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Initial Results of the Japanese Broadcast Satellite (BSE, "Yuri") Experiment

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The Japanese Medium-Scale Broadcasting Satellite for Experimental Purpose (BSE), or Yuri, was launched successfully on April 8, 1978 JST. The BSE was stationed on April 26 at the predetermined geostationary orbit position, 110-deg east longitude. After the initial check of the satellite function, various kinds of satellite broadcasting experiments started on July 20, 1978. The experiments will be conducted for three years in order to obtain the technical data necessary for establishing future operational domestic satellite broadcasting systems. Most parts of experimental items planned in the BSE program have been carried into operation. This paper will present the results of BSE experiments which have been obtained heretofore along with a brief description of future experiment plans.

Introduction

THE Japanese Medium-Scale Broadcasting Satellite for Experimental Purpose (BSE) was launched successfully on April 8, 1978 JST from the Eastern Test Range of the U.S., using a Delta 2914 launch vehicle. After several precession maneuvers, the apogee kick motor (AKM) was fired at the third apogee and put into the drift orbit.

On April 26, the BSE was stationed at the predetermined geostationary orbit position, 110-deg east longitude. The BSE is held within the accuracy of ± 0.1 and ± 0.2 deg in orbit position and antenna beam pointing, respectively.

The BSE is a three-axis stabilized spacecraft weighing about 350 kg in orbit. It has two sets of Ku-band (14/12 GHz) transponders with 100-W output power, and a uniquely shaped beam paraboloidal antenna for color TV broadcasting.

On July 20, 1978, various kinds of satellite broadcasting experiments were started. The experiments will be conducted for three years in order to obtain the technical data necessary for establishing future operational domestic satellite broadcasting systems.[1] Prior to the BSE, CTS of a joint U.S./Canadian program was launched in January 1976, and some broadcasting experiments using 12- and 14-GHz bands were conducted.[2]

The Earth terminals which participate in the BSE experiments are the main transmit and receive station (MTRS), two types of transportable transmit and receive stations (TTRS's, type A and B), three types of receive only stations (ROS's), and many simple receive equipments (SRE's).[3]

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Since the beginning of experiments, most parts of experimental items planned in the BSE program have been carried into operation.

The main experimental items of the BSE program are experiments on the evaluation of broadcasting service area, TV signal transmission, radio wave propagation, frequency sharing, satellite broadcasting signal reception, control and operation of satellite broadcasting systems, and so on.[4]

Details of the results of these experimenal items will be described in the following sections.

Experiments on the Evaluation of the Broadcasting Service Area

The service area can be evaluated by measuring the field strength and received TV signal quality at many places throughout Japan. The satellite antenna has a suitable radiation pattern for providing high quality color TV broadcasting services to the whole Japanese territory. Figure 1 shows the BSE antenna radiation pattern and locations of the various Earth terminals which participate in the BSE experiments plotted on a map of Japan.

The main transmit and receive station (MTRS) is located in Kashima, which provided not only TV signal transmission and reception, but also Ku-band TT&C operation for experimental purposes. The receiving stations (ROS's and SRE's) usually receive TV signals which are transmitted from MTRS or TTRS's. For TV reception tests, additional SRE's of about 30 are further incorporated.

The measurements of the received carrier level, video signal-to-noise ratio, and TV signal quality assessment have been carried out by MTRS, TTRS's, ROS's, and SRE's. One example of measurement results is shown in Table 1.

Experiments on TV Signal Transmission

Satellite Transponder Characteristics

To measure the initial performance and time variation of satellite transponder characteristics, an initial check and periodical checks per every half-year have been performed. These

