The Analogue Switch-Off and Total Digital Coverage

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On August 1, 2006, the Information and Communications Council of the Ministry of Internal Affairs and Communications (MIC) issued its third interim report, entitled "Optimal Utilization of Digital Terrestrial Broadcasting and the Role of Government toward Its Spread." The Council has submitted an interim report every year since 2004 when then MIC minister Aso Taro asked it to study measures for facilitating digital terrestrial broadcasting and ensuring the phasing out of analogue broadcasting by July 24, 2011. The feature of the latest report lay in its comprehensive discussion of questions related to transmission of digital TV signals. In the report the Council for the first time recognized the gap-filler system (the digital-wireless community-reception system)[1] as the most effective supplementary measure in digitization of relay stations, thus taking a concrete step forward in installation of the system.

Japan's terrestrial television broadcasters have set up a total of more than 14,000 relay stations covering almost 100 percent of households throughout the country. Under the government's time schedule for full-scale completion of the digital transition by July 24, 2011, however, a huge number of analogue relay stations will have to be modified for digital operations in no more than seven and a half years from the start of digital broadcasting commenced in the three major cities of Tokyo, Osaka, and Nagoya in December 2003. The National Council for Promotion of Digital Terrestrial Television Broadcasting also sought to step up the digital changeover, presenting a "Roadmap to 2010," schedule for network digitization of analogue relay stations.

NHK has announced a plan for switching from analogue to digital for almost 100 percent of its relay stations. Commercial television networks, on

[1] Under this formula, the signal transmitted by way of fiber optics under the same-frequency pass-through operating system is converted to a radio frequency and broadcast at transmission power of 10mW. The formula can be used to send all the channels to households within a radius of 1.5-2.0 kilometers. According to a test conducted in Gifu prefecture in 2005, it would cost some 2 million yen per facility. If it were decided to put the formula into practical use and mass-production of needed equipment starts, the cost is projected to be reducible to one-fourth that amount.

the other hand, have come up with a plan to provide digital coverage for only 95 percent of 48 million households across the country. As things stand now, it is not certain when the remaining two million households will receive all digital channels. To remedy the situation, various means to supplement digitization of relay stations are being considered.

The supplementary measures that have been used by viewers who cannot directly receive analogue TV signals are cable television in rural areas and community reception in remote areas, for multiple-unit housing complexes, and in urban-canyon areas. Then, in its second interim report issued in the summer of 2005, the MIC Information and Communications Council discussed the possibility of satellite broadcasting and IP multicast broadcasting, and since that time these two media have suddenly received intense attention. Ways to put them to use began to be studied.

However, given the technological and cost problems involved as well as the problem of reception of television programs that go mobile ("one seg" services that started in April 2006), it is increasingly thought that retransmission of broadcast programs using the "digital-wireless community-reception system" would be the more feasible approach. The results of verification experiments regarding supplementary measures that have been conducted in various parts of the country since the spring of 2006 have been announced, and studies have begun to determine how to put such supplementary devices into practical use. In this way, the general direction of the switchover to digital broadcasting is becoming clear.

The verification process conducted so far includes experiments held in Gifu and Hyogo prefectures by private-sector companies and in Iwate and Kochi prefectures as a part of the Ministry of Internal Affairs and Communications' pilot project. Regarding poor-reception locations in the Hokkaido region, ample time was devoted between March and July to discussing possible ways to solve the problems. It was in such new circumstances that the third interim report came out in August.

The plan to switch off analogue broadcasting as of July 2011 has been based on the premise that digital services for terrestrial broadcasting can be made as widely accessible as were analogue services. Based on the experiments and discussion on the transition process held across the country, this paper will outline the measures proposed to achieve that goal.

FEATURES OF THE THIRD INTERIM REPORT

The first interim report released on July 24, 2004 by the Information and Communications Council of MIC stated that "Accelerating the spread nationwide [of digital terrestrial broadcasting] requires development and extension of the high-level services necessary for digital terrestrial broadcasting." In order to facilitate that endeavor, the report said, it was vital to conduct verification experiments not only concerning high-level service functions and utility if they are adopted in the public sphere, but also regarding the merits and demerits of and the feasibility of various transmission methods including use of communications infrastructure. With emphasis on development of high-level services and on utilization of communications infrastructure to supplement digitization of relay stations, the first interim report appeared rather optimistic about the coming termination of analogue transmissions.

The second interim report released on July 29 of the following year went into far greater detail about supplementary means than the first report, and discussed some specific measures—utilization of communications infrastructure using IP multicast, of communications infrastructure currently in use by local governments, and of satellite broadcasting.

With regard to communications infrastructure using IP multicast, the report, which was premised on the expected spread of FTTH (Fiber to the Home), indicated the possibility of using IP multicast in the cities, not just in areas with disadvantageous reception conditions. It sought to encourage the spread of IP multicast by presenting a variety of transmission line options to viewers. The report, therefore, called for clarification of how extensively IP multicast can be placed under copyright law. The Cultural Affairs Council of the Agency for Cultural Affairs began holding meetings in March 2006 based on the assumption that legislation would be revised.

The intention of the idea for mobilizing communications infrastructure currently in use by local governments for intermediate transmission between broadcasting stations was to make efficient use of the investment. Realignment of relay stations was also proposed by combining the existing communications infrastructure and small relay stations, in other words by introduction of the gap-filler technique.

As for satellite utilization, the report stated that the technological efficiency of compression and transmission would be tested for the new H.264 and DVB-S2 systems that would replace compression formula MPEG-2. Toward that end, experiments conducted by a satellite communications company during fiscal year 2005 confirmed the technological feasibility of the new systems.

New Direction in Third Interim Report

In the third interim report issued on August 1, 2006, many pages were devoted to the chapters "Actualization of the Relay Station Roadmap" and

"Utilization of Supplementary Devices." Its focus was on specific measures to ensure transmission of digital airwaves.

The basic idea was that "all viewers who received terrestrial broadcasts, regardless of whether through direct reception or not, during the analogue broadcasting era will be enabled to view broadcasts as they did during the analogue era after terrestrial broadcasting shifts to digital operation." The report declared, in other words, that even those who did not receive broadcasts through direct reception, that is to say, people who viewed terrestrial television through some kind of supplementary device, should be enabled to receive the same broadcasting services in the new digital era as in the analogue era.

That meant that not only the more than 14,000 broadcasting relay stations across the country but also all the existing systems would have to go digital before by July 2011. A total of 1,210,000 households watch television through community reception through some 20,000 facilities in remote and rural areas. Experiments show that nearly 90 percent of the TV households in urban locations where reception is impaired because of high buildings will have no reception problems after digital broadcasting starts, but still, around one million households are expected to find their reception impaired because of large buildings. As for community reception in multi-unit housing complexes, eight million households view television through this method. The figures suggest that digitization of all television households within a short period of time will be an extremely difficult task.

