SJR No.38 Space Japan Milestone MB-SAT

Mobile Broadcasting System

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The TV broadcasting systems currently served in many countries including Japan are for fixed home users and the terrestrial analog/digital broadcasting system and BS/CS broadcasting systems have been used in Japan. The former system has the local service area and the latter has the service toward the whole country. The broadcasting services for mobile user such as a person with small receiving terminal and a fellow passenger in a car are restricted to the sound and music by AM and FM radio broadcasting and only for the local area. In recent years, data services providing sound and video in the mobile environment are spreading by the use of the mobile communication system such as mobile phones and wireless LANs. As for the broadcasting service in the mobile environment, sound and video services with high quality are expected as well as by mobile communication. Under the background above described, some features for individual broadcasting system are shown in Figure 1, which represents the relation between the service area and the mobility of users. From this figure, it is found that broadcasting system provided services to mobile users over whole country is not realized in Japan, furthermore a system provided multimedia mobile services such sound , video and data to mobile users could not be found in the world. The advanced technologies for broadcasting system which provides multimedia services to mobile users over the whole country are required and must be developed.

The mobile broadcasting system introduced in this paper is developed in order to satisfy requirements mentioned above. The new system consists of the geostationary satellite (MBSAT) and repeaters (gap-filler) to transmit broadcasting signal which includes multi-channel programs such as music sound, video and data. The Gap-filler has the roll to re-transmit to mobile users in shadow regions where a signal from MBSAT is blocked. This system which broadcasts the multimedia video services at relatively high transmission rate is developed firstly in the world.

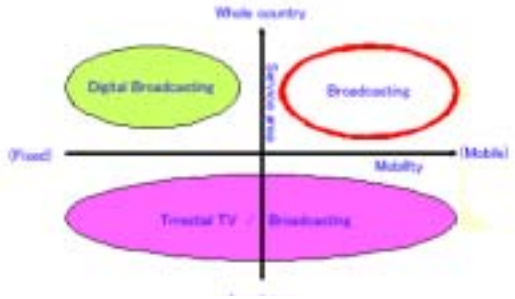


Figure.1 Relation between the service area and the mobility

2. Technologies for the mobile broadcasting system

2.1 Standardization of the mobile broadcasting system

Some technical items such as transmission, multiplexing, coding scheme, access control, receiver and operational guide-line for the terrestrial digital broadcasting system and the satellite digital broadcasting systems are standardized as shown in Table 1 in the ARIB (Association of Radio Industries and Business) in Japan. The mobile broadcasting system was also discussed on some technical proposals and experiments in the indoor and outdoor field at the working-group in the ARIB. The transmission system for the mobile broadcasting was standardized as the ARIB STD-B41.

The standardization of this system was done mainly by commercial companies such as Toshiba Co. and Mobile broadcasting Co.

In July 1997,"Technical requirements on the satellite digital sound broadcasting system used in 2.6GHz frequency band" was approved by Telecommunication Technology Council of MPT (Ministry of Posts and Telecommunications: now Ministry of Internal Affaires and Communications) in Japan. And this system was also approved as the BO.1130-4 digital system E by ITU-R (International Telecommunication Union-Radio) in April 2001.

		CS	BS/110 °	Terrestial TV	Terrestial Sound	Mobile Broadcasting
Transmission System		-	ARIB STD-B20	ARIB STD-B31	ARIB STD-B29	ARIB STD-B41
Multiplexing Scheme		ARIB STD-B10	ARIB STD-B10、32			
Source Coding	Video	-	ARIBESTD-B32		-	-
	Sound	-				
	Data	-	ARIB STD-B23、24			
Access Control		-	ARIB STD-B25			
Server Broadcasting			ARIB STD-B38			
Receiver		ARIB STD-B1,16	ARIB STD-B21		ARIB STD-B30	ARIB STD-B42
Operational Guide-line		—	ARIB TR-B15	ARIB TR-B14	ARIB STR-B13	ARIB TR-B26

ARIB STD-BXX : ARIB Standard, ARIB TR-BXX :ARIB Technical Documents

Table.1 Digital Broadcasting Standardization in Japan

2. 2 Outline 0f the Mobile Broadcasting System

The frequency band used in the Mobile Broadcasting System is the S band (2.630-2.655GHz) which was allocated to the Mobile Satellite Broadcasting System for Region 3 in WARC-92(World Administrative Radio Conference) held in 1992. There are two key issues which must be considered in order to build the Mobile Broadcasting System. One of them is to design and to develop the transmission system to operate well in the multi-path radio environment. And, the second of them is to produce the spacecraft with large EIRP(Equivalent Isotropic Radiation Power) in order for users who can easily receive the broadcasting signal with desired C/N(Carrier to Noise Ratio) using a small receiving terminal and small receiving antennas.