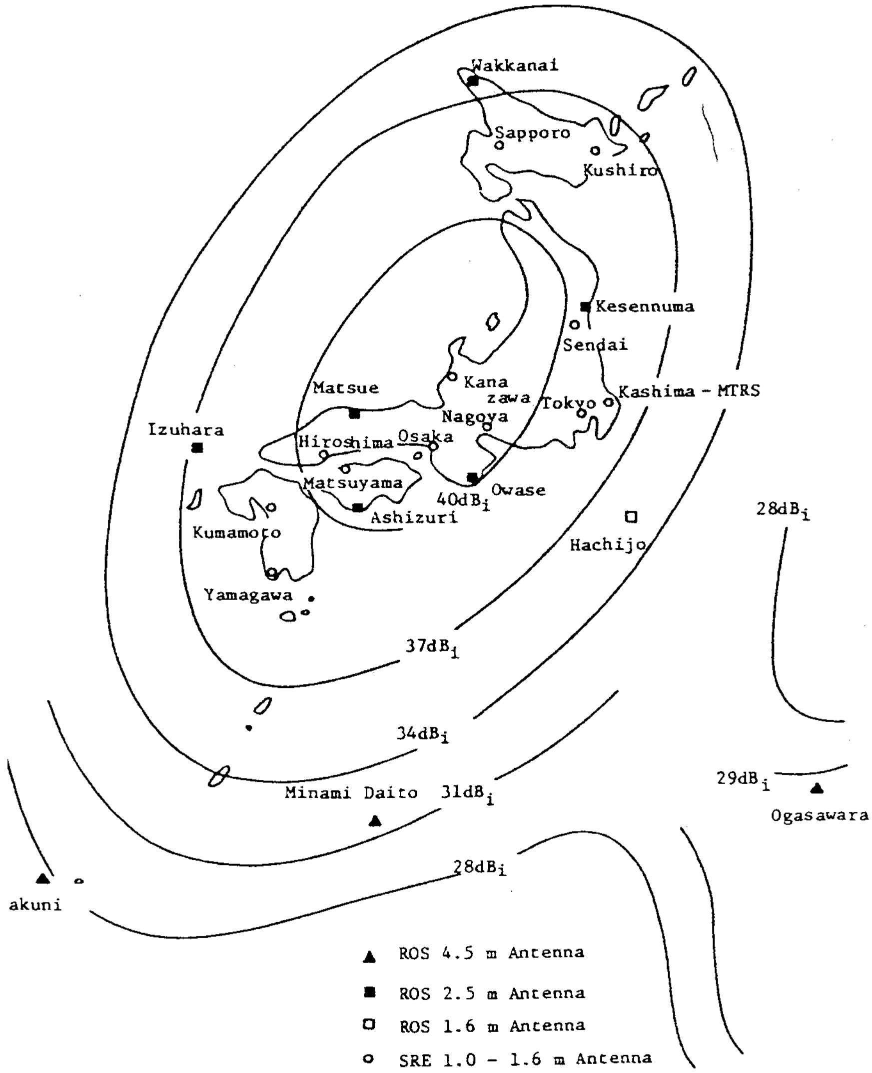

Fig. 1 BSE antenna radiation pattern and ground station location.

Table 1 Measurements of received television signal characteristics

Location	Station	Antenna diameter, m	Received carrier level: Calculated, dBm	Received carrier level: Measured, dBm	Weighted S/N, dB
Kashima	MTRS	13	−59.9	−(59.8-60.2)	59
Osaka	TTRS A-type	4.5	−66.7	−(63-64.5)	58
Tokyo	TTRS B-type	2.5	−74.0	−(73-74)	54
Wakkanai	ROS	2.5	−75.9	−(77.5-81.2)	47
Kesennuma	ROS	2.5	−72.8	−(72.8-74.4)	48
Owase	ROS	2.5	−71.2	−(72.4-74)	50
Matsue	ROS	2.5	−70.6	−(72-73)	49
Ashizuri	ROS	2.5	−70.6	−(69.7-71.3)	54
Izuhara	ROS	2.5	−73.1	−(75.4-76.2)	49
Ogasawara	ROS	4.5	−75.3	−(78.6-81.6)	45
Yonakuni	ROS	4.5	−79.1	−(77.5-79.5)	48
Minami Daito	ROS	4.5	−74.2	−(73.5-74)	51
Hachijo	ROS	1.6	−80.7	−(81-83.3)	45

checks include input-output characteristics (linearity, AGC characteristic, etc.), output characteristics (intermodulation, mutual modulation, spurious emission, etc.), amplitude characteristics, delay characteristics, frequency stability, and noise characteristics.

The measurement results of all these characteristics were satisfactory. The variation of satellite output power measured from July 1978 to March 1979 was less than ±0.5 dB.

Standard TV Signal Transmission

Radio Frequency Transmission Characteristics

To clarify the rf transmission characteristics of satellite transmission links, various characteristics have been measured at the main station. These include level diagrams of satellite links; transmitting power and its variations in up- and down-links; carrier-to-noise (C/N) and signal-to-noise (S/N)

Table 2 BSE link budget

	MTRS	Mainland	Remote islands
Up-link (MTRS to BSE)			
MTRS, E.I.R.P., dBm/ch		112.2	
Free space loss, dB		−207.4	
Rx. antenna gain, dB		38.1	
Noise power, dBm/25 MHz		−92.9	
Up-link C/N, dB		35.8	
Down-link			
Service area	MTRS	Mainland	Remote islands
Antenna of Rx., m	13.0	1.6	4.5
Tx. power, dBm/ch	...	50.0	...
Tx. feeder loss, dB	...	−1.7	...
Tx. antenna gain, dB	37.6	37.0	28.0
Free space loss, dB	−205.9	−205.8	−205.4
Rx. antenna gain, dB	61.9	43.0	53.5
Received carrier power, dBW	−58.1	−77.5	−75.6
Noised power, dBm/25 MHz	−96.4	−97.3	−96.6
Down-link C/N, dB	38.3	19.8	21.0
Total C/N, dB	33.9	19.7	20.9
TV signal quality			
FM improvement factor, dB	...	18.6	...
Emphasis improvement factor, dB	...	2.9	...
Unweighted S/N, dB	55.4	41.2	42.4

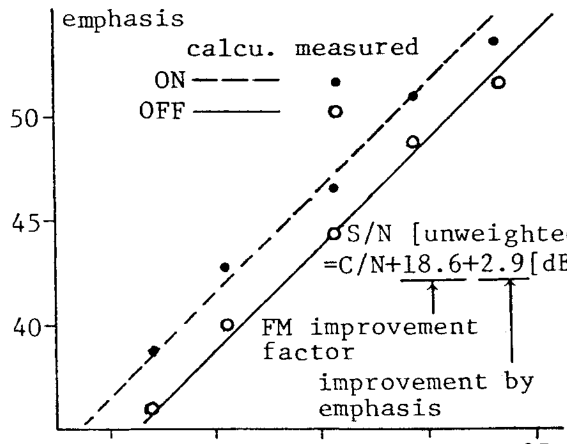

Fig. 2 Relation between C/N and S/N ratios.

ratios in up, down, and overall links; frequency characteristics [amplitude, delay, differential gain (DG), differential phase (DP)]; transponder input-output and frequency stability; spurious and intermodulation characteristics; and so on.

