



## READY FOR 8K UHDTV BROADCASTING IN JAPAN

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### ABSTRACT

NHK will present highly realistic broadcasts of the 2020 Olympic Games in Tokyo via 8K Super Hi-Vision, the world's most sophisticated broadcasting system. Here, we describe our preparations for 8K broadcasting, particularly for the test broadcasting via satellite due to start in 2016.

In particular, we describe our activities related to standardization and development of program production equipment, play-out, and a distribution system for the 8K broadcasting.

Regarding the production and distribution systems, we present the results of experimental satellite broadcasting performed this year. We also discuss the current status of the high dynamic range (HDR) function for the 8K system, the multi-format production workflow, and remaining issues.

### INTRODUCTION

8K Super Hi-Vision (UHDTV) is a broadcasting medium featuring 16 times the number of pixels as Hi-Vision (HDTV) and 22.2 multichannel sound to provide a highly realistic “you are there” sensation. Since 1995, NHK has been researching and developing UHDTV as a next-generation broadcasting system to succeed HDTV and has been active in specification studies, equipment/device development, and technology standardization. In 2012, NHK's specifications for the UHDTV video signal was approved as an international standard by the International Telecommunication Union (ITU) <sup>1)</sup> and 8K public viewings of the London Olympic Games were successfully held in Japan, the United Kingdom, and the United States.

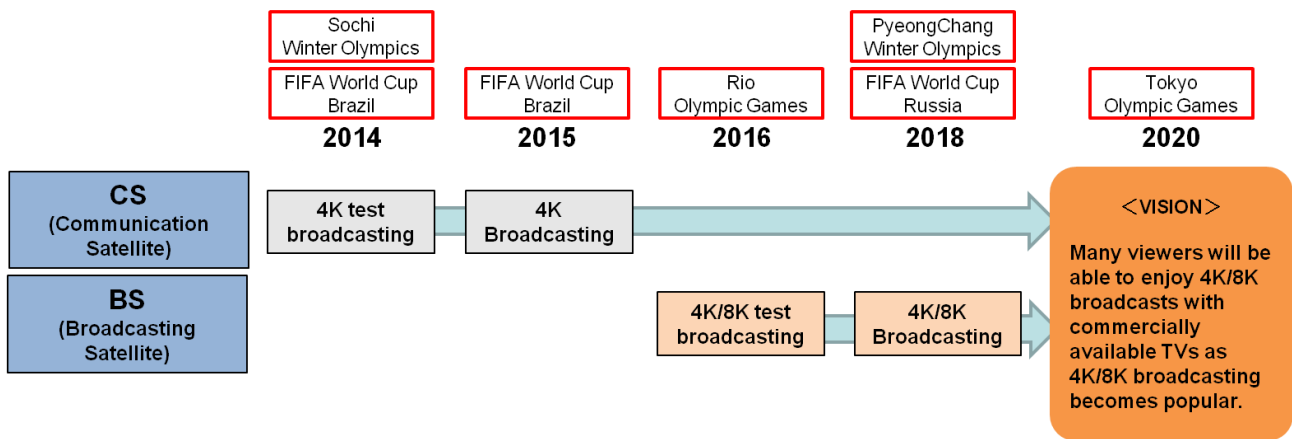
Now UHDTV has made a transition from the research and development stage to the implementation and promotion stage. The formulation of a roadmap toward early adoption of UHDTV (4K/8K) broadcasting has been progressing since 2012, with the Ministry of Internal Affairs and Communications (MIC) being the center of this effort. In September 2014, an interim report announced the goal of “beginning 4K/8K test broadcasting using Broadcasting Satellites (BS) in 2016 and launching 4K/8K commercial broadcasts by BS and other means by 2018 or earlier if possible.” <sup>2)</sup> In parallel with these activities, the Next Generation Television & Broadcasting Promotion Forum (NexTV-F) <sup>3)</sup> was established, with participants including broadcasters, manufacturers of receiving equipment, and telecom companies, as an “All Japan” promotional body for UHDTV.

NHK aims to commence test broadcasting in 2016, and to this end, it is developing and preparing UHDTV facilities and equipment covering a range of functions from content

production to play-out, transmission, and reception. This paper describes the present state of development activities and preparations for the test broadcasting.