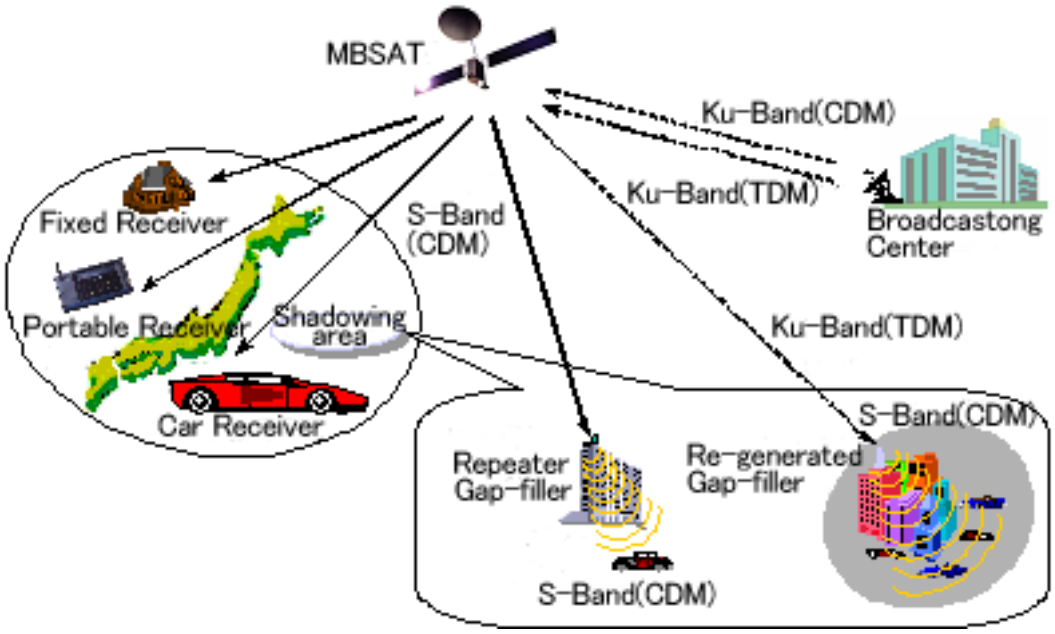


Figure.2 Mobile Broadcasting System

To cope with these difficulties, the new broadcasting transmission scheme using CDM (Code Division Multiplex) was developed. The system consists of the large- sized spacecraft (MBSAT) with large EIRP, the large deployable antenna and terrestrial gap-fillers which are distributed in the shadow regions of the signal blocked from high buildings and other obstacles.

The outline of Mobile Broadcasting System is shown in Figure 2.

2.3 Transmission system and their technologies

Some technical issues on the transmission system were investigated for providing mobile broadcasting services with high transmission quality. Basic requirements to this system are (1) whole Japanese territory is covered by broadcasting signal with single frequency, (2) mobile users(receiving terminals) can receive mixed signal with signal from the satellite and signal from gap-fillers. (3) receiving terminal has desired C/N in multi-path radio-wave environment, (4) on-board power amplifier in satellite has high efficiency with less signal distortion(by minimum back-off level).(5) providing of some functions to receive broadcasting signal by using a small mobile receiver is feasible by making LSI. As a result of careful investigations, a broadcasting system with CDM (Code Division Multiplex) scheme was developed. Transmission system parameters are shown in Table 2.

