DiBEG
Digital Broadcasting Experts Group

ISDB-T_N for DSB

YASUO TAKAHASHI

Digital Broadcasting Experts Group(DiBEG)

Japan

DiBEG
Digital Broadcasting Experts Group

Contents

1. Introduction
2. ISDB-T_N system
   - features, channel coding, transmission examples, transmission parameters, frequency utilization
3. Comparison of DSB systems
4. Service content examples for ISDB-T_N
5. Field Experiments
6. Summary

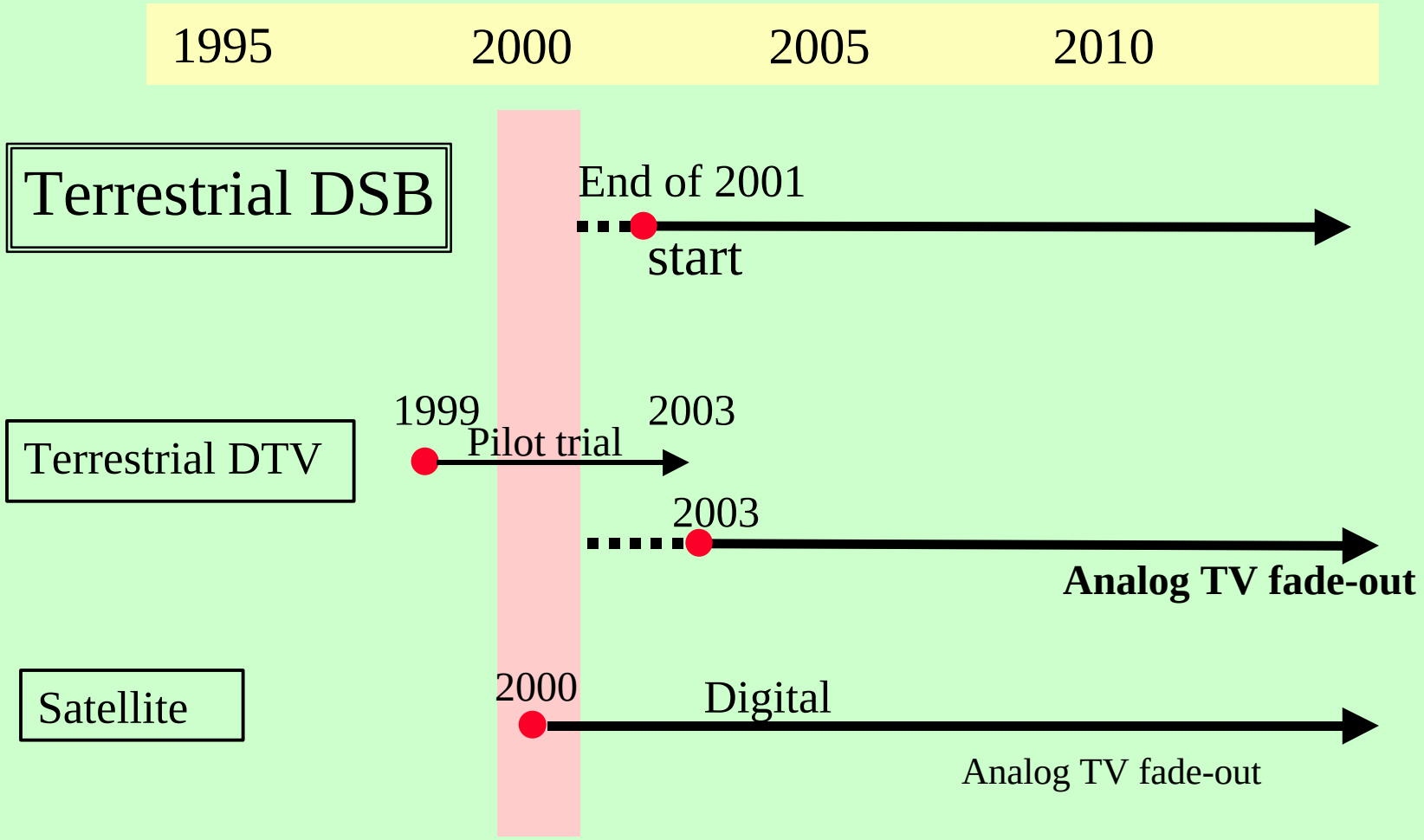
DiBEG
Digital Broadcasting Experts Group