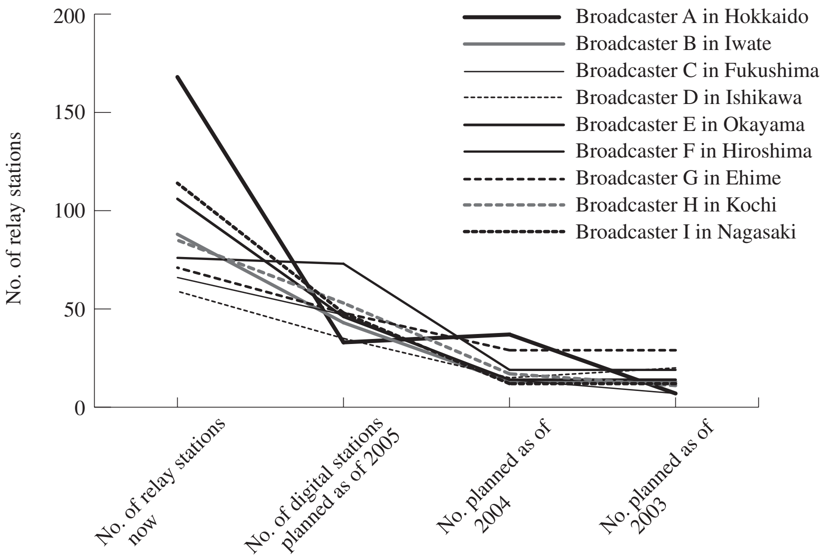
The report called digitization of relay stations "the most efficient means" of making digital broadcasts accessible but, given the limited time frame of five years, it also considered it "essential to make the best use of all possible supplementary measures, including cable TV, IP, and satellite services." According to the broadcasting companies' schedule, however, as of spring 2006 some 900 relay stations had yet to be digitized. The report, stated it was necessary to "make efforts to expand digital broadcasting coverage area by utilizing supplementary measures as much as possible while taking into account social costs, service content, viewers' needs, and so forth."

As shown above, conditions have gradually improved in favor of using supplementary measures. Let us now look at how, among a number of supplementary devices cited so far, gap-filler techniques came to be judged the most hopeful.

DIGITIZATION OF RELAY STATIONS

By December 2006 all the main broadcasting stations were transmitting digital terrestrial broadcasts to about 80 percent of all television households in

Figure 1. Broadcasters' Relay Station Digital Plan



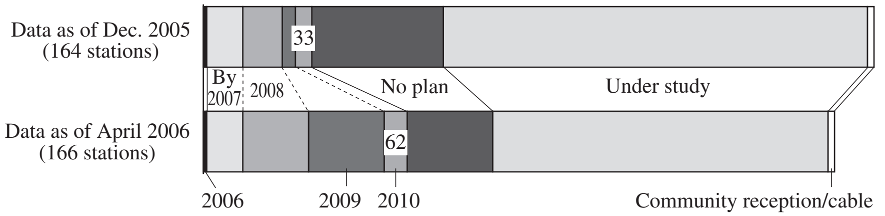
Japan. But as suggested by the results of NHK Broadcasting Culture Research Institute questionnaire conducted in March 2006, considerable difficulties are projected before all of the 14,000-odd relay stations in the country are able to do so.[2] Based on the results of the Institute's previous questionnaire surveys, Figure 1 shows the number of relay stations of local broadcasters as of the latest survey as well as the number they planned to digitize toward materialization of the sixth action plan announced in December 2006 by the National Council for Promotion of Digital Terrestrial Broadcasting. This chart indicates the difficulties for broadcasters in implementing the digital switchover for their relay stations.

Hokkaido's Challenge

Take Broadcaster A in Hokkaido, for example. Of its current 168 relay stations, the company answered in the Institute's 2003 survey that it would digitize only 7 stations, in the 2004 survey 37 stations, and in the 2005 survey 33 stations. "We expected to make the digital transition only at one 'parent station' and six 'key stations.' When we first received instructions from the national authorities, we were told that in areas like Hokkaido that have many

[2] The questionnaire survey, made in March 2006, targeted 127 television broadcasting companies, of which 102 companies, or 80.3 percent, responded.

Figure 2. Hokkaido Broadcaster Relay Station Digital Plan



locations with difficult signal reception it would be all right to achieve 85 percent digital broadcast area coverage. So our initial target was seven." (Person in charge of digitization at Broadcaster A, Hokkaido)

In Hokkaido, which accounts for 22 percent of Japan's land area, local broadcaster's relay stations are not only numerous but are high-power stations that cover a wide radius. Inevitably the unit costs for many stations are high. The number of relay stations it can digitize within the budgets at its disposal is inevitably limited, the company said.

Nevertheless, in the 2004 survey, the company answered that 37 of their stations would become digital, and as of the end of 2005, the commercial broadcasters in Hokkaido reached an agreement to put the number at 33 each. This figure represents a mere 20 percent of Broadcaster A's relay stations. "Following the strong request of the government, management discretion increased the number from the initial seven. Thanks to cost reductions made possible by joint construction with the other Hokkaido commercial broadcasters of digital relay stations, we were able to raise the number of stations to be digital. Management realities, however, makes it utterly impossible to achieve digital switchover for all the relay stations on our own resources." (Person in charge of digitization at Broadcaster A, Hokkaido).

In April 2006, the four commercial broadcasters in Hokkaido each increased the number of relay stations planned for digitization from 33 to 62 (Figure 2). That would cover 98 percent of households in the region, they said. The reason that the number of each broadcaster's relay stations decreased from 168 to 166 was due to the special characteristics of digital airwaves and realignment of relay stations. Cost reductions achieved through joint construction of main digital stations by the Hokkaido broadcasters made it possible to double the number of relay stations to be digital.

"The cost of digitization of relay stations itself will be 4 billion yen, and the total cost for transmission facilities will be over 5.4 billion yen. If the cost for broadcasting facilities is included, the burden on each broadcaster will be more than 10 billion yen. For a Hokkaido broadcaster whose ordinary annual income averages a little over 1 billion yen, making an investment worth 10 years' income would be extremely hard." (Same person as above) With the analogue shut down date soon to come, all the Hokkaido broadcasters were forced to make a very harsh decision.

Heavy Burden on Local Broadcasters

In Iwate prefecture, in both land area and number of relay stations the second largest next to Hokkaido, one broadcaster showed a large increase in the number of stations to turn digital from the initial 13 to 46 in 2005. "That was the result of government pressure. It has made certain that we will be in the red for five to six years. Within a short period of five years, we will have to shift to digital amid fierce competition among the four commercial companies in the region and without receiving public assistance as we did during the analogue era. Worse, the local economy continues its downward march. I can only say the situation is very, very harsh." (Broadcaster B in Iwate prefecture)

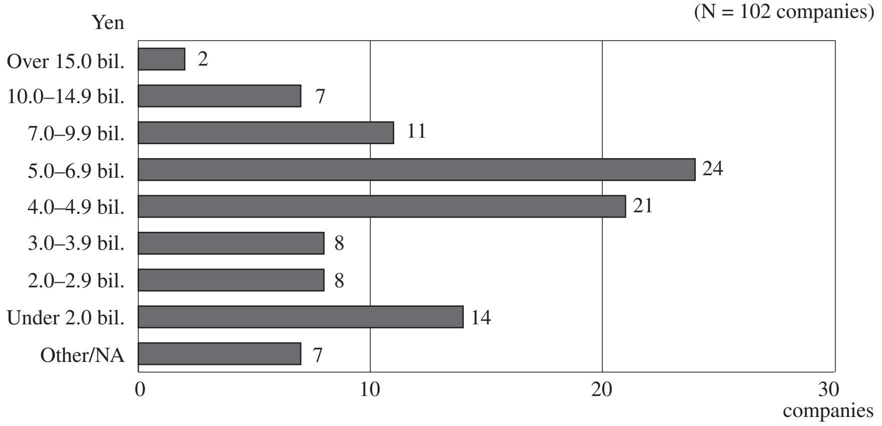
There are also many other broadcasters across the country that, as of the end of 2005, had greatly pushed up the number of relay stations they planned to digitize. Broadcaster C in Fukushima prefecture had brought the number of such stations up from 7 (the figure mentioned in the 2003 survey) to 47, a seven-fold increase. With Broadcaster D in Ishikawa prefecture, the figure rose from 20 to 35; Broadcaster E in Okayama prefecture from 14 to 46; Broadcaster F in Hiroshima prefecture from 19 to 73; Broadcaster G in Ehime prefecture from 29 to 48; Broadcaster H in Kochi prefecture from 11 to 53; and Broadcaster I in Nagasaki prefecture from 12 to 48. Thus, throughout the country there were many broadcasters showing a two- to seven-fold increase.