Center Frequency	2642.5MHz
Band Width	25MHz
Polarization	Satellite：Left Hand Circular Pol. Gap-Filler：Vertical Pol.
Modulation ／Multiplexing	QPSK/CDM
Chip-Rate	16.384Mcp
Transmission Rate	256kbps/Code
Spreading Code	Walsh Code & M-Sequence
Error Correction Code	Convolution & Reed-Solomon(204,188)
Interleaver	Bite Interleaver：Convolutinal Bit Interleaver：Convolutional Intealeaver with 3-Segmental Grouping
Baseband Multiplexing	MPEG-2 Systems
Audio Coding	MPEG-2 AAC+SBR
Video Coding	MPEG-4 Simple Profile

Table 2. Transmission System Parameters of Mobile Broadcasting

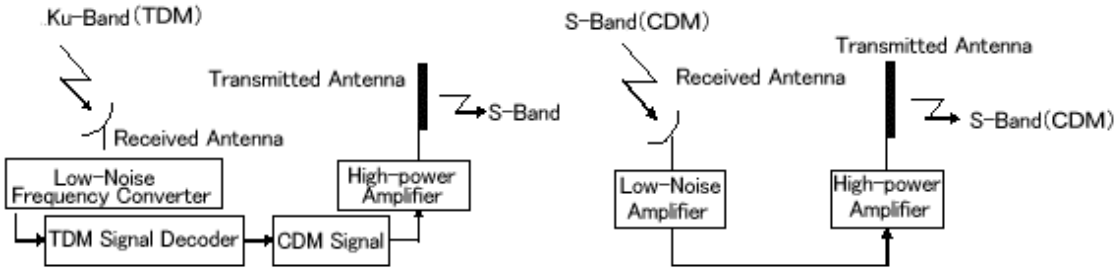
From the wireless-link calculations, the EIRP (Equivalent Isotropic Radiation Power) of 67dBW for the satellite is required to receive with desired C/N using small receiving antenna (antenna gain 2.5dBcpi) at everywhere in Japanese territory. Under the requirement, the high power TWT amplifiers with 1.2kW output-power and the large-sized deployable antenna with diameter of 12m was developed.

Broadcasting programs are transmitted by the up-link with two Ku-band frequencies (14GHz-band) from the broadcasting center on the ground to MBSAT. Two frequencies

are used to transmit the CDM signal and the TDM (Time Division Multiplexing) signal respectively. The CDM signal is converted frequency from Ku-band to S-band (2.6GHz) by the transponder on MBSAT and is transmitted to mobile users directly. On the other hand, the TDM signal is converted from 14GHz-band to 12GHz-band on MBSAT and is transmitted to gap-fillers on the ground. Gap-fillers distributed on the ground receive the TDM signal with 12GHz frequency band and convert to CDM signal with frequency of S-band (2.6GH). And then, CDM signal is transmitted to mobile users.

The feature of the conversion from TDM (14GHz) signal to CDM(2.6GHz) signal is to be obtained more C/N compared with a simple frequency conversion such as a conversion from CDM(14GHz) signal to CDM(2.6GHz) signal. Simple repeaters which amplify the CDM (2.6GHz) signal from MBSAT are used in small service coverage areas.

Figure 3 shows the transmission system of the gap-filler.



(a) Gap-filler(Regenerated Repeater) (b)Gap-filler (Repeater)

Figure 3 Transmission System of a Gap-filler

2.4 MBSAT

The feature of MBSAT is high RF output-power and a deployable antenna with the large-sized aperture so as to receive 2.6GHz signal using small antenna for mobile user.

16 TWT amplifiers are used to obtain the high power of 1.2kW at S-band frequency and their multiple out- puts are provided to multiple feeds horns of the large reflector antenna to obtain shaped antenna radiation pattern which meets to the shape of Japanese territory. The S-band large reflector antenna is the deployable antenna made of meshes ,nets and torus structures and was produced in Northrop Gramann / Astro Co. in U.S.A. MBSAT has plasma thruster engines with low thrust to operate stably the large aperture flexible structure antenna.

Some parameters of MBSAT are shown in Table 3. Figure 4 and Figure 5 show MBSAT on orbit and on the ground respectively.

