Trends in Digital Terrestrial Broadcasting

Countermeasures for analog channel adjustments that will be necessary to accommodate the upcoming launch of digital terrestrial television broadcasting began in the three largest metropolitan areas on February 9 of this year. The basic policy of the National Promotion Committee for Digital Terrestrial Broadcasting was determined in July for the other areas of the country, where work will advance on establishing a nationwide system. This article provides an overview of the schedule for analog channel adjustment countermeasures, broadcasts in Tokyo/Nagoya/Osaka, digital broadcasting standardization, and work being conducted by related organizations toward digitalization of terrestrial broadcasts. It also explains broadcast-wave relay technology, which will play an important role in the future nationwide service.

1. Digital Terrestrial Television Broadcasting

Analog channel adjustment countermeasures

The Joint Committee Concerning Digital Terrestrial Broadcasting, established in September 1999 by the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT), prepared the initial plan regarding the number of broadcasting stations and households to be affected by the analog adjustment countermeasures and an estimate of the cost for the changeover. Its report was released in April 2000. The ministry dissolved the Joint Committee, recently, and founded the National Promotion Committee for Digital Terrestrial Broadcasting. The MPHPT is charged with revising the Radio Law, the basic plan for promoting broadcasting in Japan, and the frequency use plan for broadcasting. The new committee spent about a year conducting a nationwide survey on all aspects affecting the planned countermeasures, including ones that haven't been covered in the initial plan, such as subscribers who receive broadcasts from transmitters other than the nearest ones (Table 1).

The document detailing amendments to the basic plan for promoting broadcasting and the frequency use plan was released on September 27, 2002. It describes how the digitalization of terrestrial services would advance in phases: first, the Tokyo / Osaka / Nagoya areas would be digitalized; then, other regions would be digitalized. It took into account that the survey had required a substantial time and revealed a need to change the original plan.

Analog Channel Adjustment Countermeasures Schedule

The amended plan's schedule states that digital broadcasting should start in the three major metropolitan areas by the end of 2003 and in other areas by the end of 2006 and that analog broadcasting service should be terminated in 2011. The countermeasures for the analog channel adjustment are to be implemented as follows:

- Digitalization of the three major metropolitan areas: to start in 2002, and be completed by 2006.
- Other areas: digitalization by region to start no later than 2005.
- The entire cost will be covered by the government (financed by radio usage fees).
- The details of the plan, such as specific countermeasures to be implemented, have not been determined.

In conjunction with the analog channel countermeasures, digital terrestrial broadcasting will gradually be started in areas outside the three major metropolitan areas (Figure 1).

Table 1: Cost of analog channel adjustment countermeasures

	April 26, 2000 (initial estimate)	August 1, 2002 (National Committee Meeting)
Number of stations being affected by analog channel adjustment countermeasures)	418	801
Number of households requiring countermeasures	2.46 million	Approx. 4.26 million
(of which households require cable TV countermeasures)	(7000)	(Approx. 0.13 million)
Countermeasures cost	Approx. 72.7 billion yen	Approx. 180 billion yen

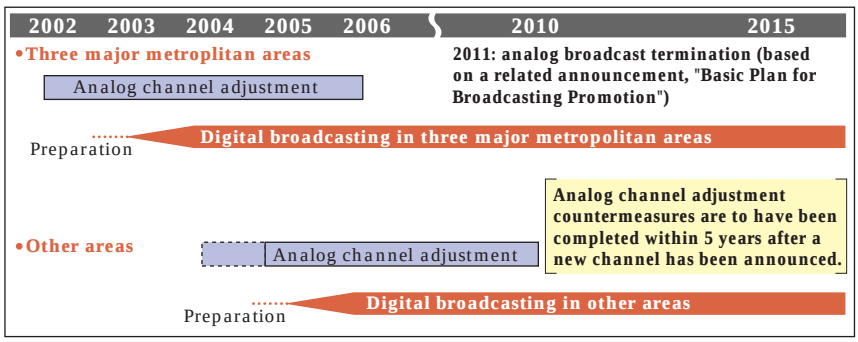

Figure 1: Analog channel adjustment countermeasures implementation schedule

Digital Terrestrial Television Broadcasting Licensing

Figure 2 shows a general description of the MPHPT's licensing policy and an example of the broadcasting forms. Applications for licenses were submitted by NHK and 16 commercial broadcasters, and preliminary radio licenses with a December 1 start date for the Kanto, Chukyo, and Kinki regions were granted on April 18.