Here several representative characteristics will be described. As level diagrams are the most fundamental characteristics, they have been measured from the initial check period up to the present.

An example of radio frequency link levels between the MTRS and the BSE is shown in Table 2. The results show good correspondence with calculated design values.

At the main station, C/N is usually very high compared with other satellite links. So C/N can be measured over a very wide range in the BSE links. C/N in uplink can be estimated from EIRP of the main station, and also from telemetry data of the satellite. Both estimated C/N values coincide within tolerances of 1-2 dB, which correspond to telemetry quantization errors.

Figure 2 gives the relation between the C/N and S/N ratio. Measured values coincide fairly well with calculated curves, and the improvement effect by emphasis (2.9 dB) is also apparent.

It is fundamental to examine the frequency characteristics of the amplitude, delay, DG, and DP to know the satellite links characteristics for transmitting FM television signals.

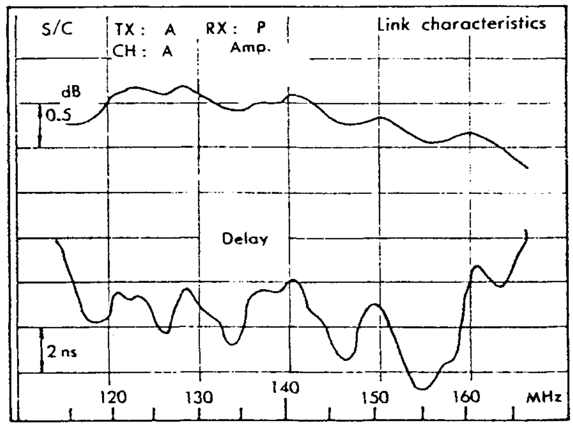

Fig. 3 Amplitude and delay characteristics of link.

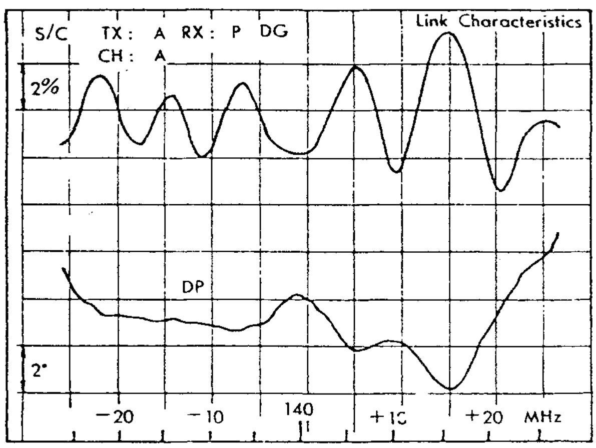

Fig. 4 DG and DP characteristics of link.

In the satellite loop-back measurements, characteristics of both the satellite transponder and the Earth station are mixedly measured. The characteristics of the satellite transponder are obtained by subtracting the characteristics of the Earth station from the characteristics measured in the satellite loop-back.

To transmit FM television signals faithfully, it is necessary to have flat amplitude and delay characteristics in the passband. Figure 3 shows measured amplitude and delay characteristics of the overall link. Equalizers in the main station are effective in improving overall amplitude and delay characteristics. Figure 3 gives the measurement results in March 1979, showing little change from the characteristics measured in July 1978.

Figure 4 shows DG and DP characteristics of the overall link, which were measured at the same period as those of Fig. 3. It is seen from these measurement results that the BSE links have excellent rf transmission characteristics as television transmission links.

Baseband Transmission Characteristics

Measurements of the baseband transmission characteristics have been performed for many items. For video signals, they include modulation characteristics, amplitude and delay characteristics, waveform distortion, linearity (DG, DP), S/N, and subjective assessment of picture quality. For sound signals, they are modulation characteristics, emphasis characteristics, frequency characteristics, distortion, S/N, and subjective assessment of sound quality, and so on. The BSE experiments have been conducted under the same parameter setting, assuming FM transmission of conventional NTSC-M color television signal as standard. Since January 1979, a dispersal signal has been added.

Table 3 Provisional standard of high-definition TV

Number of scanning lines	1125
Aspect ratio	3:5
Line interface	2:1
Field repetition frequency	60 Hz
Video frequency bandwidth	
Brightness (Y) signal	20 MHz
Color (C) signal	6.5 MHz[a]

[a] Line sequential.