Item	Performance
(Satellite System)	
Geostationary Orbit	The east Long144°
Bus	SS/L Co.1300Bus
Weight	4.1t
Size	22m×31m (Deployed)
Attitude Control	Control Bias- Momentum
	Three Axis Attitude Control
Propulsion System	South-North Maneuver：Plasma Thruster Engine
	East-West Maneuver／Attitude Control：Bi-Propulsion
Life Time	More than 12years
(Pay-road for Broadcasting)	
Service Area	Whole country in Japan
Frequency	Ku-Band (Up-Link), S-Band & Ku-Band (Down-Link)
EIRP	67dBW
Transponder	135WClassTWTA×16 (S-Band)
	150WClassTWTA×1 (Ku-Band)

Table3 Features of MBSAT

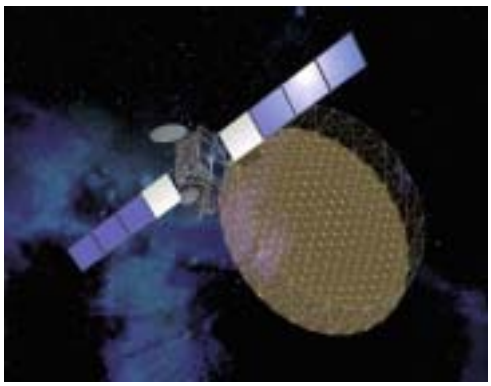


Figure.4 MB-SAT on orbit

Figure.5 MB-SAT on the ground

2.5 Multimedia Transmission Technologies

The Mobile broadcasting transmission system provides not only sound such as speech and music, but also provides video with high quality and data. The source coding scheme used for speech and music is MPEG-2AAC (Advanced Audio Coding ISO/IEC13818-7) LC-Profile as the same coding method as that of the BS digital and the terrestrial digital broadcasting system in Japan. The audio coding method includes the SBR (Spectral Band Replication) processing to improve quality at low-bit-rate such as speech. As a result, monaural, stereo and dual-monaural mode audio at bit-rate up to 144 kbps are coded with high quality.

As for video coding scheme, MPEG-4 (ISO/IEC14496-2) Simple profile is used and can transmit high quality pictures with maximum bit-rate of 384kbps and maximum frame-rate of 15 frames/s. The functions of multiplexing and de-multiplexing of coding signal are done by using MPEG-2 Systems (ITU-T H.222.0, ISO/IEC13818-1) which is common coding scheme with the BS digital and the terrestrial digital broadcasting system in Japan too.

Encoding and multiplexing from sources such as ausio , video and data are processed by software in the broadcasting station on the ground. On the other hand, a receiving terminal has decoding and de-multiplexing functions processed by the special LSI which has been developed in Toshiba Co..

2.6 Broadcasting Center

Functions of the broadcasting center are production and organization of broadcasting programs , encoding for source information, multiplexing and modulation to transmit CDM signals and TDM signals toward MBSAT and managements of some information for customer etc. The broadcasting center is located at Oimachi in Tokyo and has facilities in the building. The main reflector antenna with diameters of 7.6m and preliminary antenna with 4.5m diameters for backup are installed on the rooftop.

The center consists of the management system for program information , the management system for customer, the program transmission system, the PSI/SI(Program Specific Information/Service Information) transmission system, the conditional access system, the key management system, the encoding and multiplexing system for video and audio , the TDM/CDM modulation system and the antenna/transmitter. Figure 6 shows function block of the broadcasting center and Figure 7 shows facilities in the broadcasting center.