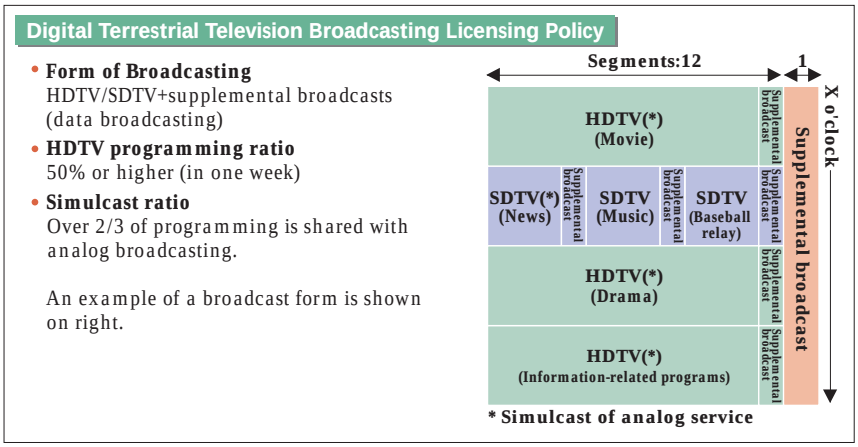

Figure 2: Digital terrestrial television broadcasting licensing policy

Broadcasting in the Three Major Metropolitan Areas

Table 2 lists the transmitting powers of each broadcasting station, whose signals will be progressively intensified until they are at full strength sometime between the end of 2004 and the end of 2005. The figures are based on the MPHPT press release "Report on Preliminary Radio Licenses for Digital Terrestrial Television Broadcasters," dated April 16, 2002. The transmitters of the Kanto and Kinki regions are to reach their maximum output in three phases, and the Chukyo area transmitters are to reach it in two phases.

Table 2: Transmitting power for December-launch stations

Wide area	Begin in 2003	End of 2004	End of 2005	Broadcasters
Extended Kanto area Tokyo	300W	410W	10kW	NHK General TV
	15.5W	700W	10kW	NHK Educational TV and extended area commercial broadcasters
	29W	700W	3kW	Metropolitan
Extended Chukyo area Aichi pref.	30W	3kW		NHK GTV/ETV and extended area commercial broadcasters
	30W	1kW		TV Aichi
Extended Kinki area Osaka	10W	100W	3kW	NHK GTV/ETV and extended area commercial broadcasters
	10W	100W	1kW	TV Osaka

Tokyo/Nagoya/Osaka Digital Broadcast Transmitting Facilities Overview

In the Tokyo area, eight broadcasters have placed new antennas at a height of 250 m on Tokyo Tower. A transmitter room was built under the tower's large observatory. In the Nagoya area, a new facility with a 246-m steel tower and a broadcasting station will be opened in Hatanaka, Seto city and will broadcast the signals of NHK and other broadcasters. In the Osaka area, NHK has installed an antenna for its exclusive use at the top of an existing backup steel tower on Mt. Ikoma, which is approximately 690 m above sea level. Other broadcasters installed antennas on their own towers. An overview of these facilities is shown in Figure 3.