"At a strong request of the Ministry of Internal Affairs and Communications we increased the number from 14 to 47 at each of the commercial broadcasters in Fukushima. Initially we planned to digitize only 14 major stations, but because we were strongly pressed to achieve the 'same coverage as with analogue" we decided that the broadcasters would jointly construct 47 digital stations. With the initial plan, in our simulation, we either could manage to avoid falling into the red, or if we showed a loss we would be in the red for only two years. Under the current plan, however, we expect to show a deficit for five or more years." (Broadcaster C in Fukushima prefecture)

"Because our six major stations can cover 95 percent of our viewing households, we will digitize them on our own. Our large increase in the number of stations to be digitized to 35 is premised on the assumption that we will receive a government subsidy." (Broadcaster D in Ishikawa prefecture)

"At first we offered to digitize 14 stations at management's discretion, but the authorities urged us until we finally agreed to the [digitization of] 46 stations.

Figure 3. Commercial Broadcaster Digital Investment Amount
(in case of implementation of the 6th action plan)



We know we will be in the red for more than four years, starting around 2007." (Broadcaster E in Okayama prefecture)

In the same manner, the number of stations to be digitized was raised at Broadcaster F in Hiroshima, Broadcaster G in Ehime, Broadcaster H in Kochi, Broadcaster I in Nagasaki, among other broadcasting companies. They said they have gotten into financial difficulties as a result.

Measures to Survive the Difficulties

How do the broadcasting companies cope with the financial burden they thus bear? The following picture emerges from the questionnaire survey.

The cost of digitization estimated as of the time of the March 2006 survey was 10 billion yen or more at 9 companies, 5.0-9.9 billion yen at 35 companies, 2.0–4.9 billion yen at 37 companies, and less than 2.0 billion yen at 14 companies (Figure 3). The average cost will be over 5 billion yen.

The cost will be a huge financial burden. While slightly less than 30 percent of the broadcasters surveyed can absorb the cost using internal reserves, a majority will be forced to take out loans (Figure 4). One-third will have to obtain a loan equivalent to more than six years of ordinary income, and slightly less than 20 percent will need a loan equivalent to more than eleven years of ordinary income. From financial institutions' point of view, they are potentially bad-loan companies.

Even if they overcome the financial burdens and achieve all the planned digitization of relay stations, they would still cover only about 95 percent of their viewing households. What would they do about the remaining 5 percent,

Figure 4. Commercial Broadcaster Loans for Digital Investment
(in case of implementation of the 6th action plan)

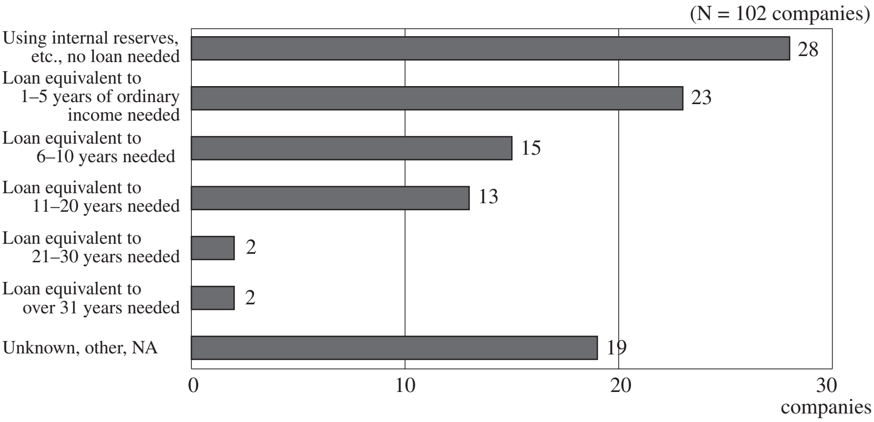
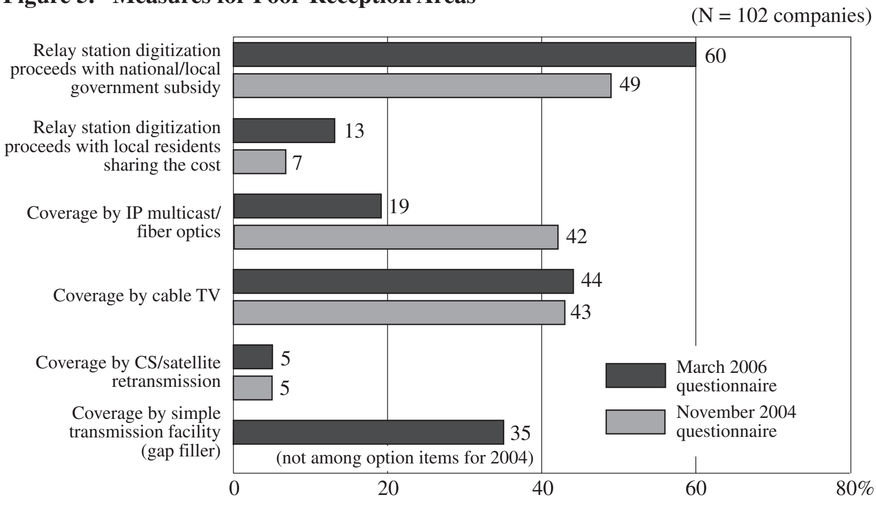


Figure 5. Measures for Poor-Reception Areas



the areas with poor reception of television broadcasts? The previous and recent questionnaire surveys asked about this question using a list of items offering almost identical options. The item most frequently selected was: "Digitization of relay stations will proceed with subsidies from national and local governments" (Figure 5). It is the national government's policy to achieve the switch to all-digital broadcasting within seven years and a half after the start of digital terrestrial broadcasting. The honest view of the broadcasting companies, which took some fifty years to construct their analogue relay station networks, are probably best expressed in the response of a digital affairs person in a Hokkaido broadcaster: "We will do our utmost, but then we will have no choice but to rely on the injection of public funds to support the project as a national policy."

The second largest number of broadcasting companies expects to rely on "coverage by cable television." There are now 18.88 million households with cable television of the type that provides independent broadcasting services.[3] If cable television providing retransmission services only is included, the spread of cable television now stands at more than half of television households. Given this reality, broadcasting companies apparently pin great hopes on cable television as a means of making up for the gaps in the digitization of relay stations.

With regard to supplementing by means of IP multicast as discussed in the second interim report, on the other hand, broadcasting companies' thinking changed greatly between the previous and recent NHK surveys. While 42 percent of the companies supported the idea of IP multicast in the 2003 survey, the percentage decreased by half, to 19 percent, in the 2006 survey, indicating their wariness about IP multicast. At a colloquium on communications and broadcasting[4] held by Internal Affairs and Communications Minister Takenaka Heizo it was argued that IP multicast would not be confined to the retransmission of digital terrestrial broadcasts and questioned whether the prefecture-based licensing system was still appropriate in the digital age. Afraid that the very foundations of their existence might be at risk, many broadcasting companies apparently answered negatively in the 2006 survey.