Digital Sound Broadcasting Systems

	USA	Europe	Japan
TV	DTV	DVB-T	ISDB-T
Sound	IBOC	DAB	ISDB-T

DiBEG
Digital Broadcasting Experts Group

Schedule of Digital Broadcasting in Japan



DiBEG
Digital Broadcasting Experts Group

Outline of ISDB-Tn(1)

- Source coding
  - MPEG-2 AAC audio (ISO/IEC 13818-7)
  - bit rate : 144kbps / two-channel stereo
  - sampling frequency : 32, 44.1, 48kHz and half rates (16, 22.05, 24 kHz) for mobile
  - XML data coding

DiBEG
Digital Broadcasting Experts Group

Outline of ISDB-Tn(2)

- Multiplexing
  - MPEG-2 system(ISO/IEC 13818-1)
- Transmission scheme
  - BST-OFDM
  - Concatenated error correction code (Reed Solomon + Convolutional code,1/2,2/3,3/4,5/6,7/8)
  - Flexible channel coding (modulation, error correction, time-interleave)

DiBEG
Digital Broadcasting Experts Group

AAC (Advanced Audio Coding)

- MPEG-2 standard (focusing on audio quality)
- Coding rate of stereo sound
  - MPEG AAC:128 - 144 kbps (MPEG BC:256 kbps)
- Japan's broadcasting standard
  - BS Digital (starts in the end of 2000),
    Satellite Audio Digital( ),
  - Terrestrial Digital TV (2003),
  - Terrestrial Digital Sound (the end of 2001)

DiBEG
Digital Broadcasting Experts Group

Test results

This section is reserved for figures derived from ARIB paper.

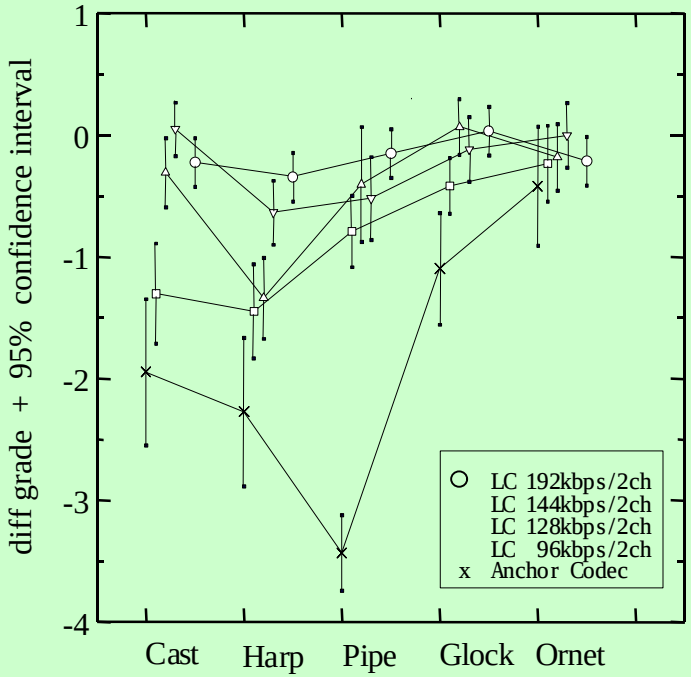


Fig.1 Results of AAC listening test (higher bit rate)