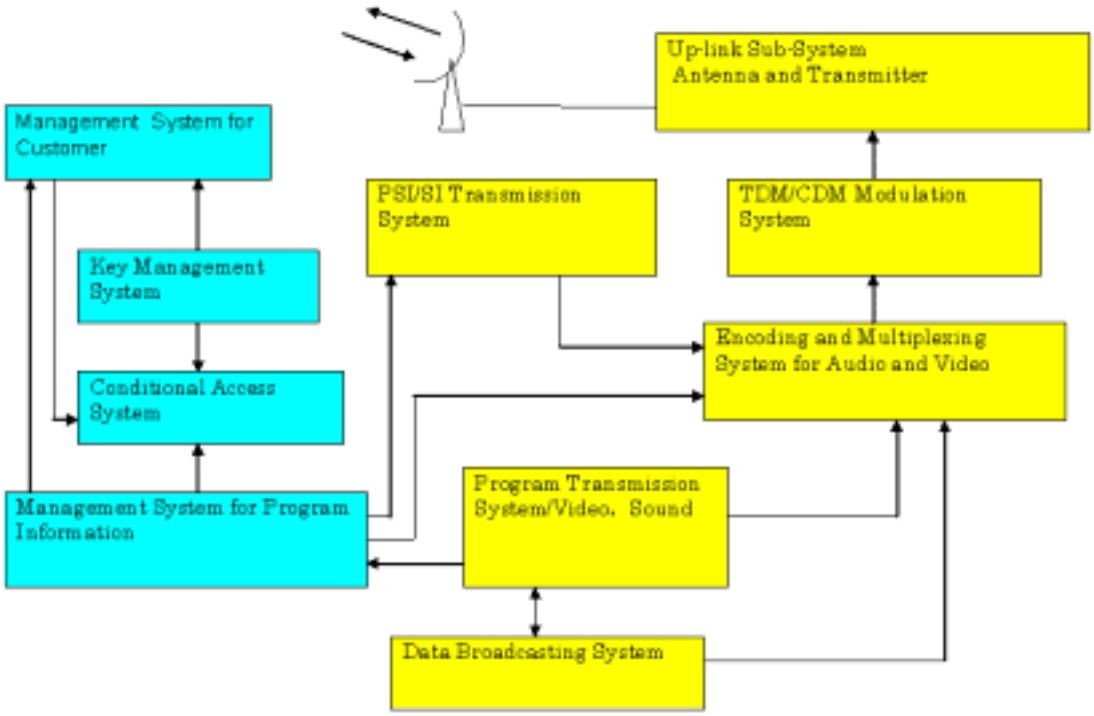


Figure.6 Function Block of the Mobile Broadcasting Center

Figure.7 Broadcasting Center

2.7 LSI chip-set and receiving terminal

A receiving terminal (MTV-S10) for mobile broadcasting is organized to some blocks as shown in Figure 8. A tuner receives a RF signal at 2.6GHz by small antenna and converts to frequency of 400 MHz, and demodulates QPSK signal. A CDM/FEC (Forward Error Correction) processes CDM signal to extract the desired signal and to correct signal errors . A CA(Conditional Access) block encodes the scrambled broadcasting signal. An AV decoder de-multiplexes the audio and video signals and decodes signals which are coded by AAC and MPEG-4 respectively. A CPU and some memories are used for control of block functions described above. A spaced diversity scheme with two small receiving antennas is adopted to obtain more C/N in both environments of the satellite link and the gap-filler link.

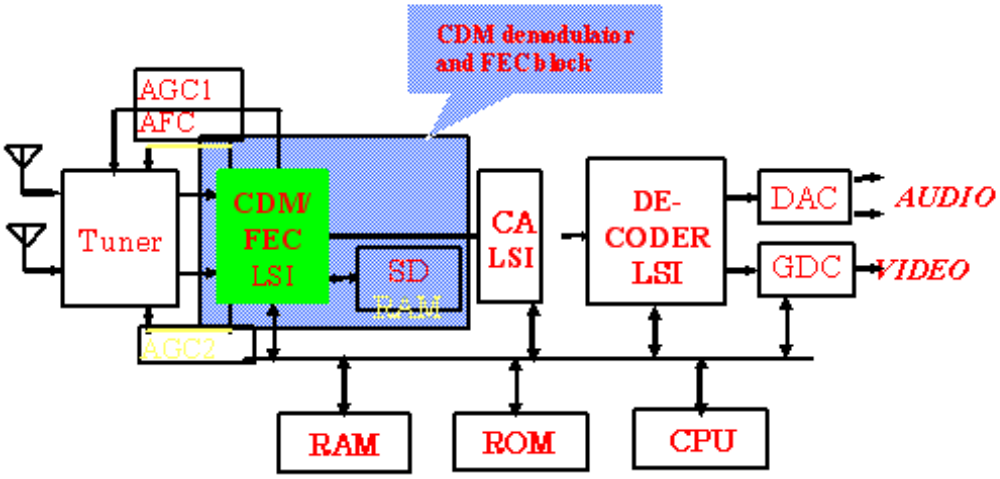


Figure.8 Block Diagram of a Mobile receiving terminal

In order to miniaturize and to reduced power consumption of the receiving terminal, five kinds of LSI such as PLL LSI (TB1292FLG) and IQ transformer LSI(TB1374FLG) for the tuner, CDM/FEC LSI(TC90A82XBG), CA LSI(T6NA7XBG) and AV decoder LSI(TC3582XB) were developed.