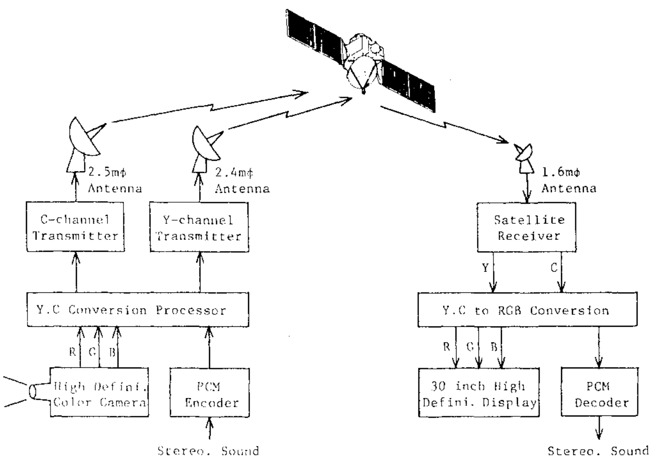

Fig. 5 High-definition TV experimental system with BSE.

It is seen from these measurement results that baseband characteristics are almost determined by those of the main station, and are scarcely influenced by the satellite transponders.

Advanced TV Broadcasting System

Various kinds of signal transmission experiments have been carried out for the purpose of developing advanced TV broadcasting techniques or new applications of satellite broadcasting systems. Among them are PCM-TV transmission, ranging systems using the TV synchronization signal, standard time and frequency dissemination system via satellite, high-definition TV transmission, and so on.

High-Definition Television Transmission[5]

A high-definition television system parameter tentatively specified by NHK Technical Research Laboratories is shown in Table 3.

Figure 5 shows the experimental system for the high-definition TV transmission with the BSE. A unique feature of this system is that the brightness (Y) and color (C) signals are transmitted through the separate radio frequency channels. Necessary rf bandwidths are 80 and 25 MHz for Y and C signals, respectively. The major advantage obtained by the Y/C separate transmission over the conventional composite color signal transmission is a great improvement, approximately 10 dB, in the signal-to-noise ratio. In other words, the satellite transmitting power can be decreased to one-tenth of that required for the conventional transmission method.

In November 1978, the first transmission experiment through the BSE was carried out at the NHK Technical Research Laboratories for four days. As the signal sources, a color print of a landscape scene and a strip from a 70-mm movie were picked up by the return beam Saticon camera and the special telecine equipment, respectively. The quality of the received picture was quite satisfactory so that one could hardly tell the degradation after the satellite transmission

Table 4 Carrier-to-noise ratio for Y and C channels

Date, Nov. 1978 Time, h	8th 15:40	9th 10:00	13th 15:40	15th 15:40	Mean
CNR, dB					
Y channel	16.7	...	16.4	16.6	16.6
C channel	21.7	21.2	23.2	22.7	22.2

Table 5 Picture signal-to-noise ratio for Y and C channels

	Y channel	C channel	Remarks
CNR, dB	16.6	22.2	Mean
SNR, dB	40.6	49.2	Unweighted

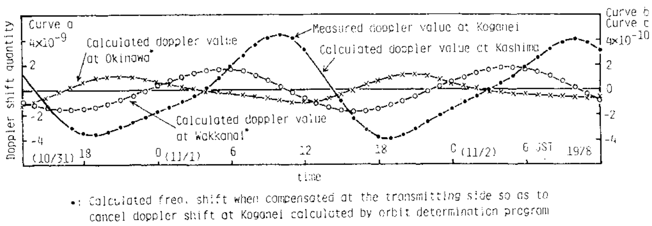

Fig. 6 Doppler frequency by BSE.

except for a very slight increase in noise. Table 4 shows the carrier-to-noise ratio (CNR) measured on the Y and C channels. Also an average picture SNR is shown in Table 5. At the second transmission experiment held in March 1979, a high-definition TV reception was successfully demonstrated in downtown Tokyo.

Preliminary Experiment on the Dissemination of Time and Frequency[5]

The dissemination of time and frequency standards by means of TV signals from a broadcasting satellite has a great advantage in the sense that one can utilize such a system at any place throughout the country, using a simple receiving system with the same type of calibrating apparatus. But such a system suffers from the frequency Doppler shift due to the satellite orbital position variation. It is, therefore, necessary to take some preventive measures against this sort of frequency shift in order to disseminate the highly precise frequency standard.

In the Doppler shift measurement system, Rb (rubidium) and Cs (cesium) atomic frequency standards were installed respectively at the BSE main station (at Kashima) and the RRL headquarters (at Koganei) about 100 km apart from each other. The two frequency standards are precisely synchronized in frequency to 1×10^{-12}, via TV synchronizing signals in the terrestrial TV signals. At both places the same type frequency synthesizers (hp 5100A) are used to generate reference color subcarriers. At Koganei, simple receiving equipment with a 1-m ϕ antenna was used, and the received composite video signal was used to "GENLOCK" a sync-generator, of which the 3.58-MHz output signal was used to measure the frequency Doppler shift averaged over 10 min by way of reading the phase comparison record.