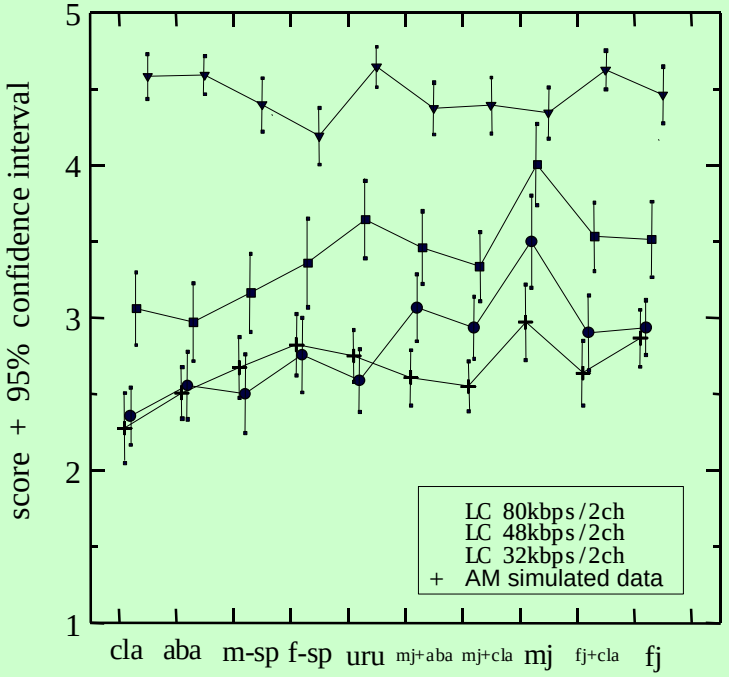
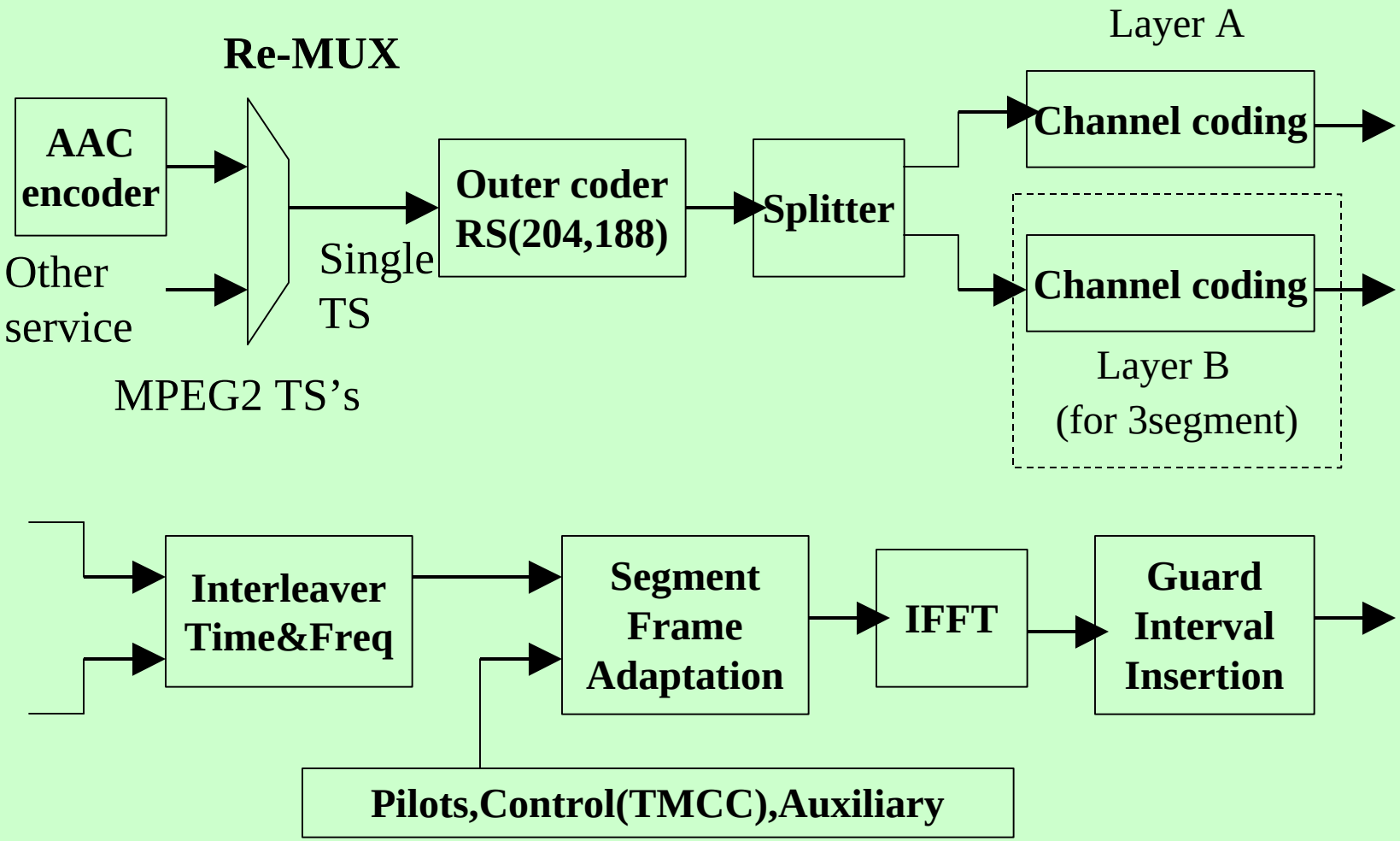