A CDM/FEC LSI which has a key function in receiving terminal is consisted of the path-searcher to estimate the propagation environment and the RAKE for multi-path diversity. Bit-deinterleaver, Viterbi de-coder, bite-deinterleaver and Reed-Solumon de-coder are used in FEC. Among them, the use of a bit-deinterleaver is very effective when the received signal is intercepted during several seconds by a bridge or obstacles on a highway.

The size and weight of the receiving terminal are 99.8 x 31.4 x 112mm and 300g

respectively. The display has a 3.5 inches TFT LCD and power consumption of 3.5W. Two small micro-strip antennas are built to receive both signals from the satellite and from gap-fillers in the receiving terminal. The CDM/FEC LSI de-modulates five channels simultaneously which has a pilot channel for synchronization and for information to control receiving functions, a CAS (Conditional Access) channel, a EPG(Electric Program Guide) channel and two broadcasting channels. Where, a channel means 1 coded- channel with bit-rate of 256kbps. A video signal with bit-rate of about 500kbps is combined with two channels. The external appearance is shown in Figure 9.

Figure.9 Mobile Receiving Terminal

3. Outline of mobile broadcasting services

Contents of the mobile broadcasting services are provided by MBCO(Mobile Communication Company) . The broadcasting programs are 30 audio/music channels, 7 video channels and 60 data channels.

Audio/music programs relayed from FM broadcasting in USA west coast, music programs of a various genre and video programs of sport relay such as a baseball and a horse race are provided. And the latest information such as news, a weather forecast and information about amusement and culture are served as data broadcasting.

Moreover not only broadcasting services for mobile users on the ground but the services for passengers in a airline and a ship and for a crew in a shipping boat will be provided

soon. And the role of the mobile broadcasting for disaster is so important that MBCO cooperates with local governments to broadcast the urgent alarm.

Table 4 shows the services of mobile broadcasting channel.

Video channel (more than 7 channels)

Channel genre	Channel logotype	Contents
1. Variety Program (Weekday) Cartoon (Weekend)		Popular Program in CS and CATV. Animation produced by TAKARA.
2. Variety Program and News		Special Contents Produced by MBCO.
3. News		News From Nihon TV and etc.
4. Business news (Weekday) Sports (Weekend)		24 hours Economic News and Sports.
5. Entertainment Channel		Dramas Produced by TBS.
6. Music Channel		Foreign Music.
7. Premium Channel		Special Horse Racing Program.

Table4. Mobile Broadcasting Channel Service

Audio channel

Channel title		Channel logotype / Contents
Original channel	Mobile 301	Mbco Mix
	Katsuya Kobayashi Channel	Katsuya Kobayashi produce
	Red shoes	Welcome to Red shoes
	rockin'on	Rock channel
	Oricon	Oricon hit chart
	Billboard Radio	Billboard channel
Usen channel	J-POP Chart	The newest Request Hit Chart.
	J-POP Select	Familiar music to everybody
	J-POP Drive	The music for drive.
	J-POP 80's	The 80's hit selection.
	Best For k Song	The 60`s 70's hit selection.
	JAPANESE Music	The Japanese nostalgic music.
	JAPANESE Music	The Japanese music.
	Club Mix	The newest club music
	Popular 80's	The best hit selection
	Popular ballad	The love song selection
	Sound Truck Music	The music of the movies.

Channel title		Channel logotype / Contents
Jazz & Classic	Jazz 8	The jazz special channel.
	Classic 7	The classic special channel.
Tokyo FM	KKJP-Jazz&Blues	The popular FM broadcasting station in USA.
	KBZT-Altemmative Rock	
	KSON-Country	
	KLLY-AC	
	KKBB-R&B Oldies	
FM Selection	J-Wave	The popular FM broadcasting station in JAPAN.
	FM802	
News (Audio)	News(Japanese)	The news special channel.
	Market Channel	The Market information.
English (Audio)	English conversation	
	BBC	The BBC world service.(Asia version)

Table4. Mobile Broadcasting Channel Service

4. Mobile broadcasting has been started

MBSAT was launched successfully by Atlas ⅢA in March 14 ,2004 and has bee started to operate in April 27,2004. After the checkout of the broadcasting system under the broadcasting test program, the regular broadcasting has been started in October 20, 2004.

We expect that the spreading of receiving terminals will create a new life style.