While the evaluation of IP multicast and CS digital broadcasting as supplementary measures ended up being low, "supplementing by gap-filler system," a newly added option item in the 2006 survey, by contrast received positive responses. Thirty-five percent of broadcasting companies chose this item. Considering that the feasibility of gap-filler systems is low unless local improvements are made in the information highway, broadcasting companies in locations with better information highway seem to have high hopes for this option.

[3] "(1-1) Keburu terebi no fukyu jokyo" [(1-1) Cable Television Penetration Trends], in *Keburu terebi no genkyo* [The Present State of Cable Television], Ministry of Internal Affairs and Communications, 2006.

[4] Chaired by Toyo University professor Matsubara Satoru, the colloquium has been discussing matters related to communications, broadcasting, and NHK since January 2006 with a view to making communications and broadcasting services more convenient. It convened 12 times as of the end of May 2006.

OFFICIAL VERIFICATION EXPERIMENTS

The Ministry of Internal Affairs and Communications conducted in fiscal 2005 a "survey research on digital terrestrial broadcast transmission using communications infrastructure: digital terrestrial broadcasting public application pilot project." Based on the survey results, a report on the details of verification experiments made in three locations (Iwate prefecture, Kochi prefecture, and the city of Mitaka, Tokyo) was compiled and published by the Nippon Telegraph and Telephone Corporation (NTT) in March 2006.

Outline of Experiments

In the experiments three kinds of surveys were conducted regarding digital terrestrial transmission via communications infrastructure: 1) on the linking of relay transmission lines, 2) on linking of subscriber transmission lines, and 3) IP multicast signal transmission.

Linking of Relay Transmission Lines

To verify whether or not existing communications infrastructure could be utilized as an alternative means, experiments were conducted of converting broadcast waves into different transmission systems and transmitting them to viewers or their nearest reception station by way of relay stations. Comparison was made between transport stream (TS),[5] radio frequency (RF),[6] and Internet protocol (IP)[7] transmission systems (Figure 6). The experiments dealt not only with the use of broadcasting companies' communications infrastructure but also with the use of existing facilities and infrastructure used by local governments.

Linking of Subscriber Transmission Lines

The RP and IP transmission systems were compared in the transmission of broadcast waves to communication service subscriber transmission lines. The image quality obtained when each of the two systems was linked to various existing networks, such as FTTH, ADSL, and CATV, was assessed. The "digital-wireless community-reception system" for transmitting broadcast waves locally to resolve reception difficulties was also inspected to assess its effectiveness as a means to combat impaired reception. In that survey, both cases in

[5] Transport stream is a signal that transforms multiple programs into a multiple stream.

[6] Radio frequency is wireless frequency. The TR system transmits digital terrestrial frequency as it is.

[7] The IP transmission system defines the Internet address structure and distributes and processes data.

Figure 6. Linking of Relay Transmission Lines

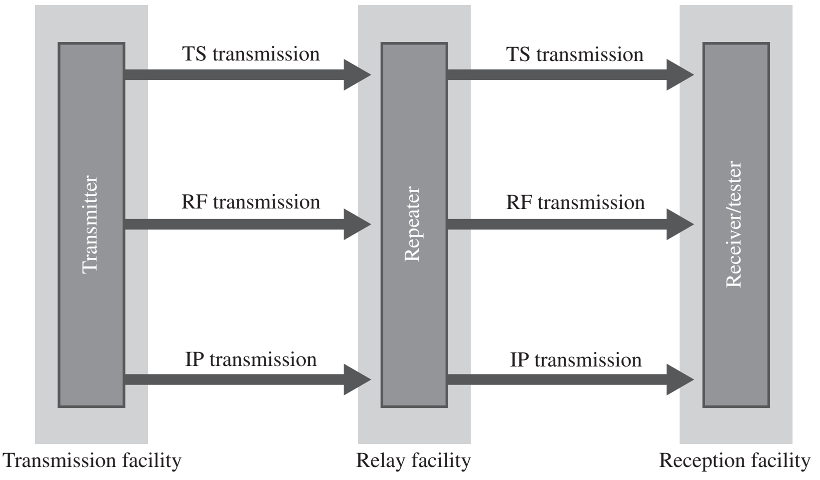


Figure 7. Linking of Subscriber Transmission Lines

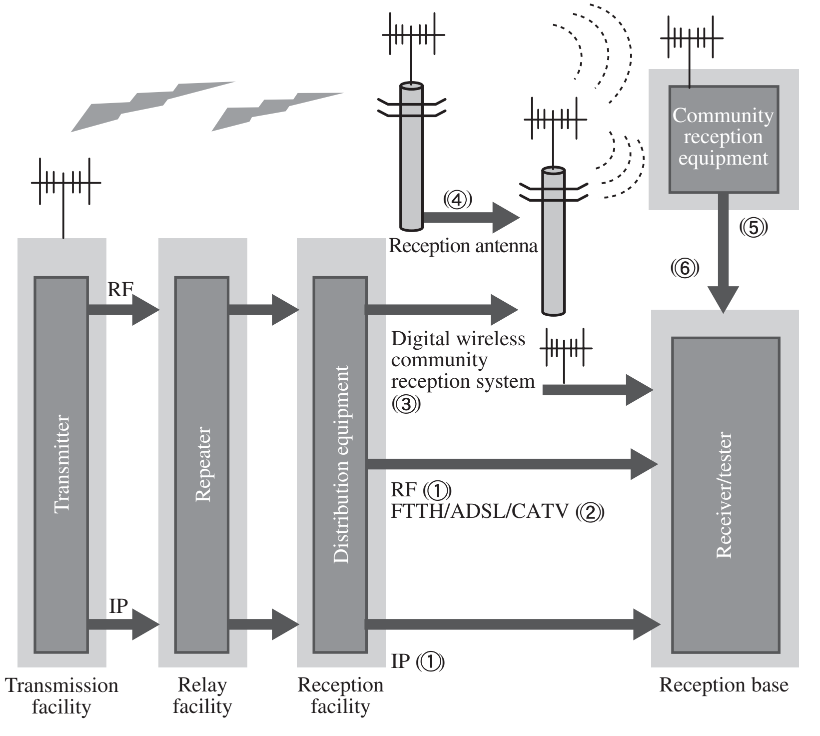
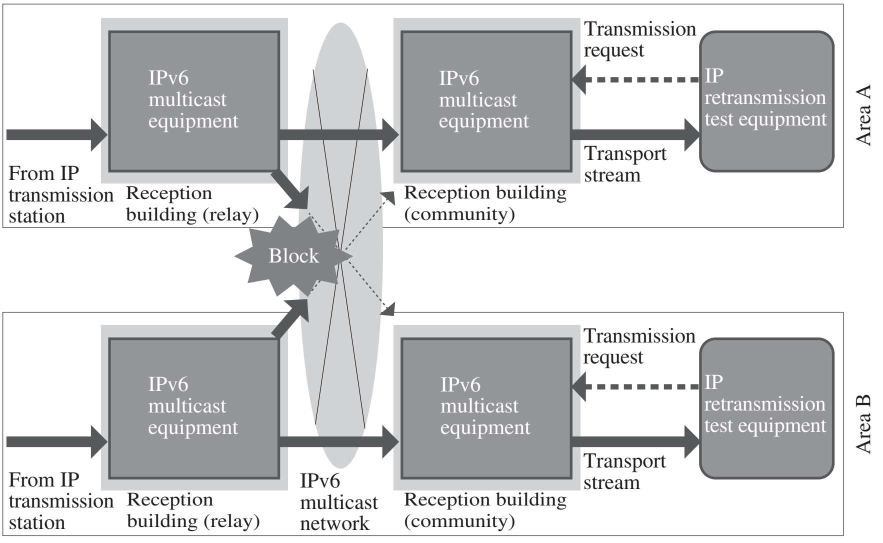


Figure 8. IP Multicast Signal Transmission



which broadcasts are received directly and in which broadcasts are received through community reception were assessed. Reception measures for mobile terminals were also tested. (See Figure 7.)