### Roadmap for UHDTV Broadcasting

The roadmap for 4K/8K broadcasting that appeared in “The Interim Report of the Follow-up Meeting on 4K and 8K Roadmap” of August 2014 is shown in **Figure 1**.<sup>4)</sup> In addition to test broadcasting in 2016 and commercial broadcasting in 2018, this roadmap sets out the goals of 4K/8K broadcasting of the 2020 Tokyo Olympics and Paralympics and provision of 4K/8K programs that can be enjoyed by many viewers with commercially available TVs. NHK is making preparations in line with this roadmap.



※ Based on an interim report from the study group for 4K8K broadcasting at the Ministry of Internal Affairs and Communication (MIC)

Figure 1 – 4K and 8K Roadmap

### 8K UHDTV Broadcasting System

**Figure 2** shows the entire 8K UHDTV broadcasting system. To enable the broadcasting of live and recorded programs by 2016, NHK is preparing outside production facilities as well as editing facilities and play-out/transmitting facilities. It is also developing prototype receivers to enable viewing of test broadcasts. Testing of the technology in the field-transmission and studio facilities has already begun. The plan is to prepare these facilities in so that they will eventually be capable of broadcasting.

An overview of facility preparations up to 2020 is shown in **Figure 3**. There are two major phases. The first phase, which runs up to 2016, covers development of outside production facilities such as cameras and outside broadcasting (OB) vans needed for content production. It also covers editing rooms, audio dubbing studios, play-out/transmitting facilities, and receiving equipment and an

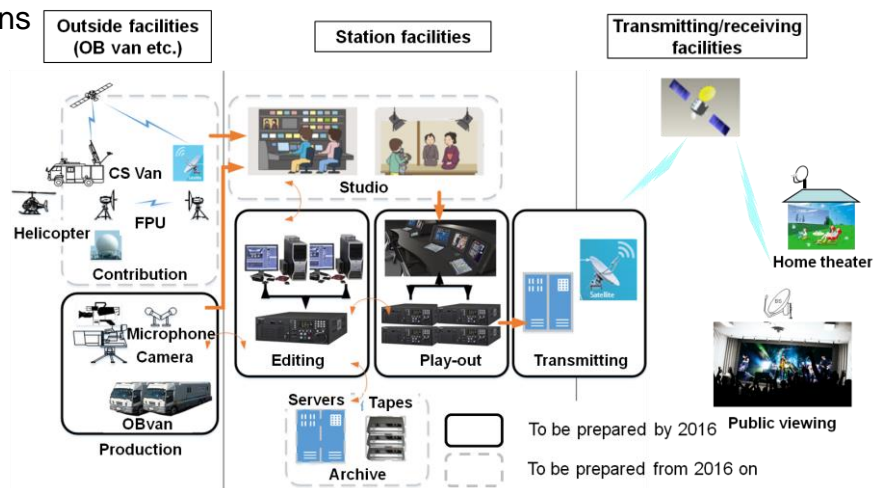


Figure 2 – UHDTV broadcasting equipment

effort to downsize 8K equipment to make it less bulky.

The second phase, from 2016 on, will expand and enhance facilities and improve the system performance and reliability toward broadcasting in 2018 and the Tokyo Olympics and Paralympics in 2020. It also covers improvements to equipment needed for supporting a wide colour gamut (ITU-R BT.2020)<sup>5)</sup>, high dynamic range (HDR), high frame rate (HFR), etc. The goal for the facility preparations is to lower the cost of equipment by making use of 4K technology where possible and unifying facility specifications.