Fig.2 Results of AAC listening test (lower bit rate)

DiBEG
Digital Broadcasting Experts Group

Transmission scheme



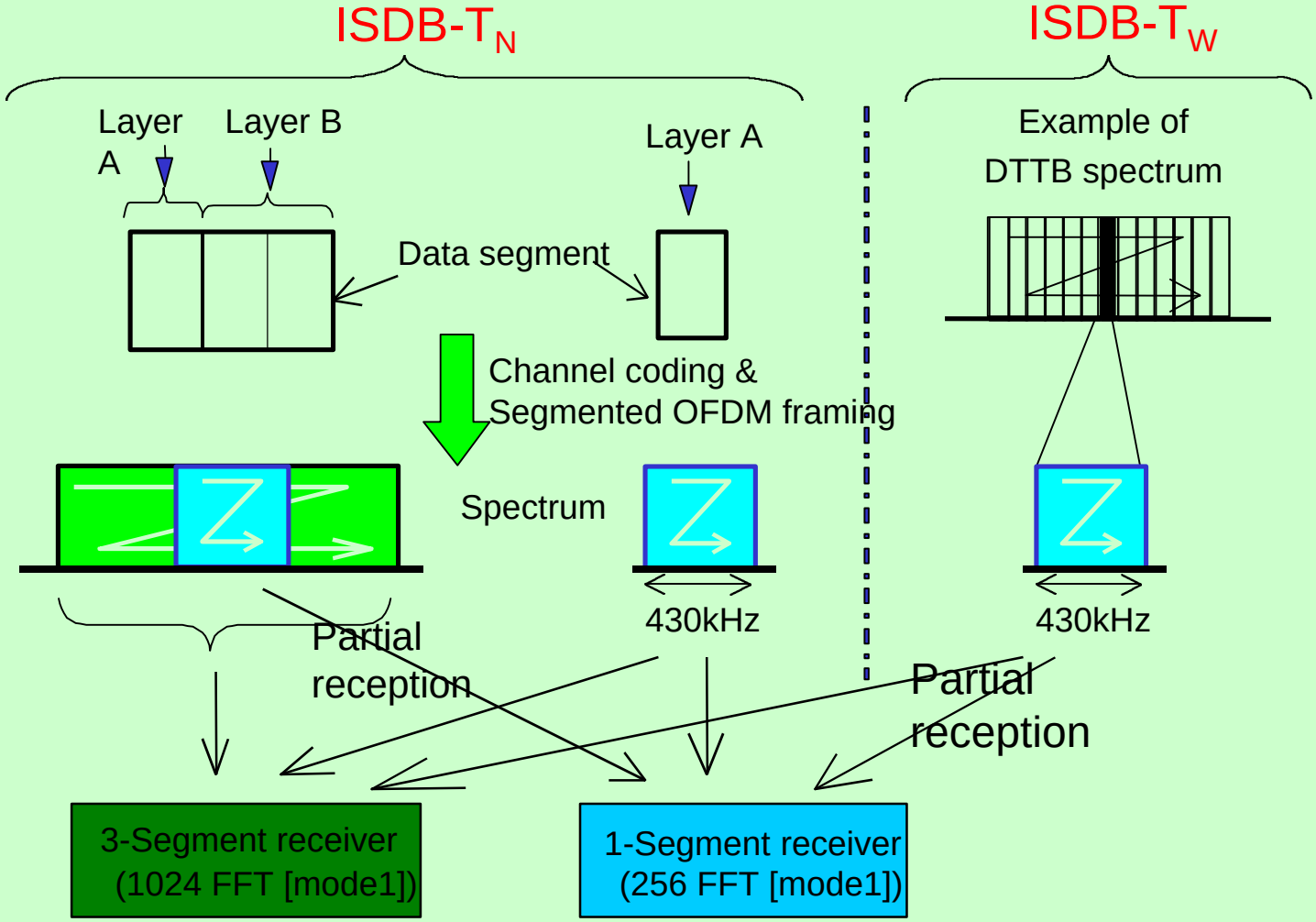
DiBEG
Digital Broadcasting Experts Group