IP Multicast Signal Transmission

MIC considers IP multicast signal transmission as a broadcast supplement in areas suffering from poor-reception conditions as well as a measure for broadening television view options. The experiment consisted of technical evaluations of "limited broadcast distribution within broadcast service areas," "the principle of preserving same programming and services," "simultaneous transmission to all channels," "delay accompanying IP transmission technology," and "television navigation system." The operating and management dimensions were also examined. (See Figure 8.)

Results of the Experiments

The following conclusions were confirmed in the results of the MIC experiments.

Where the linking of relay transmission lines is concerned, all three (RF, IP, TS) transmission systems are feasible as means of supplementing terrestrial digitization. Regarding the linking of subscriber transmission lines, too, both

Figure 9. Characteristics of Transmission Systems

Transmission system	Characteristics
RF system	High connectivity and affinity for transmission with subscribers; unsuitable for long-distance transmission
IP system	High usability; good for long-distance transmission; worries about signal fluctuation, packet losses, delays, etc.
TS system	High-quality long-distance transmission possible; a dedicated line needed; subscribers need frequency modulation equipment

the RF and IP systems are feasible. Image quality is maintained in each case when linked to FTTH, ADSL, and CATV. Image quality will also be maintained in cases when: 1) a digital-wireless community-reception system is introduced, 2) wireless relay of the system is adopted, 3) the system is linked to community reception facilities, and 4) broadcasts are received by mobile terminals. Regarding IP multicast signal transmission, too, almost the same services will be provided, as in the case of television sets capable of receiving both analogue and digital terrestrial broadcasts. It has also been confirmed that the contents local governments write in html can be compiled as contents for broadcasting and distributed seamlessly. Further details are as follows.

Linking of Relay Transmission Lines

The testing on the RF, IP, and TS transmission systems has verified that each can achieve image quality suitable for digital terrestrial broadcasting. Besides conventional wireless signal transmission, the use of communications infrastructure has proven technologically feasible. Each of the transmission systems, however, has advantages and disadvantages. Because the RF method transmits existing wireless signals (RF signals) in their raw form, its connectivity and affinity for transmission with subscribers are quite high. The method is unsuitable for long-distance transmission, however, because RF signals are analogue and so the longer the distance the poorer the quality. (See Figure 9.)

The IP transmission system uses existing IP networks, reducing both investment and operational costs and taking advantage of high usability. With signals digitized, the multilayered connection of its relay equipment would not lower quality, making the system good for long-distance transmission. There are worries, however, about signal fluctuation, packet losses, delays, and other problems stemming from transmission networks, and a signal correction function would need to be installed.

The TS transmission system transmits original broadcast signals without being modulated for transmission. The experiment has shown that it enables long-distance transmission while maintaining high image quality. But, a dedicated line is needed for TS signal transmission, and furthermore, each reception facility that transmits broadcasts to subscribers needs a frequency modulation equipment, which will push up cost.

Linking of Subscriber Transmission Lines

The experiment has demonstrated that the transmission of broadcasts to communication service subscribers by each of the RF and IP methods produced normal sound and image results, and that there is little difference between the two methods. Transmitting actual broadcasts (five or more channels), however, requires either application of new image compression technology or wider broadband availability in the communications infrastructure. With the IP transmission method, line packet loss may be a problem, so an error-correction function for "low delay" may need to be built into the system. (See ① in Figure 7.)

The experiment made it clear that sufficient image quality is basically maintained even with connections to FTTH, ADSL, and CATV. With ADSL, however, as distance gets longer, packet loss increases, making television viewing that much more difficult. (See ② in Figure 7.)

The digital-wireless community-reception system, which transmits broadcast airwaves to local areas, has been proven to maintain good sound and image quality. However, the power output is 10 mW, and transmitted at a low height of 10 meters or so above ground. Therefore even if a reception point is only 500 meters away, electric field strength may not be adequate if forests and buildings intervene. (See ③ in Figure 7.)

In using the digital-wireless community-reception system, there are some cases in which broadcast waves are received or in which they are transmitted by a wireless relay system. In order to prevent float transmission from occurring, retransmission using vertically and horizontally polarized waves was tested, and these tests demonstrated that cross polarization measures are not necessary. (See ④ in Figure 7.)

The experiment on connection to community reception facilities confirmed its feasibility both with a pass-through system[8] and by using MID conversion technology[9]. (See ⑤ in Figure 7.)

[8] System for transmitting to community reception facilities the digital UHF signals in their raw form.

[9] System for transmitting to community reception facilities the digital UHF signals by setting the transmit frequency to the 108–170 MHz band.

As for mobile reception, the areas where conditions for reception are favorable are smaller compared with stationary reception, but it has been confirmed that mobile reception can be made possible in larger areas by using the digital-wireless community-reception system. (See ⑥ in Figure 7.)

IP Multicast Signal Transmission

The experiment with IP multicast confirmed that almost all the difficulties pertaining to retransmission of digital terrestrial broadcasts can be overcome. Specifically, it demonstrated that it is possible to achieve "limited broadcast distribution" in response to prefecture-based terrestrial TV licensing system and to preserve the "same programming and services." The system for protection of contents rights, it has been confirmed, can also be continued in the case of IP multicast signal transmission.

Where "simultaneous transmission of all channels" is concerned, because the channels are transmitted to the nearest local switch in the IPv6 multicast network, it is possible to watch whatever channels the viewer requests. Regarding "delay accompanying IP transmission technology," it has been found that the average delay is approximately 1.257 seconds more compared to a digital-compatible television set. Channel switching time at the terminal in the IP retransmission experiment was almost the same as that with a digital compatible television set. In other words, the testing verified that even in the case of IP retransmission, viewing pleasure is not lost. The television navigation system—such as display of the EPG (Electronic Program Guide) screen that shows what programs are currently being aired on each channel, and allows the viewer to move directly to the channel he/she wants to watch—was confirmed as providing the same services as for digital compatible television.

VERIFICATION EXPERIMENTS IN KOCHI

The MIC experiments on digital terrestrial transmission using communications infrastructure has confirmed that there are no technological problems with the supplementary measures it tested. On the other hand, the Kochi prefecture survey research project, the results of which were compiled into a report published in March 2006, performed comparative studies to find out which supplementary measures were more realistic and feasible, focusing on the communications infrastructure not only from a technological viewpoint but also in terms of cost.

As a result, while the MIC experiments concluded that all the supplementary methods it had tested were possible, the Kochi report clearly showed what was the best option, given local conditions. It concluded that it would be best to combine digitization of existing community reception facilities with a gap-filler system that would be cost-efficient in a long run. This conclusion was supported by understanding of the background situation and interpretation of the experiment results as follows.