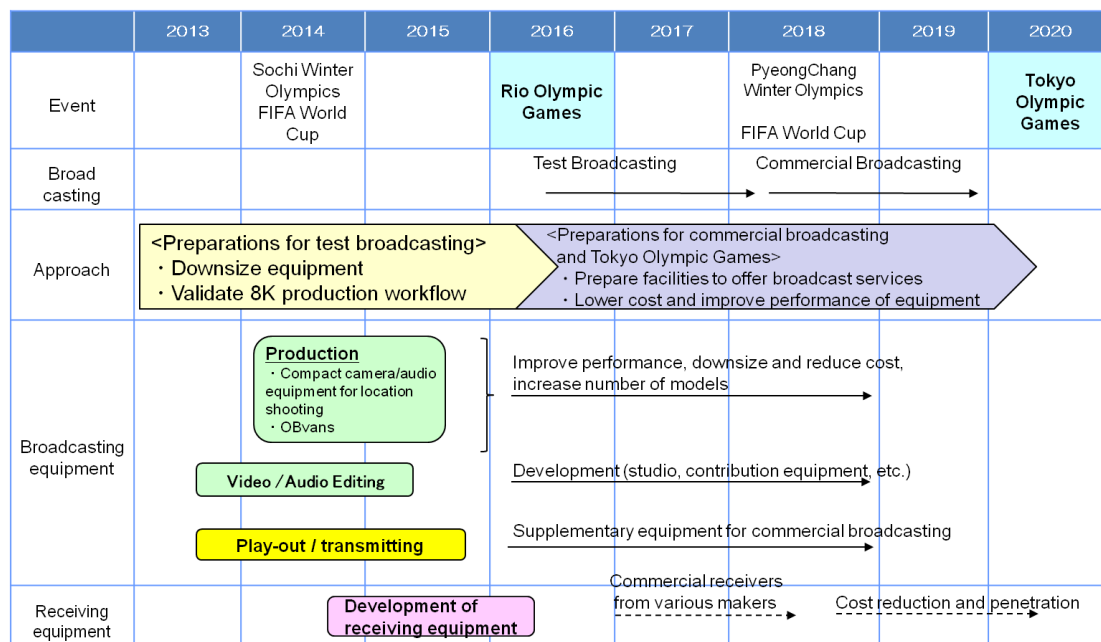


Figure 3 – Roadmap for preparing Super Hi-Vision equipment

### Preparations Policies

The main policies governing the preparation of UHDTV facilities are as follows.

- Steady development and preparation of play-out/transmitting facilities and receiving equipment toward the launch of test broadcasting in 2016
- Provision of highly mobile production equipment enabling diverse program production
- Improvement of facility functionality and performance for efficient content production and shorter production times
- Enhancement of outside production facilities such as video/audio OB vans

At NHK, we are concentrating on developing play-out/transmitting facilities for test broadcasting in the next year. Furthermore, in anticipation of broadcasting in 2018 and broadcasts, public viewings, and overseas distribution of programming of the Tokyo Olympics and Paralympics, we plan to construct reliable multifunctional facilities of the system in a stepwise manner.

Continuous efforts must be made to raise the performance and functionality of production facilities to enable the production of diverse 8K content. To date, 8K cameras and recorder equipment have been bulky and severely deficient in their mobility as tradeoffs for their abilities to handle high-data-rate video/audio signals. We are therefore attaching great

importance to improving mobility, downsizing, and reducing the power consumption of production equipment for practical use.

Additionally, for postproduction needs, we are preparing video editing and audio dubbing studios to create an environment in which high-quality content can be produced in as short a time as possible. In the video editing room, offline data consisting of video material converted to HD will be used as an efficient means of inputting 8K material into editing equipment. The audio dubbing studios will support not only 22.2 multichannel sound but also stereo and 5.1 multichannel productions.

Live broadcasts of sports events, music concerts, etc. are the sort of programming that can take full advantage of the features of 8K UHDTV. To expand and enhance content production functions for such outside broadcasting, we are developing video OB vans that can carry a maximum of ten cameras. We have already developed an audio OB van for production of 22.2 multichannel sound within the vehicle.

The following introduces preparations that we are making in line with the above policies and major facilities now in development.

### Play-out/transmitting facilities and receiving equipment

We are developing UHDTV broadcasting facilities in keeping with the “Transmission System for Advanced Wide Band Digital Satellite Broadcasting” standard <sup>6)</sup> developed by the Association of Radio Industries and Businesses (ARIB) in Japan and the operating provisions presently being formulated at NexTV-F. An overview of play-out/transmitting facilities for test broadcasting is shown in **Figure 4 and Figure 5**.

Using a Broadcasting Satellite (BS), these facilities can transmit a single 8K program or two 4K programs in a multi-level format (main-channel/sub-channel) simultaneously with 22.2ch, 5.1ch, and 2ch audio channels (32 audio channels maximum). Here, we will construct core facilities for 8K equipment that will up-convert (UC) and down-convert (DC) input/output 4K signals so that all video signals can be routed in a uniform manner as 8K signals.

We are also preparing a variety of multimedia services in addition to video and audio services. We have already begun development of an electronic program guide (EPG) and captioning/subtitling functions, and we plan to implement a data broadcasting service, a copy-protection function, and other services over time.