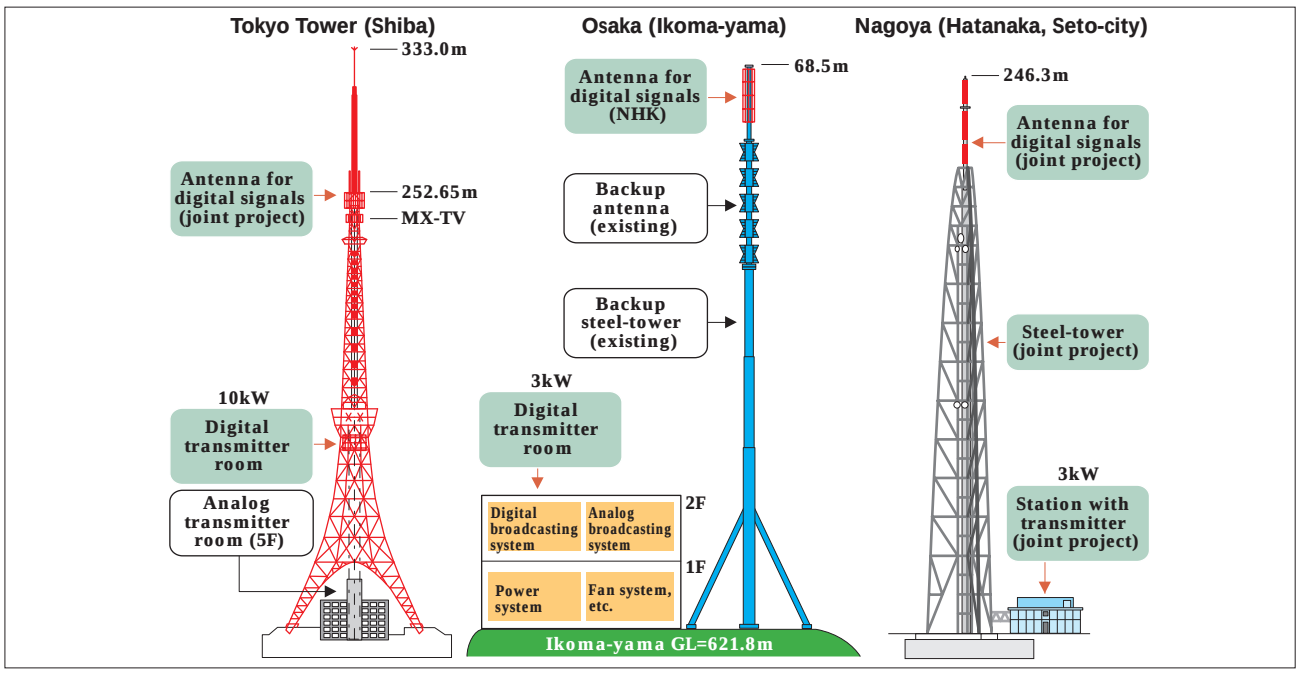

Figure 3: Tokyo/Nagoya/Osaka digital transmitting facility overview

Analog Channel Adjustment Countermeasures in Other Areas

The National Promotion Committee for Digital Terrestrial Broadcasting announced its basic policy in July 2003. The policy calls for implementation of analog channel adjustment countermeasures throughout the country in fiscal 2004, with broadcasting to have begun by the end of 2006 (Figure 4). Areas needing more involved countermeasures will follow an accelerated schedule. The release of master station frequencies for each region is scheduled for September, except in areas that require further studies on interference, for which the release date is December. These exceptional areas are the Ariake region of Fukuoka, Saga, Nagasaki, and Kumamoto, and the San-in region of Tottori, Shimane, and Yamaguchi. As in Tokyo/Osaka/Nagoya, the transmitting power of the master stations in each region will gradually increase as analog channel conversion progresses.

Coinciding with this process, the MPHPT amended its frequency use plan for allocating frequencies to the master stations that will be established outside the three metropolitan areas and setting up the analog channel adjustment countermeasure stations. This is in line with the amendment to the frequency use plan for broadcasting.

2. Digital Terrestrial Sound Broadcasting

The Digital Radio Promotion Association (DRP) comprises 81 organizations and companies, including NHK, commercial sound broadcasters, new broadcasters, and manufacturers. Its members will begin digital terrestrial sound trial broadcasts in Osaka and Tokyo in October 2003. Table 3 gives an overview of the preliminary licenses issued in September 2001. The frequency bandwidth to be used for broadcasting is 4 MHz, which is common to Kanto and Kansai and corresponds to part of VHF Channel 7. Eight densely packed segments will be transmitted in the 4-MHz bandwidth by connecting together the segments that have the same structure as ones used for digital terrestrial television broadcasting.