Broadcasting Situation in Kochi

Kochi prefecture has a population of 796,196 with 324,286 households. It has a long configuration east to west, bordered on the north by the Shikoku Mountain Range and with its southern side facing the Pacific Ocean. It has 713 kilometers of convoluted coastline. For most of the coastline, although interspersed with small plain areas, the mountains rise up sharply from the sea. With a forest-coverage ratio of about 84 percent, Kochi is the most densely forested prefecture in Japan.

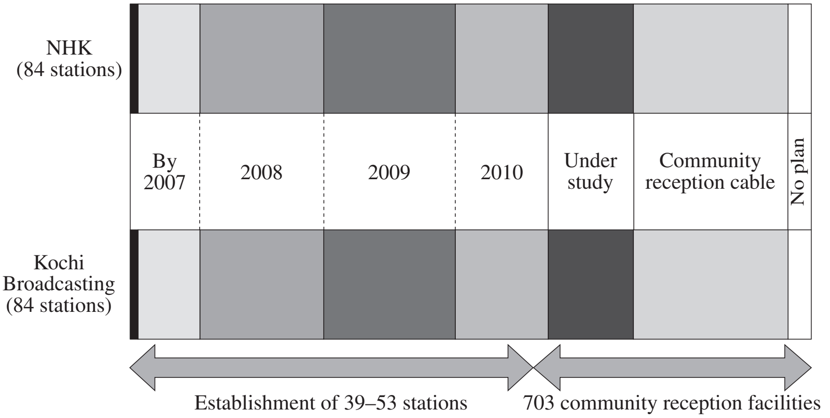
Due to these topographical conditions, local networks of digital terrestrial broadcasting relay stations face complex circumstances. The number of analogue transmitting and relay stations in Kochi is 93 for NHK and 86 for Kochi Broadcasting Co. Ltd. (one of three local commercial broadcasters). The greatest challenge for digitization in this region is the presence of numerous poor-reception areas. Kochi is one of the prefectures with the highest number of community reception facilities in Japan. Some 29,446 households, or 9 percent of households in the prefecture, use these facilities.

NHK and the local commercial broadcasters plan to jointly construct 53 digital relay stations (Figure 10), which are expected to bring the digital coverage ratio to 93.7 percent of households. The problem is how to digitize the community reception facilities located in the areas for the remaining 6.3 percent of the households. Some 30 percent of community reception facilities, numbering an estimated 211, in the prefecture are so out-of-date that they will have to undergo major overhauls by 2011. By that year 656 facilities will be receiving digital waves. This leaves 34 facilities outside the digitization timetable, and something must be done about them. These are the circumstances under which broadcasters must grope for the most effective means to achieve full-scale digitization.

Simulations of Better Infrastructure

In order to determine the optimal way to improve the digital infrastructure, the Kochi prefectural government made a trial calculation of the cost, using the Ino-cho area of Kochi city as a model district. The main supplementary methods for digital terrestrial broadcasting it considered were: cable television; IP multicast; via satellite; community reception facilities; and digital wireless community reception system.

Figure 10. Relay Station Digital Plan in Kochi



Compiled from the website of National Council for Promotion of Digital Terrestrial Television Broadcasting and other sources. (As for commercial broadcasting networks, data from Kochi Broadcasting Co. Ltd. is used.)

Cable Television

If cable television were to be provided to all the villages and other locations outside the areas to be covered by digital broadcasting, the required cost per household would be an estimated ¥710, 000 yen. Generally, it is said, installment of cable television in an area of high household density would cost ¥200,000 to ¥300,000 per household. Obviously the cost would be much higher for mountainous regions. The prefecture decided that investment efficiency for cable television is low compared to community reception facilities and that, therefore, installation of cable television in poor-reception locations is not appropriate.

IP Multicast

Retransmission of digital terrestrial broadcasts by IP multicast is premised upon fiber-optic network infrastructure. In Kochi prefecture, two commercial broadcasters and the Ministry of Land, Infrastructure and Transport have their own prefecture-wide optical networks. Where mountainous regions are concerned, however, infrastructure is very limited, and achieving 100 percent coverage of all households in these areas requires a huge additional investment.

Kochi prefecture's estimation for this method is that the cost will be too high and that, like cable television, the introduction of IP multicast in poor-reception areas will be extremely difficult unless the central government helps to improve fiber-optic infrastructure.

Via Satellite

For digital terrestrial broadcasts to be transmitted via satellite, each household will need a reception antenna or a digital set-top box. It will be necessary for terrestrial broadcasting companies not only to install satellite relay equipment for five Hi-Vision channels but also to either set up a terrestrial transmission facility aiming in the direction of a satellite or transmit broadcasts to a satellite base station far away.

That method does have the merit that broadcasts can be transmitted over a wide area. However, the cost to be shouldered by broadcasting companies and viewers will be quite high. Considering this point, Kochi prefecture decided that the "via satellite" method would not be a feasible measure against poor reception.

Community Reception

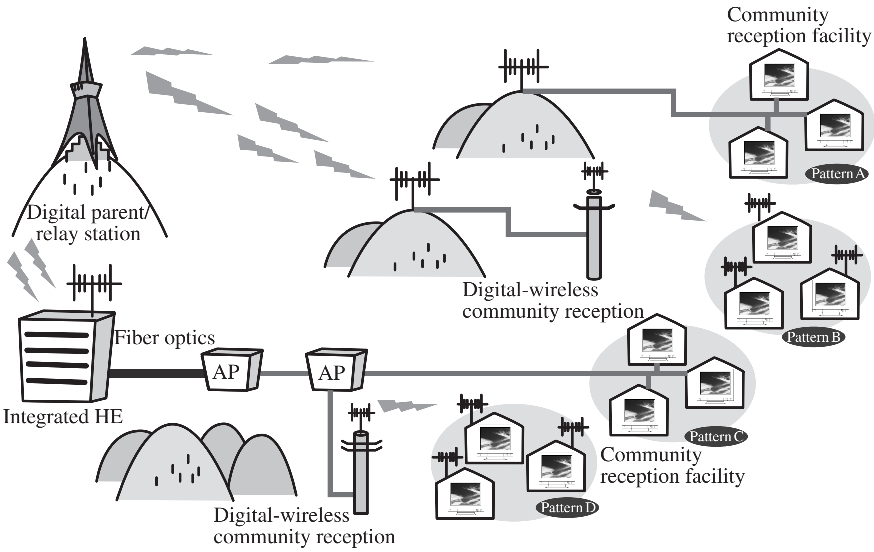
Regarding utilization of existing community reception facilities, it will be necessary to decide, for each facility, whether it will require remodeling only on a small scale (simple digitization) or need large-scale modifications or have to be completely rebuilt, depending on the degree to which it is outmoded. According to the prefecture's criteria, facilities with a reception point to be reached by the digital waves that were repaired (or newly established) less than 20 years prior to 2010 will be repaired on a small scale. Facilities 20 years old or older prior to 2010 and facilities whose reception point the digital waves cannot reach will have to be either drastically repaired or completely rebuilt.

In the case of the prefecture's Ino-cho area, of all 53 facilities it was judged that 36 would need small-scale repair and 17 would need either large-scale repair or rebuilding. As a result, the minimum cost of making the entire Ino-cho area go digital was estimated to cost 210 million yen, or 97,000 yen per household, half to one-third the cost of laying cable television lines in a densely populated area. Estimated cost on the basis of all the households with access to the existing reception facilities in the entire prefecture would be approximately 2.86 billion yen.