BST-OFDM

- BST-OFDM transmission
  - composed of a set of frequency blocks (OFDM-segment)
  - common to DTTB transmission
- OFDM-segment
  - bandwidth ; 1/14 of TV channel (430kHz ; 6 MHz)
  - common structure in carrier usage
  - unit of channel-coding

DiBEG
Digital Broadcasting Experts Group

ISDB-T_N transmission and partial reception



DiBEG
Digital Broadcasting Experts Group

Transmission parameters

Mode	1	2	3
Segment(s)	1 or 3		
Bandwidth	430kHz or 1.3MHz		
Carrier spacing	3.97kHz	1.98kHz	0.99kHz
Total carriers	109 / 325	217 / 649	433 / 1297
Data carriers	96 / 288	192 / 576	384 / 1152
TMCC,AC,CP, SP carriers	13 / 37	25 / 73	49 / 145
Modulation	QPSK, 16QAM, 64QAM, DQPSK		

DiBEG
Digital Broadcasting Experts Group

Transmission parameters (con't)

Mode	1	2	3
Symbol duration	252µs	504µs	1.008ms
Guard interval	1/4 - 1/32 of symbol duration		
Symbols/frame	204		
Frame duration	53 - 64ms	106 - 129ms	212 - 257ms
Inner code	Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)		
Outer code	(204,188) RS code		
Interleaving	Time and Frequency		

DiBEG
Digital Broadcasting Experts Group

Example of information bit-rate(TS rate)

	1segment	3segment	note
DQPSK,r=1/2,Tg=1/4	280kbps	0.84Mbps	Min. rate
DQPSK,r=1/2,Tg=1/16	330kbps	0.99Mbps	for mobile
DQPSK,r=2/3,Tg=1/16	440kbps	1.32Mbps	for mobile
16QAM,r=1/2.Tg=1/16	660kbps	1.98Mbps	for mobile
64QAM,r=7/8,Tg=1/32	1.87Mbps	5.20Mbps	Max. rate
Bandwidth	430kbps	1.3Mbps	

The information bit rates do not depend on transmission mode1,2 or 3, They depend on modulation ,coding rate and guard interval

DiBEG
Digital Broadcasting Experts Group

Spectrum utilization (1)

Broadcasting frequency bands are looked upon as a sequence of segments,which have a bandwidth of one fourteenth of a TV channel.