The experimental result is shown in Fig. 6. Curve a gives measured Doppler values at Koganei, together with calculated ones at Kashima, which were estimated from predicted orbital values. Measured values coincide with calculated ones fairly well within the measurement error of 10^{-11} in the phase difference recording, although the Doppler shift amounts to $\pm 4 \times 10^{-9}$, which is a comparatively large value due to the fact that the measurement period was just before BSE orbital

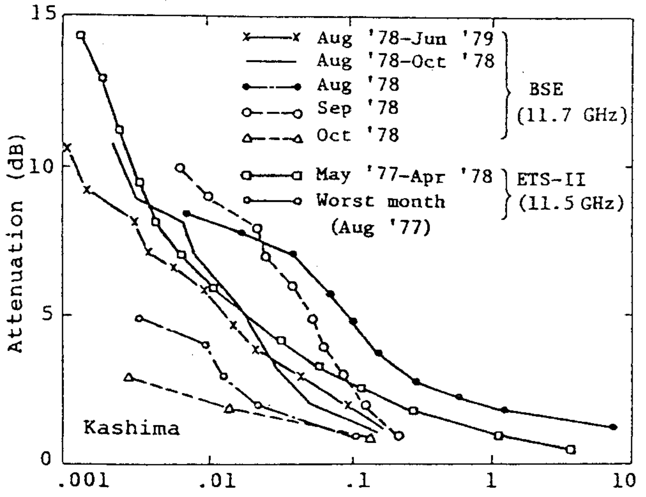

Fig. 7 Measurement of rain attenuation at Kashima.

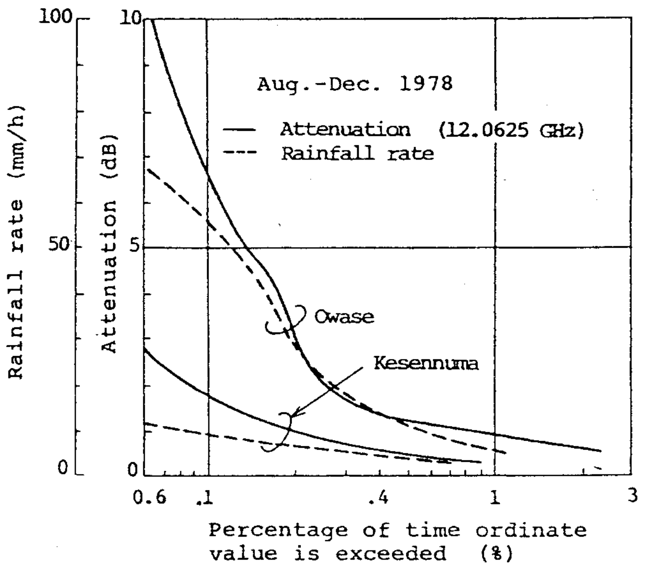

Fig. 8 Measurement of rainfall rate and attenuation at rainy and dry locations.

correction maneuvers, and also just at a new moon time, causing much influence from heavenly bodies.

Curves b and c show respectively the values of the Doppler shift relative to the values at Kashima, Wakkanai, and Okinawa, the farthermost locations in the country. These two curves show variation amplitudes of $\pm 2\times 10^{-10}$. This means that it is possible to receive standard frequency, with the error within 2×10^{-10}, everywhere in the country if some measures are taken to cancel the Doppler shift as received in the Tokyo area. That will be realized by the phase (frequency) control of the transmitter by use of the precorrection of orbital prediction value or the servo-control loop.

Multichannel Still Picture Broadcasting System

Experiments on the transmission of approximately 50 still picture signals, each consisting of a series of still color pictures accompanied by digitally coded sound signal were conducted using one television channel exclusively.

The basic transmission parameters of the still picture broadcasting system, such as the very low frequency transient characteristics and the pulse code transmission characteristics, were measured by the transmission test via satellite.

From these test results it was concluded that a still picture broadcasting system could be realized that is compatible with the satellite broadcasting of the standard television system.

Multichannel Sound Multiplexed Television System

The sound multiplexing system was designed to transmit several sound signals using two subcarriers: 4.5 and 5.0 MHz. The 4.5-MHz subcarrier which carries the main sound signal is compatible with the terrestrial television broadcasting. The 5.05-MHz subcarrier is capable of transmitting up to four 5-kHz signals.

As a result of transmission tests via satellite, the compatibility with the standard transmission system was confirmed and the cross talks between each of the sound channels and the cross effect from sound channel to video channel were found to have no major problems.

PCM-FM Sound Transmission

The purpose of the experiment is to provide data to establish sound program broadcasting as a means of broadcasting high quality stereophonic or multichannel sound programs. The experiment was conducted with PCM transmission of stereo sound signals of 1.544 Mbits/s using a 4-phase PSK modulator. As a result of the experiment, the relation between C/N and the bit error rate was quantitatively cleared and the result was very near to that of the theoretical value.

Digital TV Transmission

To search the possibility of digital TV broadcasting, a series of experiments on the digital transmission of TV signals have been conducted in both MTRS and TTRS of type B.

Measurements were performed to obtain fundamental data such as the transmission characteristics of the satellite link, bit error rate characteristics for 4- or 8-phase PSK transmission in satellite links, and 4-phase PSK transmission of DPCM coded color TV signals.

Experiments on Radio Wave Propagation[6]

Here several propagation characteristics obtained at various locations in Japan, concerning 14 and/or 12 GHz along the satellite-Earth path for periods up to about one year, will be described.