The plan is to divide broadcasters into groups that will develop their own multimedia services for these segments. There will be five one-segment groups and one three-segment group in Tokyo, and eight one-segment groups in Osaka.

3. Standardization Trends in Digital Terrestrial Broadcasting and Other Services

Operational Guidelines for Digital Terrestrial Television Broadcasting: ARIB TR14

The Digital Terrestrial Television Broadcasting Standardization Panel comprises NHK and five commercial broadcasters in Tokyo. It was inaugurated in October 2000 and is working to establish or revise the operational guidelines for broadcasters. To provide digital terrestrial television broadcasting based on ARIB standards, these guidelines should specify the areas of services, data broadcasting, conditional access systems (CAS), receiver specifications, and rights management and protection. The first version, ARIB TR-B14, was completed in January 2002, and several modifications have been made to it. The current version, 1.4, was issued in June 2003.

Examples of the operational guidelines' contents are shown in Tables 4 to 6).

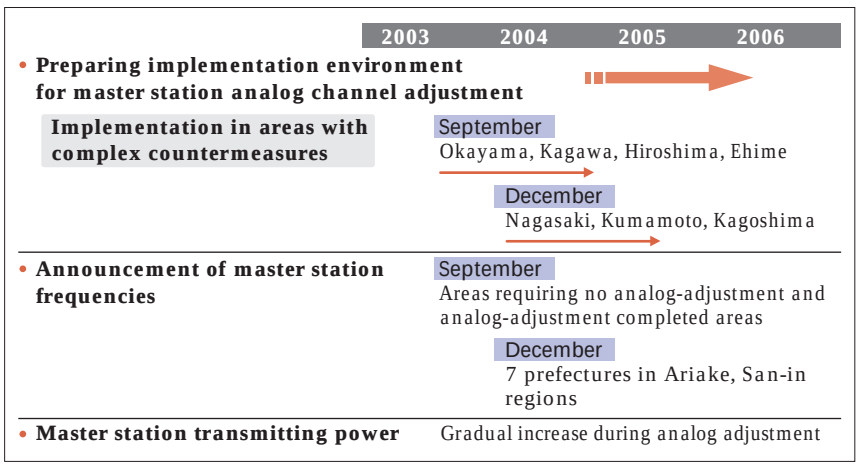

Figure 4: Analog channel adjustment countermeasures in areas other than the three major metropolitan areas

Table 3: Digital terrestrial sound broadcasting preliminary license overview

Licensee	Digital Radio Promotion Association	
Station name	Osaka experimental station	Tokyo experimental station
Frequency	190.214286MHz (Channel 7 on television)	
Transmitting power (per 1 segment)	240W (30W)	800W (100W)
Transmitting location	Ikoma-yama	Tokyo Tower
Broadcasting area	Parts of Osaka, Kyoto, Nara, and Hyogo prefectures	Parts of Tokyo, Kanagawa, Chiba, and Saitama prefectures

Standards for Broadcasting Based on Home Servers: ARIB STD-B38

Broadcasting based on home servers uses a receiver equipped with a communications function and large-capacity storage equipment such as a hard disk. The server will record and replay program contents according to metadata giving the description and characteristics of the contents and rights related information. This lets programs be tailored to the individual viewer's preferences. In September 2002, the Telecommunications Council released a report titled, "Coding, Transmission, and Storage Specifications for Broadcasting System Based on Home Servers," and drafted ARIB STD-B38 in February 2003.