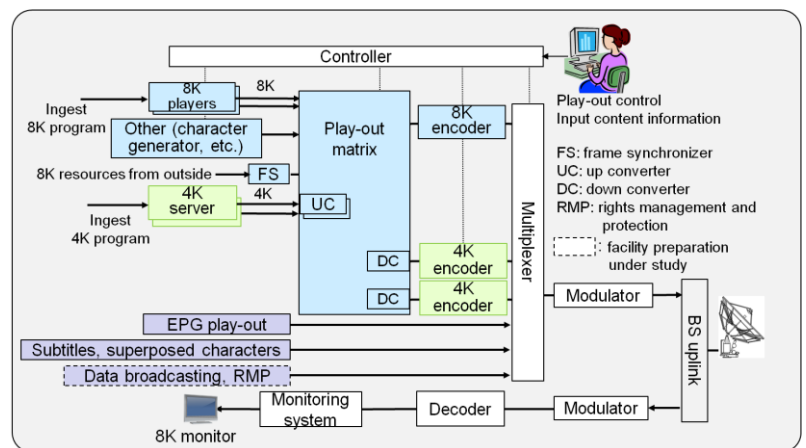


Figure 4 – Overview of Super Hi-Vision play-out/transmitting equipment for test broadcasting

#### ■ Play-out

Item	Configuration
Broadcasting service	One 8K channel or two 4K channels (main-channel/sub-channel)
Number of resources	8K-dedicated resources: 8K player x 7, outside lines x 4, subtitles x 3 4K-dedicated resources: 4K player x 2 (extendable up to 32 resources)
Play-out/EPG/subtitles	Automatic play-out by registered content information
Superposed characters	Manual creation and play-out of characters and graphics on a dedicated terminal

#### ■ Transmission

Item	Specifications
Transmit channels	BS 17ch
Modulation systems*	$\pi/2$ shift BPSK, QPSK, 8PSK, 16APSK

\* Hierarchical modulation for dealing with rainfall attenuation will not be applied initially in test broadcasting



To efficiently transmit high-capacity and high-quality video/audio information in UHDTV broadcasts, we are adopting new source coding schemes such as High Efficiency Video Coding (HEVC) and MPEG4 Advanced Audio Coding (AAC). We are also looking to introduce advanced technologies such as the newly developed MPEG Media Transport (MMT) multiplexing system, the latest browser standard (HTML5), and other facilities that can enable diverse broadcasting services tailored to the digital age.

Figure 5 – Overview of Super Hi-Vision play-out/transmitting facilities

In parallel with the above efforts, we are also developing receiving equipment so that public viewings can be held at NHK broadcasting stations throughout Japan and as many people as possible can enjoy test broadcasts beginning in 2016. The development of thin, compact 8K monitors has been accelerating in recent years, and we are working to make the receiver section of these monitors as compact as possible by introducing advanced technologies (**Figure 6**).



Figure 6 – 8K Monitors

### Production Facilities

In the commercialization stage, it is important that the equipment have high operability reflecting experience of actual production in addition to high functionality and performance. The appearance and specifications of new 8K cameras developed in 2015 are shown in **Figures 7** and **8**, respectively. The specifications of these cameras reflect improvements on the previous cameras and the results of pickup tests conducted with prototype cameras at production sites.

The handheld camera features a built-in 4K viewfinder and functional improvements such as automatic lens chromatic aberration correction. It is also supersensitive and quiet (reduced fan noise) for shooting in theaters. The dockable-type camera, meanwhile, enables a wide range of shooting styles thanks to it having a separate camera head section (weight: 3 kg) and function-extension unit attached to the rear of the head. Changing the function-extension unit enables the camera to be used as a camcorder, a relay camera, and other functions.



Figure 7 – Appearance of compact cameras

Items	Handheld-type	Dockable-type
Pickup	33-megapixel, single-chip, color image sensor	
Video output	8K/59.94P, 4K/59.94P, HD/59.94i	
Sensitivity and S/N	F5.6* @ 2000 Lux S/N approx. 60 dB (In case of down converting to HD)	
Function	4K view finder, focus assist automatic correction for lens chromatic aberration, etc.	
Features	Ability to mount box-type lenses with high magnification or wide viewing angle feature	Enables selection of record/playback module or optical transmission module

Figure 8 – Basic specifications of compact cameras

We have also developed UHDTV Recorder , the appearance and specifications of which are shown in **Figures 9** and **10**. While the previous model needed 16 memory cards for recording, the new model needs only four memory cards, thanks to its high compression efficiency and high-speed, large-capacity memory. The main unit is

about one-third the size of the previous unit. We also developed equipment for making backups from memory to tape media using Linear Tape-Open (LTO) technology. Furthermore, while the backup time from memory to tape media was about eight times the recording time with the previous equipment, the new equipment shortens it to about three times.