The locations of the stations concerned with the propagation measurements have already been shown in Fig. 1. The ratio of rain attenuation of the up- to the down-link in decibels measured on a rainy day at Kashima is about 1.4, which is almost equal to the theoretical value. As this relation was kept for various other rain events, it is possible to convert the statistics of the down-link to the ones for the up-links.

Figure 7 shows the cumulative distribution curves of the attenuation of the BSE beacon signal (11.7 GHz) as well as the ones from the propagation experiment with the Engineering Test Satellite type II (ETS-II), which was performed from May 1977 to April 1978 using 11.5 GHz.

Cumulative distributions of rain attenuation and rainfall rate were derived from the data obtained at the ROS's and the TTRS from August to December 1978. Figure 8 shows the distributions for two typical locations, Owase and Kesennuma, where the maximum and minimum rainfalls occurred respectively during the observation. In Table 6 the rain attenuation and rainfall rate are given for 1 and 0.1% of the time at each location, which were read from the above-mentioned distributions, together with the corresponding observed time.

The analysis of the propagation measurements has revealed preliminary but interesting results on statistics of rain attenuation at various locations of Japan, which would lead to final fruitful results at the end of the experiment for the expected full three years, besides an efficient method for eliminating nonpropagation effects from obtained data.

Table 6 Measurements of attenuation and rainfall rate at ROS's and TTRS (12.0625 GHz, August through December 1978)

Item	Attenuation exceeded for given %, dB		Rainfall rate for given %, mm/h		Observation time, 1000 min	
Location	1	0.1	1	0.1	Attenuation	Rainfall
Ogasawara	[a]	1.1	3	19	29	82
Minamidatio	0.8	2.3	6	15	37	98
Yonaguni	2.3	5.5	6	39	34	59[b]
Kesennuma	0.3	1.7	4	12	38	160
Owase	0.8	6.5	13	52	41	164
Matsue	1.2	3.0	7	15	40	162
Ashizuri	1.2	3.3	6	28	39	162
Izuhara	[a]	[a]	7	20	32	161
Osaka	1.6	3.9	5	12	34	165

[a] No significant data due to trouble of equipment.
[b] Observation time becomes shorter due to failure of rain gage.

Table 7 Transmission parameters of up-link signal

BS/FM-TV	Video signal deviation	12 MHz
	Emphasis	CCIR rec. 405-1
	Energy dispersal	600 kHz
CS/FM-TV	Video signal deviation	21.5 MHz
	Emphasis	CCIR rec. 405-1
	Energy dispersal	1 MHz
CS/FDM-FM	Noise-loaded with the following test-tone deviation: 972 ch; 802 kHz/ch 60 ch; 270 kHz/ch	

Table 8 Protection ratio required for interference from FM-TV signal[a]

Wanted	Unwanted	Antenna offset method, dB	Laboratories test, dB
BS/FM-TV	BB/FM-TV	35	37.8
BS/FM-TV	CS/FM-TV	29.3	31

[a] Test picture: color bar.

Table 9 Protection ratio required for interference from FDM-FM signal[a]

		Antenna offset method[b], dB		Laboratory test, dB	
Wanted	Unwanted	60 ch	972 ch	60 ch	972 ch
CS/FDM-FM	BS/FM-TV	26.4	23.9	35.5	32.4

[a] Test picture: color bar. [b] Values were limited by signal-to-noise ratio of received signal.

Experiment on Frequency Sharing

In order to lay down a basis for sharing criteria between up-links to a broadcasting satellite (BS) and between up-links to a BS and to a communication satellite (CS) using the same frequency band at around 14 GHz, an experiment on the evaluation of interference criteria was carried out using the BSE.

In this experiment, interferences between the following simulated links have been considered: 1) BS (FM-TV)→BS (FM-TV); 2) BS (FM-TV)→CS (FM-TV); 3) CS (FDM-FM)→BS (FM-TV); 4) BS (FM-TV)→CS (FDM-FM). Transmission parameters used for each up-link are shown in Table 7.

The TTRS type B was transported to be used mainly as an interfering station at the Kashima Branch of the RRL, where the MTRS is located, to eliminate error generated by satellite attitude drift.

Evaluation of Interference to the Wanted FM-TV Signals from the FM-TV and FDM-FM Signals (Cases 1-3 Above)

Subjective assessment of the wanted FM-TV signal interfered with FM-TV and FDM-FM signals, by varying an offset angle of unwanted station antenna, was conducted to obtain the protection ratios required and the various margin which might be needed to compensate for the difference between theoretical and actual values.

Tables 8 and 9 contain results obained from this experiment. The viewing condition used for this experiment is so different that viewers stand in front of the picture monitor to facilitate the detection of interference in order to obtain a protection ratio for high picture quality, which may be applied for up-link interference evaluation.

Although additional experiments are required, the following preliminary conclusion can be derived: 1) BS/FM-TV→BS/FM-TV: protection ratio = 38 dB; 2) BS/FM-TV→CS/FM-TV: protection ratio = 31 dB; 3) CS/FDM-FM→BS/FM-TV: protection ratio = 35-32 dB (60-972 ch).