The standard defines two types of transmission system: a streaming type (I), and a filing type (II). The fact that Type I is the same scheme as the current digital broadcasting makes

Table 4: Digital terrestrial television broadcasting service pattern

Service pattern	Segment number	Transmission parameter	TV system	EPG	
				Basic	Extension
(1)	13	64QAM	HDTV, SDTV	Home	–
(2)	13	16QAM, QPSK	HDTV, SDTV	Mobile	Home
(3)	1	16QAM, QPSK	LDTV	Portable	Home/Mobile
	12	64QAM	HDTV, SDTV	Home	–
(4)	8-2	16QAM, QPSK	SDTV	Mobile	Home
	5-11	64QAM	HDTV, SDTV	Home	–
(5)	1	16QAM, QPSK	LDTV	Portable	Home/Mobile
	12	16QAM, QPSK	HDTV, SDTV	Mobile	Home
(6)	1	16QAM, QPSK	LDTV	Portable	Home/Mobile
	7-1	16QAM, QPSK	SDTV	Mobile	Home
	5-11	64QAM	HDTV, SDTV	Home	–

Note 1 LDTV(Low Difinition TV) will be implemented for data broadcasting.
Note 2 The basic EPG transmits data to a hierarchy that is the same as that of the service hierarchy. The extension indicates a data transmission that differs from the basic EPG and can be made regardless of service hierarchy whenever the broadcaster chooses to do so.

Table 5: Data broadcasting profile

Profile	Description
A	Basic operation profile for data broadcasting services designed mainly for home receivers (fixed, STB, portable, etc.).
B (T.B.D)	Basic operation profile for data broadcasting services designed mainly for portable receivers (car TV, portable TV, PDA, etc.).
C	Basic operation profile for data broadcasting services designed mainly for portable receivers (cellular phone, etc.).

Table 6: EPG operation

	Digital terrestrial television broadcasting	Digital BS broadcasting
EPG type	H-EIT (EPG for home receivers) M-EIT (EPG for mobile receivers) L-EIT (EPG for portable receivers)	1 type
Transmitted data	Transmits only own-station data	Transmits all-station data
Receiver operation	- Receivers capable of nighttime power control; e.g., fixed receivers collect data for all stations in standby mode. - Portable receivers can also receive own-station data.	Presents received data without any processing.

feasible real-time viewing using a conventional receiver. Along with regular program contents, Type II transmits characteristics about the contents' file format, such as its pixel number and coding scheme, by using a data carousel scheme compliant with MPEG-2 system multiplexing. The standard also specifies schemes for metadata, rights management and protection, and CAS. An unconventional charging-at-replay fee mechanism will be introduced. It does not charge for stored contents until they are played. The broadcasters' operational guidelines for broadcasting based on home servers are being compiled, including details about receivers and their standard operation.

Access Control System Standard for Digital Broadcasting: ARIB STD-B25

The previous standard, "Conditional Access System Specifications for Digital Broadcasting: ARIB-STD-B25," was renamed after the replay control scheme for broadcasting based on home servers was added to Section 2, in February 2003.

Application Execution Environment Standard for Digital Broadcasting: ARIB STD-B23

This standard defines the procedural (execution-type) application execution environment, in addition to conventional declarative (presentation-type) data broadcasting standards. With regard to monomedia coding schemes, it considers compliance with the digital BS and CS broadcasting systems that are already in use, and includes schemes required by DVB/MHP (Multimedia Home Platform). The application execution environment has the necessary standards for domestic broadcasting, such as an extension for Japanese language fonts, and it conforms with network applications and DVB/MHP standards, including the GEM (Globally Executable MHP) standard.

H.264 Added to ARIB STD-B24

MPEG-4 data broadcasting coding is the coding scheme assumed for digital terrestrial broadcasting's one-segment service. However, MPEG-4 rights holders are demanding use-based royalties, and whether to accede to this demand has become an issue among broadcasters. Consequently, the commencement of services employing MPEG-4 is not presently within sight. ARIB is discussing a proposal from broadcasters aiming at an early start of services. Increased system options would offer alternative standards to MPEG-4; In fact, H.264 has already been selected as an alternative in the ARIB STD-B24 standard.

This concludes our overview of the main standardization trends related to digital terrestrial broadcasting. Nearly all of the ARIB digital broadcasting standard systems are listed in Figure 5.

4. Related Organizations

National Promotion Committee for Digital Terrestrial Broadcasting (National Committee)

This private organization was established in July, 2002 and is chaired by Makoto Kitagawa, President of the Broadcasting System of Niigata Inc. It consists of the MPHPT, NHK, and 127 commercial television broadcasters, and it discusses with regional councils analog channel adjustment countermeasures and related publicity activities.