In addition, we have been developing equipment to enable conversion between 8K and 4K/HD video signals so that our production system will be as efficient as possible.<sup>7)</sup>

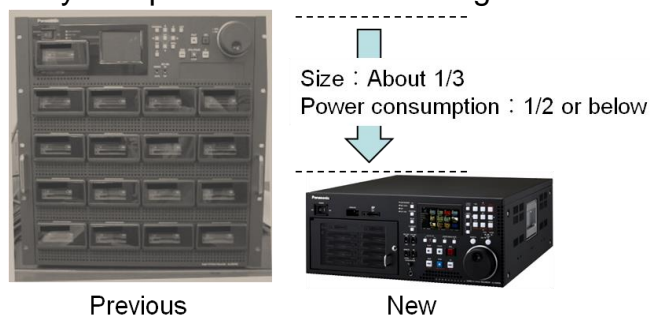


Figure 9 – Appearance of UHDTV Recorder

### OB van

We developed two models of video OB van, each equipped with up to ten cameras to ensure the same scale of relay performance as that of existing HD OB vans. The vans incorporate 8K switchers with 16 or more inputs to make it easy to increase the number of in-vehicle cameras and special-effects equipment such as for slow-motion playback. The appearance and specifications of the OB vans are shown in **Figures 11** and **12**. The production room also has an extension function on one side to provide enough space for an operator of slow-motion playback equipment, for example.

Item	Specifications(New model)
Video Input/output signal formats	Input: 8K/3G-SDI x 8 Output: 8K/3G-SDI x 8, 4K/3G-SDI x 4, HD/HD-SDI
Compression method	AVC-Intra4K/10bit
Recording media	8K video: memory card x 4, HD video: memory card x 1
Audio Input/output signals	SDI embedded/MADI (max. 32channels)
Record time	Max. 65 min (256GB card x 4)
Dimensions (mm)	W424 x H176 x D500
Power (W)/Weight (kg)	152/18 (main unit only)

Figure 10 – Basic specifications of UHDTV Recorder

In 2015, we also developed an audio OB van for 22.2-multichannel sound production. The vehicle is 11.5 m long, 2.5 m wide, and 3.5 m high. By widening the van and lengthening the workspace, we created a 22.2-multichannel mixing room in which speakers are arranged on a 2.1m-radius spherical surface centred on the mixer (**Figure 13**). The van can handle 5.1ch and stereo sound.



Figure 11 – Appearance of OB van

Item	Specifications	
	Video OB van 1	Video OB van 2
Vehicle size	Length: 11.9 m, height: 3.3 m	
Maximum in-vehicle equipment	10 cameras, 4 record/playback units 4 slow-motion units	
Switcher	16 inputs 1 video-synthesis function	20 inputs 2 video-synthesis functions

Figure 12 – Basic specifications of OB van

### Content Production and other industrial use

NHK has a proven track record in public viewings (**Figure 14**) and other presentations of 8K live broadcasts, starting with the London Olympic Games in 2012 and continuing with the Sochi Winter Olympics, FIFA World Cup in Brazil in 2014, the FIFA Women's World Cup in Canada and Wimbledon Tennis in 2015. We have also accumulated diverse 8K content through on-location shoots of nature and travel programs, recording entertainment

presented in theatres and concert halls. Moreover, we are studying how 8K can be used in a variety of areas besides broadcasting, including in medicine (8K-video recording of heart surgeries and 8K endoscopes) and in education (electronic blackboards) , in digital signage and so on.

### Future Facilities Preparations and Remaining Issues

In anticipation of the 2020 Tokyo Olympics and Paralympics, NHK will work to expand and enhance its facilities.

The following issues must be addressed with an eye toward widespread use of UHDTV broadcasting:

- Development and preparation of wireless transmission facilities, studio facilities, etc.
- Further performance gains in the production system
- Commoditization and price reduction of equipment

What type of 8K broadcasting services to provide through an all-Japan system consisting of broadcasters, manufacturers of receiving equipment, etc., is now a subject of discussion. Finding an answer to this question will require studies on the scale of facilities and the development of new equipment and systems in accordance with service requirements. These developments may include an 8K satellite OB van (8K-CSvan and 8K microwave link(8K field pickup unit (8K-FPU)) to simplify relays of sports events and news stories and the transfer of video materials as well as an 8K studio for switching between outside and in-station resources in program production. Preparation of such facilities will require studies on specifications suitable for 8K production, such as transmission schemes and frequencies that can transfer large amounts of data without delay, camera arrangements and studio size/designs conducive to 8K studio productions, etc.