Interference from Broadcasting Satellite Service (Earth to Space) Earth Station into Fixed Service Satellite

Interference from FM-TV into FDM-FM was measured using the 14-GHz band for up-links, changing various parameters such as the ratio of desired-to-undesired signal power (DUR), TV video signals (color bar or color test chart), energy dispersal (with or without), and frequency deviation. The signal-to-interference noise ratio was proportional to D/U, as shown in Table 10, and was not affected by TV video signals and energy dispersal.

The signal-to-noise ratio was also measured, changing the antenna direction angle of BSE Earth station. Experimental results agree with the calculated values as shown in Fig. 9.

Experiments on Satellite Broadcasting Signal Reception

Received Power and Its Stability

It has been confirmed by the measurements carried out simultaneously at 39 locations all over Japan that received powers generally coincided with the corresponding predicted ones as shown in Fig. 10. Deviation of the received powers from the prediction was within 1 dB for 75% of the measurements.

Comparatively long term variations of received power were measured at the ROS's. At the beam edge of the satellite transmitting antenna, where the ROS's are situated on the

Table 10 Interference from FM-TV into FDM-FM in the same frequency channel

Capacity	S/I[a], dB	d/U[b], dB	Test condition
	43	17.5	With the parameters for the Intelsat
972 ch	50	24.5	972-ch carrier
	60	34.5	FM-TV (color bars) without energy dispersal
	43	8.5	Test-tone deviation 270 kHz rms
60 ch	50	16.0	Emphasis off
	60	26.5	FM-TV (color bars) without energy dispersal

[a] Signal-to-interference noise ratio in the worst channel due to interference from an anolog FM-TV transmission. [b] Ratio of wanted-to-unwanted signal power at the satellite input.

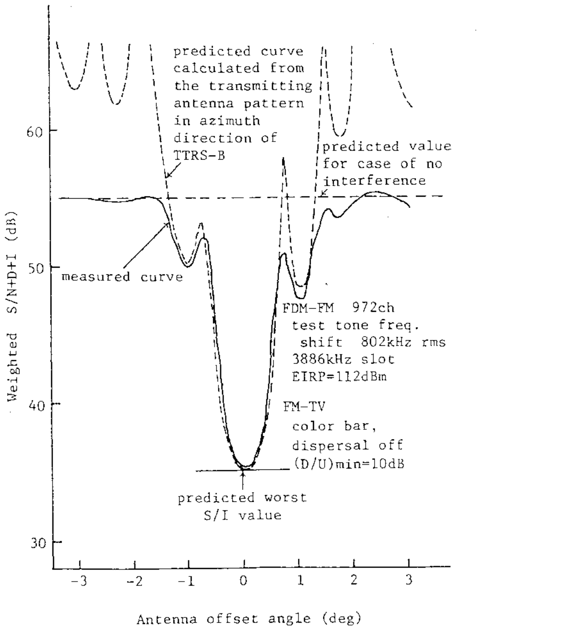

Fig. 9 Weighted S/N ratio measured in changing MTRS antenna direction.

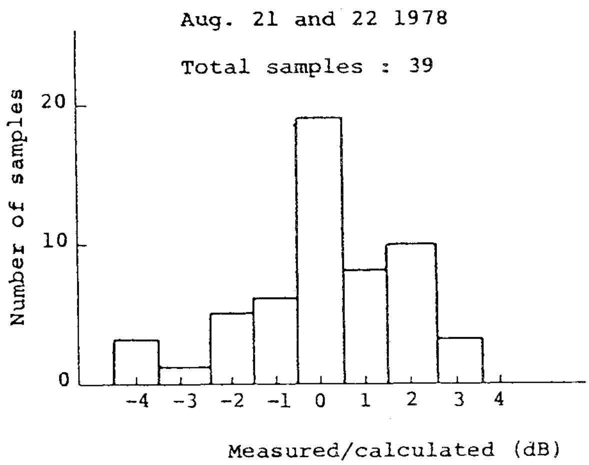

Fig. 10 Deviation of received power from calculated value.

isolated islands, the variation showed a maximum and reached up to about 5 dB, which included a 2-dB pointing error inevitable to the simple tracking antenna equipped there.

The quality of the received picture has been assessed subjectively, which was almost excellent at each location, using color-bar and specially prepared VTR signals.

From the TV reception tests, an antenna size has been derived which was required to obtain a weighted S/N ratio of picture of more than 45 dB for 99% of the time at each location. The required diameter is about 1 m around the center of the beam of the transmitting antenna, about 1.6 m for the fringe area of the mainland, and 2.8-4.5 m for the isolated islands. These approximately meet the initial design specification.

By the TV reception tests, it has been confirmed that received power was generally coincident with the predicted values and also that excellent quality of picture was obtained at each location all over Japan. The influence of snow, especially the fall of wet snow on a receiving antenna, causes severe degradation of reception. There is a keen need to clarify its mechanism and statistics and to develop a method for improvement.

Field tests in urban and rural areas have also been conducted to investigate the influence of buildings and topography. The influence of highways, rapid railways, and airports, etc. on the reception quality of TV signals from the BSE have been investigated.