BST-OFDM scheme provides followings.

-DTV uses 13 segments, remaining one ; guard band,

-DSB uses 1 or 3 segments

-1-segment reception of 13 segment-TV signal by DSB receiver

-Consecutive-segment transmission without guard bands

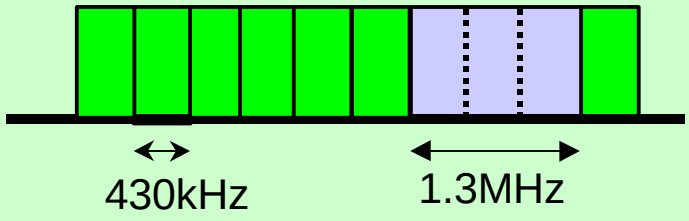
-systematic frequency re-packing towards total digital age

DiBEG
Digital Broadcasting Experts Group

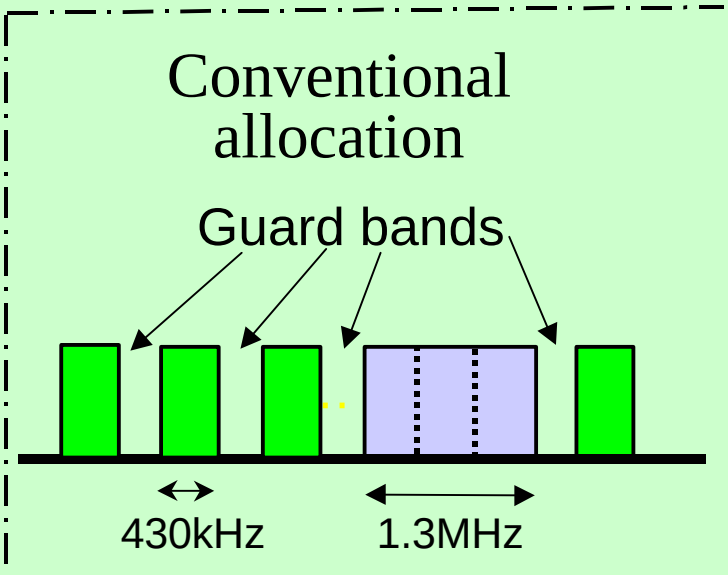
Spectrum utilization (2)
Consecutive-segment Transmission of DSB channels

Transmission from single transmitter keeping OFDM - condition

Example of allocation



Conventional allocation



Frequency utilization efficiency will be improved up to 150%.

DiBEG
Digital Broadcasting Experts Group

Summary of Features

- MPEG-2 coding and MPEG-2 systems
- High-quality and efficient sound broadcasting
- High-reliability with powerful error correction
- Mobile and portable reception
- Flexible transmission scheme common with DTTB
- Highly effective frequency utilization

DiBEG
Digital Broadcasting Experts Group

Comparison of DSB Systems (1)

Requirement		ISDB - Tn	DAB
Transmission Bandwidth		429KHz at 1 segment 1,289KHz at 3 segments	1,536MHz at mode I - IV 768KHz at mode V
Source Coding		6MHz Band : 21 Stereo + 379Kbps(max) 4MHz Band : 12 Stereo + 320Kbps(max) One system : 1 Stereo + 87Kbps(1 Segment) 5 Stereo + 73Kbps(3 segments) GI=1/4 r=1/2	6MHz Band : 12 Stereo + 384Kbps(max) 4MHz Band : 8 Stereo + 256Kbps(max) One system : 4 Stereo + 128Kbps(mode I – IV) r=1/2
Multiplexing		MPEG 2 Audio AAC and MPEG 2 Systems	MPEG 1(Layer II) and Own Systems
Carrier Modulation		OFDM(DQPSK , QPSK , 16QAM , 64QAM)	OFDM (DQPSK)
Error Correction	Inner Code	Convolution code ½ ,2/3 ,3/4 , 5/6 , 7/8	Convolution code ½ ,2/3 ,3/4 , 5/6 , 7/8
	Outer Code	RS (204 ,188)	——
Note		BER improved from 2 x 10^{-4} to 10^{-11} by outer code(RS) Satisfied ITU R Broadcast Quality with 144Kbps By MPEG 2 Audio AAC (Higher efficiency than DAB) Interoperability : MPEG 2 Audio AAC MPEG 2 Systems	Weakness BER 2 x 10^{-6} Satisfied ITU R Broadcast Quality with 256Kbps by MPEG 1(Layer II)