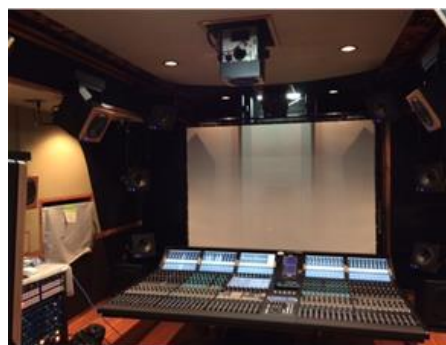


Figure 13 – Mixing room in audio OB van



Figure 14 – 8K Public viewing

How to extract further performance gains for the production system is the major issue here. The present system has a signal format that achieves 8K video through four 4K image sensors each corresponding to a different color channel (GGRB). This system can transmit 8K signals efficiently while preserving resolution in the horizontal and vertical directions, but it suffers from degraded resolution in the diagonal direction. From 2016 on, we plan to use an 8K signal format capable of even higher picture quality (8K/YCbCr 4:2:2). We are also studying new functions such as high dynamic range (HDR) support and will strive to implement such functions as early as possible. In a parallel way, We examine how to product programs in the situation of mixed HD/4K/8K equipment.

Finally, the commoditization and price reduction of systems and equipment will be essential if 8K UHDTV is to become popular. The commercialisation of Hi-Vision is potentially illustrative; reception equipment that initially cost several hundred thousand dollars (at the current exchange rate) eventually cost about 40,000 dollars by the time of



test broadcasting in 1991<sup>8)</sup>, which despite being costly was low enough for popularization to take hold. Similarly, for 8K UHDTV, we expect the number of equipment shipments to increase at the start of test broadcasting and prices to drop as a result. We also plan to continue developing equipment and devices with cost in mind while making use of existing HD, 4K, and information-communications technology where possible to bring costs down even further.

## CONCLUSION

This paper described the state of development of 8K UHDTV facilities with a focus on facilities for test broadcasting scheduled to begin in 2016. At NHK, we have undertaken the development of facilities to facilitate diverse program production and have been working to downsize and improve equipment performance such as new and advanced compact cameras, UHDTV recorder, etc. Going forward, our plan is to promote the spread and adoption of equipment and devices that will enable more producers to become involved in the production of 8K programs and content. In addition, the development of play-out/transmitting facilities is progressing in parallel with the formulation of standards and operating provisions. Over the next 12 months, we can expect a massive number of integration tests for separately developed equipment and system trials. We must achieve the world's first 8K broadcasting system. Moreover, in conjunction with test broadcasting to begin in 2016, we would like to construct an environment that will enable many people to enjoy 8K UHDTV on prototype receivers installed at NHK broadcasting stations throughout Japan.

By continuing its leading role in promoting 8K UHDTV and working to make equipment and facilities ready for practical use, NHK is committed to delivering highly realistic, high-presence content of the 2020 Tokyo Olympics and Paralympics to all its viewers through a technologically advanced broadcasting system.

## References

1. Rec. ITU-R BT.2020: "Parameter values for ultra-high definition television systems for production and international programme exchange" (2012)
2. Ministry of Internal Affairs and Communications (MIC): "The Interim Report of the Follow-up Meeting on 4K and 8K Roadmap" (September 2014) (in Japanese)
3. Next Generation Television & Broadcasting Promotion Forum (NexTV-F)  
<http://www.nextv-f.jp/>
4. Ministry of Internal Affairs and Communications (MIC): Follow-up Meeting on 4K and 8K Roadmap (5th Meeting), Handouts (in Japanese)  
[http://www.soumu.go.jp/main\\_sosiki/kenkyu/4k8kroadmap/02ryutsu11\\_03000039.html](http://www.soumu.go.jp/main_sosiki/kenkyu/4k8kroadmap/02ryutsu11_03000039.html)
5. Masaoka et al.: "Color Management for Wide-Color-Gamut UHDTV Production", SMPTE 2014 Annual Technical Conference & Exhibition
6. ARIB STANDARD ARIB STD-B44: "Transmission System for Advanced Wide Band Digital Satellite Broadcasting"
7. For example, Ichikawa et al.: "Development of UHDTV (8K) Baseband Processor Unit "BPU-8000", SMPTE 2014 Annual Technical Conference & Exhibition





8. Ministry of Posts and Telecommunications: “Information and Communications in Japan White Paper, 1991 Edition,” Chapter 2, Section 4 “Japan’s Social and Economic Life and Information and Communications Technology” (In Japanese)