Solar Noise Interference

Solar noise interferences were measured after the autumnal equinox in 1978 and before the vernal equinox in 1979 in many Earth terminals.

It is well known that the sun transits in a ground receiving antenna toward the vernal and autumnal equinoxes, if the antenna points to the geostationary orbit. A harmful interference can occur for reception of satellite broadcasting in that case. The increase of noise was measured at several locations with antennas of different diameters.

Figure 11 shows the increase of noise power due to the solar noise interference at a receiver, a noise temperature of about 600 K. Figure 12 shows the duration time of the possible solar interference per day and the number of days of its occurrence. When comparing these results with the rain attenuation statistics, it is understood that the solar noise interference affects satellite broadcasting service only for a much smaller percentage of the time than rain attenuation does, and moreover occurrence time and intensity of the interference can be predicted with practical accuracy. The solar noise interference affected satellite broadcasting service for a much smaller percentage of time than rain attenuation.

Experiment on the Control and Operation of the Satellite Broadcasting System

Range Measurement of a Broadcast Satellite Utilizing Television Sync-Pulse

The range between the ground transmit and receive station and the satellite can be measured using the television sync-pulse.

TV ranging equipment was developed to evaluate the accuracy of the system with the BSE and TTRS type A.

The expected error has −1.0-m mean and 0.56-m standard deviation. This value comes mainly from roundoff error, and a high signal-to-noise ratio causes only a 0.3-m error component.

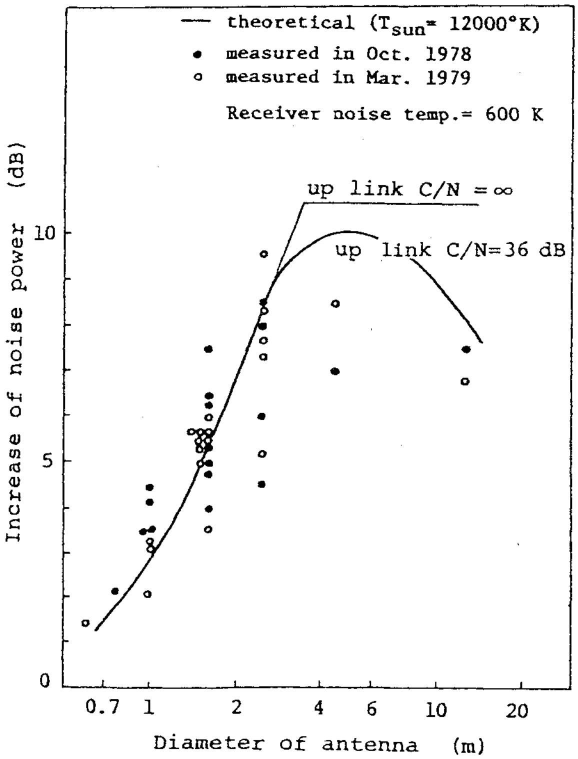

Fig. 11 Increase of noise at receiver input due to solar noise interference.

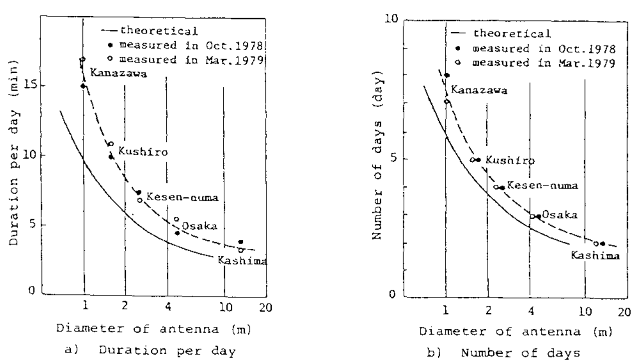

Fig. 12 Duration and occurrence of solar noise interference.

Automatic Television Signal Quality Assessment (VITS Measurement)

Transmission characteristics measurement equipment including a vertical interval test signal (VITS) inserter and digital data processor was developed to measure and examine the stability of TV signal transmission.

Access to the Satellite from the Multiple Ground Stations

Program switching tests were performed via satellite between the MTRS and the TTRS moving around Japan using multiple-access control equipment fitted with propagation time dissolution logic.

As a result of a subjective evalution test, the switching function was found to be smooth and to have no visual problems.

Conclusions

The BSE experiments have been conducted favorably since July 1978. Most of the experimental items planned in the BSE program have been carried into operation. But there are several experimental items which ought to be conducted hereafter, such as the investigation of scattering phenomena especially in the up-link path of 14 GHz, the regular experiments on standard time and frequency signals dissemination by means of TV signals, the experiments on simultaneous amplification of multiple sound signals for the purpose of sound broadcasting, and so on. They will be conducted in the latter half of the experimental period. It is expected that all the experiments in the BSE project will be performed with satisfactory results.

The operational broadcasting satellite BS-2 is now under consideration. It is expected to be launched in 1983 fiscal year with an on-orbit spare satellite.

According to the proposal, the BS-2 and its spare satellite will be similar to the present BSE satellite with respect to their scale and functions. The experimental results of the BSE program will be reflected to the system configuration of both space and ground segments.

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