Gap Filler

As for transmission via gap-filler system (the digital-wireless community-reception system), patterns B and D, shown in Figure 11, will be available. If

Figure 11. Use of Community Reception as Supplement



only pattern B is adopted, the cost will be relatively low because all that needs to be done will be set up transmission facilities for digital wireless reception. In the case in which existing reception facilities do not receive digital waves, however, pattern D will have to be introduced. In that case, the cost of building an integrated head-end system and the cost of laying fiber-optic lines will have to be figured in.

Kochi prefecture made a provisional calculation of the amount needed for replacing community reception facilities in Ino-cho by digital-wireless reception systems: it came out to 395,060,000 yen, or 174,000 yen per household. This is a lower cost than when cable television lines are laid in a densely populated area, but is nearly two times higher than in the case of using community reception facilities.

Long-term Perspective

It has become clear that, as a supplementary measure to be taken by the year 2010, the gap-filler system will cost more than community-reception-facility-centered measures. In long-term perspective, however, a different picture will emerge.

Community reception facilities will need to be remodeled within 20 years of their establishment or repair. In Kochi prefecture most of such facilities will have to be renewed by 2020, and therefore a simulation was performed to calculate the estimated cost through to the year 2020. As a result, it was found that if Ino-cho were to adopt community reception facilities as the main supplementary means for digital switchover by 2010, the estimated cost of the facilities that would have to be repaired by 2020 was ¥110 million, whereas if the gap-filler system were adopted for the 2010 switchover, the additional costs that would be borne by 2020 would be only 57 million yen. The total cost for the period through to the year 2020 is ¥421 million for the former and ¥452 million for the latter, which means that the cost difference between them will decrease to as low as ¥31 million, or about ¥14,000 per household.

Moreover, if the gap-filler measure is adopted nationwide and mass production of equipment begins, large-cost reductions can be expected, and maintenance fees will also be much lower. With community reception facilities, "one-segu" services (broadcasts transmitted to mobile terminals using one of the 13 segments of the spectrum allocated for digital terrestrial broadcasting) could not be received at mobile terminals, but there would be no such problem with gap filler.

Taking all these factors into consideration, the prefecture's report calls for adequate attention to be paid to the different short-term and long-term considerations in updating community reception facilities. It suggests, in other words, a higher readiness to introduce gap filler systems, although some uncertainty remains.

DISCUSSIONS IN HOKKAIDO

Hokkaido shows even more interest in gap filler. In March 2006 a study group to discuss how to introduce gap filler as a means of overcoming poor reception of television broadcasts was organized with the participation of local television broadcasting companies, MIC, the Ministry of Land, Infrastructure and Transport (MLIT), MLIT's Hokkaido Regional Development Bureau, the Hokkaido prefectural government, the Sapporo city government, and so forth.

Background for Discussion

Modifying analogue relay stations to digital operation will be difficult in Hokkaido, a vast prefecture that makes up 22 percent of Japan's total land area. As of January 2003, it was initially estimated that digitization of relay stations—each local broadcasting company has about 170 relay stations—would cost each company 9.1 billion yen. But the cost estimated as of March 2005 was reduced to 6.13 billion yen, and each commercial broadcaster considered it possible to digitize 37 relay stations, which, according to their calculation, would cost 4 billion yen per company. (See Figure 12.)

Figure 12. Estimated Costs of Digitization of Relay Stations
(5 commercial broadcasters in Hokkaido)

	No. of stations	Coverage	Total coverage	Construction cost per company	
				Estimated as of Jan. 2003	Estimated as of March 2005
Parent station	1 (Sapporo)	48%	48%	¥0.92 bil.	¥0.58 bil.
Key station	6 (Hakodate, Muroran, Asahikawa, Obihiro, Kushiro, Abashiri)	31%	79%	¥3.56 bil.	¥2.13 bil.
Relay station (large, medium-size, small, satellite)	119	19%	98%	¥4.48 bil.	¥3.3 bil.
Relay station (mini-satellite)	45			¥0.14 bil.	¥0.12 bil.
Total	171	98%		¥9.1 bil.	¥6.13 bil.

Compiled from data from the Hokkaido Commercial Broadcasters' Digital Promotion Colloquium

Later, partly due to the broadcasters' plans for joint construction of digital relay stations and partly due to reduced prices of parts, as of April 2006 each company planned to increase the number of digital relay stations to 62. More than 100 relay stations for each company in Hokkaido, however, would go undigitized.

From early on gap filler has been considered to be a supplementary device for those poor-reception areas that will not be able to receive digital broadcasts even after analogue relay stations switch to digital transmission (Figure 13). In the case of Hokkaido, so many relay stations will be left undigitized that the study group held in-depth discussions about adoption of gap-filler measures, finally reaching conclusions in July 2006. The following two sections examine the case of Hokkaido in more detail, based on the group's final report.

Direction of Discussion

As mentioned earlier, Hokkaido's commercial broadcasting companies answered as of April 2006 that they each would digitize 62 stations, spending 4 billion yen. The remaining 103 stations, each company said, would need government assistance. In other words, they by themselves will digitize their

Figure 13. Scale of Digital Transmission Stations

Category	Name	Scale
Parent station	Parent stations (approx. 50)	Major stations of over 3 W
	Large, important stations (approx. 500)	
Relay station	Small stations (approx. 1,500)	Under 3 W
(Supplementary)	Gap filler systems (for areas with poor-reception conditions)	

Figures in parentheses are numbers per broadcasting network

main broadcasting stations in large cities such as Sapporo, Hakodate, Asahikawa, and Kushiro as well as relay stations in smaller regional cities including Nayoro, Noboribetsu, and Nemuro. But they could not afford to do the same in remote areas with poor-reception conditions. (See Figure 14.)

In those areas they plan to use gap filler to supplement digitization of some of small and medium-size relay stations and of “mini satellite” stations. The study group’s final report states: “Adopting gap filler for mini-satellite stations alone would not be very effective in terms of cost reduction. So, assuming a higher level of gap filler performance than previously contemplated, we also considered using it for small and medium-size relay stations as well.”

The gap filler chosen for the Kochi prefecture plan was a low-power transmission system of only 10 mW. Hokkaido, on the other hand, is planning to install a 50 mW gap filler system for small and medium-size relay stations. The gap filler coverage is set at “within 2,000 households.” That means that Hokkaido has in mind a facility large enough to cover 4,000 to 5,000 people.

Cost Comparison

Costs involved in the adoption of a Hokkaido-version gap filler were calculated as follows: cost of equipment ¥7.5 million, cost of construction ¥9.0 million, totaling ¥16.50 million. Equipment cost is relatively high because adoption of gap filler for small and medium-size relay stations would require a higher-performance antenna than in the case of a 10 mW gap filler. Construction costs, too, are relatively high because access to fiber-optic networks laid by MLIT along roads is premised upon, and connecting to an underground access point would require complicated construction work. (See Figure 15.)