As of June 5, 2003

		Digital television broadcasting		Digital sound broadcasting	
		BS/wide-area CS broadcasting (enacted or revised in Nov. 1998/ Dec. 2000)	Terrestrial television broadcasting (enacted in May 2001)	Terrestrial sound broadcasting (enacted in May 2001)	2.6-GHz-band satellite sound broadcasting (enacted in June 2003)
Transmission scheme		Transmission System for Digital Satellite Broadcasting ARIB STD-B20	Transmission System for Digital Terrestrial Television Broadcasting ARIB STD-B31	Transmission System for Digital Terrestrial Sound Broadcasting ARIB STD-B29	Transmission System for Digital Satellite Sound Broadcasting ARIB STD-B41
Coding scheme, multiplexing scheme		Video Coding, Audio Coding and Multiplexing Specifications for Digital Broadcasting ARIB STD-B32M			
		Service Information for Digital Broadcasting System ARIB STD-B10			
Data broadcasting scheme	Contents-presentation type	Data Coding and Transmission Specification for Digital Broadcasting ARIB STD-B24			
	Program-execution type	Application Execution Engine Platform for Digital Broadcasting ARIB STD-B23			
Conditional access system		Conditional Access System Specification for Digital Broadcasting ARIB STD-B25			
Broadcasting based on home servers		Coding, Transmission and Storage Specification for Broadcasting System Based on Home Servers ARIB STD-B38			
Receiver		Receiver for Digital broadcasting ARIB STD-B21		Receiver for Digital Terrestrial Sound Broadcasting ARIB STD-B30	Receiver for Digital Satellite Sound Broadcasting ARIB STD-B42
Operational guideline (technical report)		Operational Guidelines for BS/wide-area CS Digital Broadcasting ARIB TR-B15 (enacted/revised in Oct. 1999/July 2001)	Operational Guidelines for Digital Terrestrial Television Broadcasting ARIB TR-B14 (enacted in Jan. 2002)	Operational Guidelines for Digital Terrestrial Sound Broadcasting ARIB TR-B13 (enacted in May 2002)	Operational Guidelines for Digital Satellite Sound Broadcasting (pending)

Note 1: "ARIB STD-BXX" and "ARIB TR-BXX" indicates ARIB "Standard" and "Technical Report", respectively.
Note 2: Standards related to digital CS broadcasting have been omitted.

Figure 5: ARIB Standards on digital broadcasting

Digital Terrestrial Television Receiver Test Center Council

This council's aim is to support the development and test manufacture of receivers and the smooth diffusion of digital terrestrial broadcasting equipment. It was founded in April, 2002 and 93 companies, including broadcasters and manufacturers, participate in it. Its work ranges from creating standard test streams and conducting high frequency tests to conducting receiver interference experiments. It is also preparing the experimental broadcasts that will be made prior to the actual service commencement in December.

Digital Terrestrial Broadcasting Promotion National Conference

This private organization was established in May, 2003. It is chaired by Mr. Nobuo Yamaguchi, Chairman of the Japan Chamber of Commerce and Industry. It consists of representatives from the MPHPT, NHK, 127 commercial television broadcasters, broadcasting related organizations, manufacturers, distributors, and consumer organizations. It works to promote various approaches toward the steady implementation of digital terrestrial broadcasting.

The Association for the Promotion of Digital Broadcasting (D-PA)

This association was incorporated in August 2003. Its president is Mr. Makoto Kitagawa. It is made up of NHK, 127 commercial broadcasters, and receiver manufacturers. Its purpose is to promote a smooth, prompt transition to digital terrestrial television broadcasting, and ensure stable operations. Its specific activities include promoting receiver diffusion, as well as the standardization of transmission/reception technologies by continuing the functions of the Digital Terrestrial Television Broadcasting Standardization Panel and the Test Center. It provides engineering services for reception function version upgrades and error removal using broadcast-waves, as well as contents protection for broadcasting programs.

