellite broadcasting"

BO.2497 "Characteristics and effectiveness of frequency sharing criteria for the broadcasting-satellite service in Regions 1 and 3 subject to RR Appendix 30"

3.2 Latest Topics on Satellite Broadcasting

3.2.1 Development of Large-capacity Content Transmission Equipment for Flexible Provision of Immersive Services cooperated with 21- and 12-GHz-band Satellite Broadcasting Channels and IP Network

To offer viewers the opportunity to enjoy immersive content –that is, to make viewers feel as though they are transported to other worlds– NHK STRL is conducting R&D on three-dimensional and omnidirectional image presentations, technologies for reproducing sound fields tied to images, and content delivery techniques capable of providing tactile sensations of three-dimensional shapes and textures.

One example of a transmission technology to provide immersive content with large capacity and high flexibility, NHK STRL developed a transmission equipment that can bundle satellite broadcasting channels in 21- and 12-GHz bands and IP network.

The 21-GHz-band satellite broadcasting allocated to the frequency band of 21.4–22.0 GHz in ITU-R Regions 1 and 3 is expected to be utilized as transmission channels for new broadcasting services with large capacity. Therefore, we assumed two 300-MHz-class wideband transponders in the 21-GHz band and developed a wideband modem with the nominal symbol rate of 250 Mbaud. The 12-GHz-band satellite broadcasting allocated to the frequency band of 11.7–12.2 GHz in ITU-R Regions 1 and 3 is widely utilized for HDTV and UHDTV services. In Japan, UHDTV (4K and 8K) services have been provided since Dec. 2018 by the "ISDB-S3" transmission system with the symbol rate of 33.7561 Mbaud.

The large-capacity content transmission equipment enables us to bundle one wideband modem for a 21-GHz-band satellite broadcasting channel and two ISDB-S3 modems for 12-GHz-band satellite broadcasting channels and an IP network to provide large-capacity content beyond the transmission capacity in each channel or network. It also enables us to allocate the channels and network in accordance with objects that are distinguished from the information in IP packets such as the destination IP address, the UDP port numbers, or the payloads.

A laboratory experiment was conducted to evaluate the functionality of this equipment using free-viewpoint AR content. Figure 3-1 shows the laboratory experimental system. The AR content consists of high and standard resolution images and the sounds of six players and their instruments. Here, the objects are assigned by each of their associated images or sounds. In this experiment, the AR content was classified into three layers: a base content layer comprising the standard resolution images (Object ID = 9 to 15) of four players and their instruments in the center and the sounds (Object ID = 17 to 23) of all players and instruments; an enhancement content layer #1 comprising the standard resolution images (Object ID = 7,8 and 16) of the remaining two players and their instruments; and an enhancement content layer #2 comprising all high resolution images (Object ID = 1 to 6). The base content layer was about 85 Mbps and was transmitted by the ISDB-S3 modem. The enhancement content layer #1 was about 45 Mbps and was transmitted by the network simulator. The enhancement content layer #2 was about 270 Mbps and was transmitted by the wideband modem. On the receiver side, AR content with the total bitrate of about 400 Mbps was reproduced and was transmitted to a tablet via a Wi-Fi router.

In the experiment, when the connection from the wideband demodulator and the network emulator to the large-capacity content receiver was terminated, the four players and their instruments in the center and all sounds were maintained as the base content layer, while the other two players and their instruments disappeared. These results demonstrate that the large-capacity content transmission equipment can operate successfully and is able to provide a flexible content production and representation of immersive content appropriate for various viewer environments.

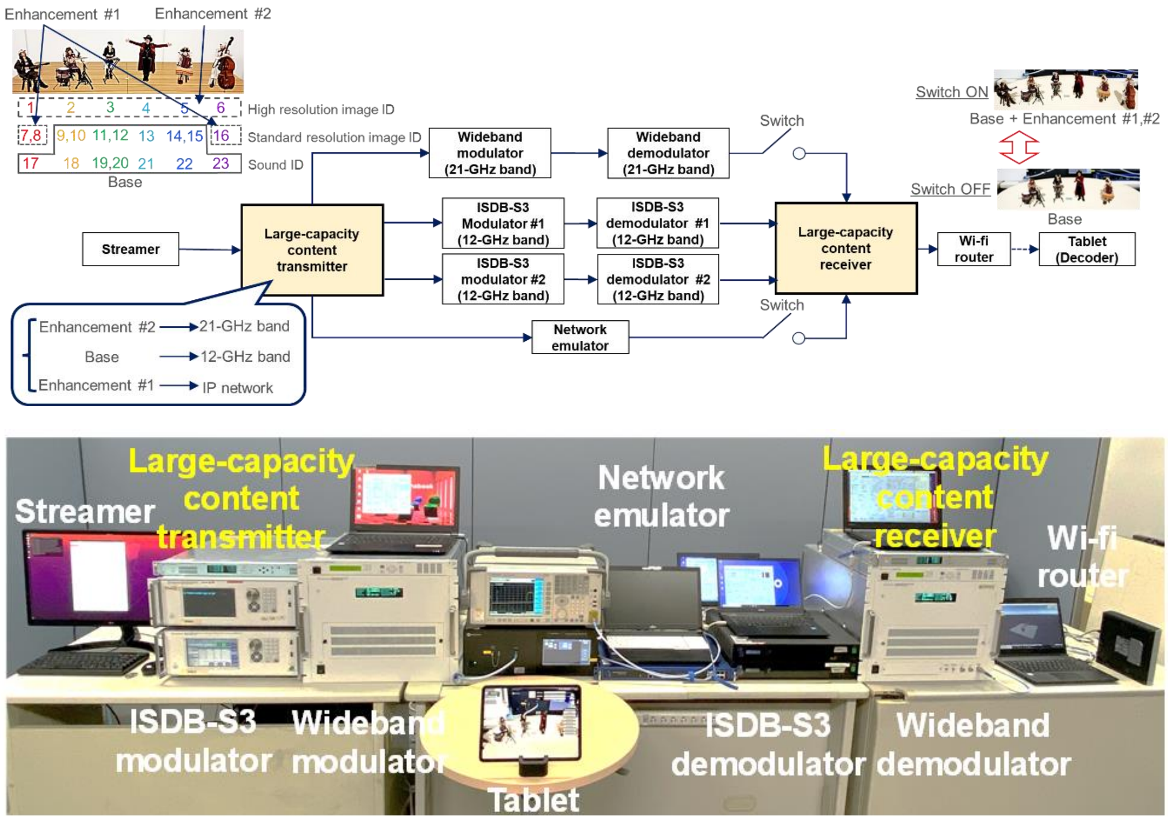


Figure 3-1 Laboratory experimental system of
large-capacity content transmitter equipment with AR content.