Figure 16 shows the costs required if a 50 mW gap filler is installed, according to the final report. In the case in which the broadcast waves received from a nearby relay station are delivered via fiber-optic cable to one

Figure 14. Hokkaido Commercial Broadcaster Relay Station Construction Plan

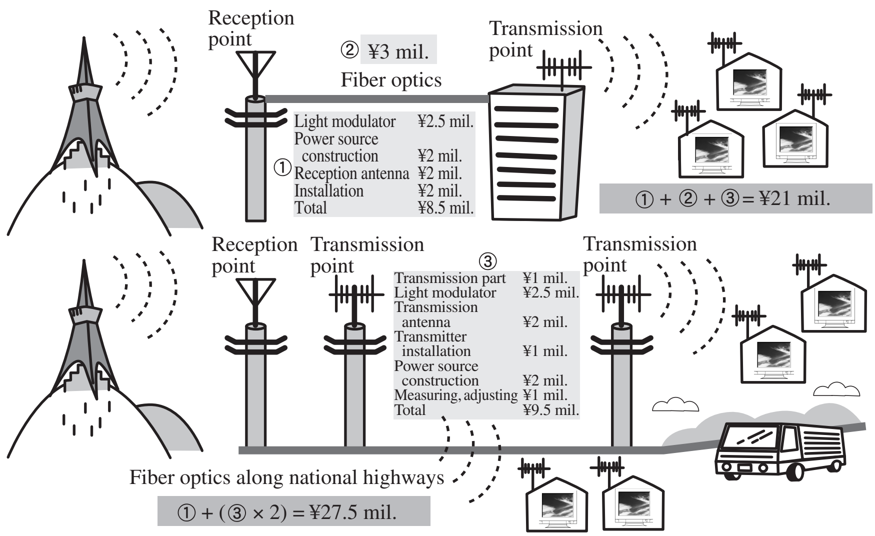
	Large station	Small station	Total no. of stations/ coverage rate	Company-funded construction	Construction needing assistance	Construction location
2006	1		1 50.2%	1 50.2%	0	Sapporo
2007	9	2	11 86.1%	11 86.1%	0	Muroran, Hakodate, Asahikawa, Kushiro, Obihiro, Abashiri, etc.
2008	19	1	20 93.6%	20 93.6%	0	Niseko, Ashibetsu, Shizunai, Noboribetsu, Nayoro, Ashoro, etc.
2009	22	28	50	23 96.8%	27	Toya, Yoichi, Furano, Nemuro, Hiroo, etc. / Erimo, Biratori, Akan, Assabu, etc.
2010	8	34 41	83 98.4%	7 97.0%	35 41	Matsumae, Maruyama, Minami-yotei, etc. / Shimamaki, Kuromatsunai, Rebun, Toyoura, Shimukappu, Kunneppu, etc.
Total no.	59	106	165	62	103	

Figure 15. Costs of Gap Filler System
—Estimated Basic Costs—

Equipment costs		Construction costs	
Gap filler transmitter	¥1 mil.	Installation of transmitter	¥1 mil.
Light modulator	¥2.5 mil.	Power source construction	¥2 mil.
Transmission antenna	¥2 mil.		
Reception antenna	¥2 mil.	Installation of receiver	¥2 mil.
		Measuring of sites, adjusting	¥1 mil.
		Optical fiber construction	¥3 mil.

*Reception antenna construction = antenna + light modulator + installation + power source construction + adjustment
*Transmission antenna construction = antenna + transmitter + installation + power source construction + adjustment
*Not including costs of using fiber optics and electric poles.

Figure 16. Examples of Gap Filler Use in Hokkaido



transmission point (gap filler), the total cost of equipment and construction will be ¥21 million. If the waves are delivered to two transmission points, the cost will be ¥27.5 million. If a 50 mW mini satellite station is built, one transmission point will cost more than ¥10 million, and assuming reception of NHK channels plus five commercial broadcaster channels, the total cost will be around ¥100 million. We can see, therefore, that in the case of gap filler, which would require between 20 and 30 million yen, the cost will obviously be much lower.

Figure 17. Cost Reduction by Adopting Gap Filler

	53 stations	S. Hokkaido	Muroran	N. Hokkaido	E. Hokkaido	C. Hokkaido	Unit: mil. yen
Conventional construction cost (no. of stations)	1W	26.50 (1)	38.75 (2)	64.36 (3)			
	0.3W		44.25 (2)	43.95 (2)	127.92 (6)	15.93 (1)	
	0.1W	17.60 (1)	20.15 (1)	16.06 (1)	17.62 (1)	38.78 (2)	
	0.05W	14.60 (1)				15.84 (1)	
	0.01W	6.00 (2)	19.22 (7)	25.20 (9)	8.40 (3)	19.16 (7)	Total 580.29 (53)
	Total for each area	64.70 (5)	122.37 (12)	149.57 (15)	153.94 (10)	89.71 (11)	
Cost using gap filler	1W	3.65	8.22	9.43			
	0.3W		9.58	5.14	24.85	2.50	
	0.1W	2.50		3.07	4.29	5.00	
	0.05W	1.15				2.93	
	0.01W	4.10	13.57	18.93	7.86	14.28	Total 141.05
	Total for each area	11.40	31.37	36.57	37.00	24.71	

Difference in cost between “conventional” and “gap filler”: ¥439.24 mil.

The study group in Hokkaido also made a cost comparison, premised on the installation of digital wireless community reception systems for 53 of the 103 relay stations for which each commercial broadcaster wants government assistance (Figure 17). According to the group’s calculation, digitization of the 53 stations would cost ¥580 million per company, whereas adoption of digital wireless reception would cost ¥140 million per company, the difference being as much as ¥440 million.

In Hokkaido, MIC had initially conducted studies from the latter half of 2005 on whether CS digital broadcasting could be used as a supplementary medium. Broadcasting companies had shown stiff resistance to using satellites, however, partly because of the issue of whether or not data broadcasts could be retransmitted and partly because “one segment” services would not be accessible. The gap filler system considered by the study group would resolve these problems, and in addition could be adopted at lower cost than other methods. The likelihood looms larger in Hokkaido that gap fillers will be adopted not only for existing community reception facilities, as in the case of Kochi prefecture, but also for small and medium-size relay stations and mini-satellite stations.

CONCLUSION

We have discussed the technological feasibility of various supplementary measures that might be introduced to make digital terrestrial airwaves accessible in poor-reception areas, as well as their realistic evaluation in terms of cost. Among them the gap-filler method is increasingly viewed as the most feasible option, as suggested in the third interim report by the MIC Information and Communications Council. Some problems remain to be overcome before it can be introduced nationwide. They include building fiber-optic infrastructure, which is a precondition for the gap-filler method, and its legal regulation.

In order to deliver broadcasting signals effectively from a reception point (integrated head-end, etc.) to a transmission point (gap filler), fiber-optic lines are needed, and moreover, fiber optics must be made available at low price. The challenge to be tackled now is how to set up this mechanism.

Under current laws, transmission facilities of less than 250 mW do not fall under the category of relay stations. On what legal basis will a gap-filler apparatus be able to transmit broadcasts? Wireless facility license requirements and other such legal problems need to be resolved. Much work remains to be done in this respect by administrative authorities and broadcasting companies.

In December 2005, the National Council for Promotion of Digital Terrestrial Television Broadcasting announced its "Roadmap" for digitization of relay stations. It released a revised version in April 2006. Another revised version came out in Dec. 2006. Studies will continue to be conducted with a view to achieving 100 percent digital coverage of areas that have received analogue broadcasts. The "Roadmap" will be upgraded and made more sophisticated each time it is announced in 2008 and 2010. Transmitting digital airwaves from relay stations is the foundation of the broadcasting industry. All possible effort should be applied to this area as well.

Be that as it may, terrestrial television broadcasting, which will shut down analogue transmissions by 2011, has become a familiar popular medium and has had a tremendous impact on the real world. With top priority given to the benefits of viewers and a high level of transparency maintained in decision-making processes, we look forward to the successful transition to all-digital broadcasting.

(*Translated by Center for Intercultural Communication*)