5. Nationwide Development after 2006

The digitalization of terrestrial service covering the nation will have started by 2006, and it will include a partially accelerated program for analog channel adjustment countermeasures in "frequency congested" areas, as previously noted. The biggest challenge will be the digitalization of the many small-scale relay broadcasting stations throughout the country, including those in mountainous areas. In the case of NHK, in

comparison with the over 90% of the nation's households that can be covered by the 550 main stations, the remaining 10% require nearly 2,000 small-scale relay stations for coverage. Issues of deficiencies in exclusive frequencies and related costs make it difficult to deliver services via microwave network to these relay stations; the remaining option is networking as many relay stations as possible via broadcast-wave relay.

Because the broadcasting frequencies allotted for relay stations are inadequate, it is essential to employ broadcast-wave relays in which the received radio waves are retransmitted over the same frequency, in addition to the conventional methods of retransmission after frequency conversion at a relay station. The realization of such a technology will make feasible the construction of a network that is both frequency and cost efficient, through the incorporation of broadcast-wave relay stations into a single frequency network (SFN). This, however, will only be possible if one can suppress coupling loop interference (CLI) caused by relayed waves feeding back to a receiving antenna. The countermeasure technologies for broadcast-wave relay operations, including a CLI canceller, are described in Table 7.

- Since 1995, efforts have been made to develop a CLI countermeasure technology for digital terrestrial broadcasting networks. The specifications for the CLI canceller are based on field trials conducted using 13 TAO digital experimental stations located from Hokkaido to Okinawa and the analysis of a full-year's worth of analog station data collected at satellite stations in Tomakomai and Kamioka.
- While an ordinary broadcast-wave relay converts the frequency at relay stations, to avoid disruptions in digital broadcasting transmissions, there must be a large enough margin against severe multi-path fading with a large fluctuation of amplitude. Two types of diversity reception system, which differ in their equalization processing, have been fabricated for this purpose. A frequency domain processing scheme is also an effective technology for Hi-Vision (HDTV) mobile reception. Processing to determine signal points improves the CN ratio, making feasible multi-stage relay broadcasting.
- The above technologies are equalization technologies for the identical channel fluctuations. A relay station is almost always installed on high ground, where besides receiving the desired waves, it is exposed to co-channel interference from other sources, sometimes from ones in other countries. A co-channel interference elimination system employs an adaptive array technology that suppresses interference waves by identifying the angle of arrival.
- The last countermeasure listed in the Table 7 is equipped with a function to cancel the coupling loop interference from its own waves in an environment where co-channel interference occurs. To expand the range of an SFN broadcast-wave relay, work is underway on new algorithms to respond to two mixed-interferences simultaneously.

Determining which countermeasure technologies to apply in SFN or MFN broadcast-wave relay stations will be done based on a network design that considers both the reception environment and future station construction plans. The most important issue, regardless of the type of countermeasure technology used, is to prevent digital signal transmission disruption, the so-called cliff effect. Broadcast-wave relay transmission of digital broadcasting in an extremely congested frequency environment like Japan's is unprecedented, intensifying the need for us to thoroughly understand all issues affecting transmission and reception, especially those related to station construction. For example, prior to the construction of a national network of stations, a long-term trial using a pilot station and a backup exclusive network could be conducted. Digitalization would then advance in stages, with the reliability of broadcast-wave relay transmissions being verified in the field at each stage.

(Makoto SASAKI, Director, Digital Broadcasting Networks)

Table 7: Interference countermeasures technology for broadcast-wave relay

Countermeasure		Interference type				Target relay station type
		Transmitting wave coupling	Multi-path	Fading	In-band interference	
CLI canceller		◎	○	×	×	SFN
Diversity reception system	Time domain processing	×	◎	◎	×	SFN
	Frequency domain processing	×	◎	◎	△	MFN
Co-channel interference elimination system		×	◎	◎	◎	MFN
CLI canceller with co-channel interference elimination function		◎	◎	◎	◎	SFN

◎ Excellent ○ Good △ Adequate × Ineffective