18

DiBEG
Digital Broadcasting Experts Group

Comparison of DSB systems (2)

Item	ISDB-T	DAB
MPEG2 multiplexing	yes	no
MPEG2 Transport Stream	yes	no
Transmission flexibility	good	no
Audio coding rate	good	poor
5.1 Multi-channel Audio	yes	no
Error correction	good	poor
Compatibility with digital TV systems	yes	no
Power consumption (Potable receiver)	good	poor
Frequency planning	easy	difficult

DiBEG
Digital Broadcasting Experts Group

Service content examples (1/3)

- High quality Sound broadcasting service
  - Adopt the most efficient audio coding:AAC (See the attachment for details)
- Support the several bit rates of audio coding
  - 144kbps or 128kbps for high quality stereo
  - support the lower bit rates for FM broadcasting class (music,information ,sports) : 96kbps
  - support the lower bit rates for speech class (news, talk): 32kbps-64kbps

DiBEG
Digital Broadcasting Experts Group

Service content examples (2/3)

- Several data services investigated in ARIB

(1) Sound program associated with data

- Words of music(scrolling): text data
- Title and jacket of music: still picture and/or text

(2) Independent data broadcasting

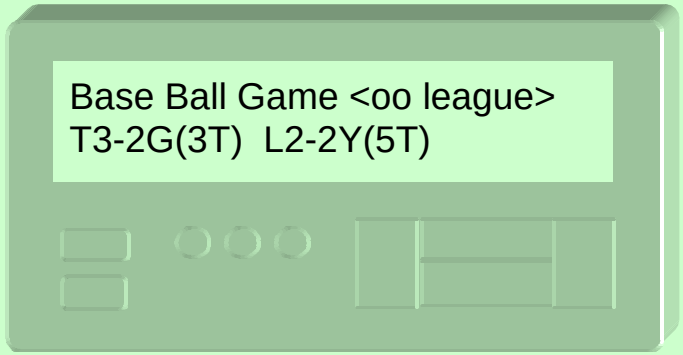
- Weather news: Audio+text+ (still picture)
- Stock market information:same as above
- Traffic information: same as above
- Shopping guide: still picture+text+(audio)

DiBEG
Digital Broadcasting Experts Group

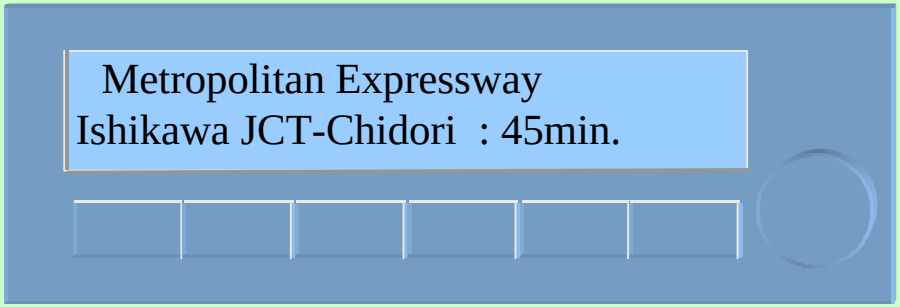
Sound program associated with data

DiBEG
Digital Broadcasting Experts Group

Data broadcasting (1)



(a) Potable receiver



(b) Car receiver

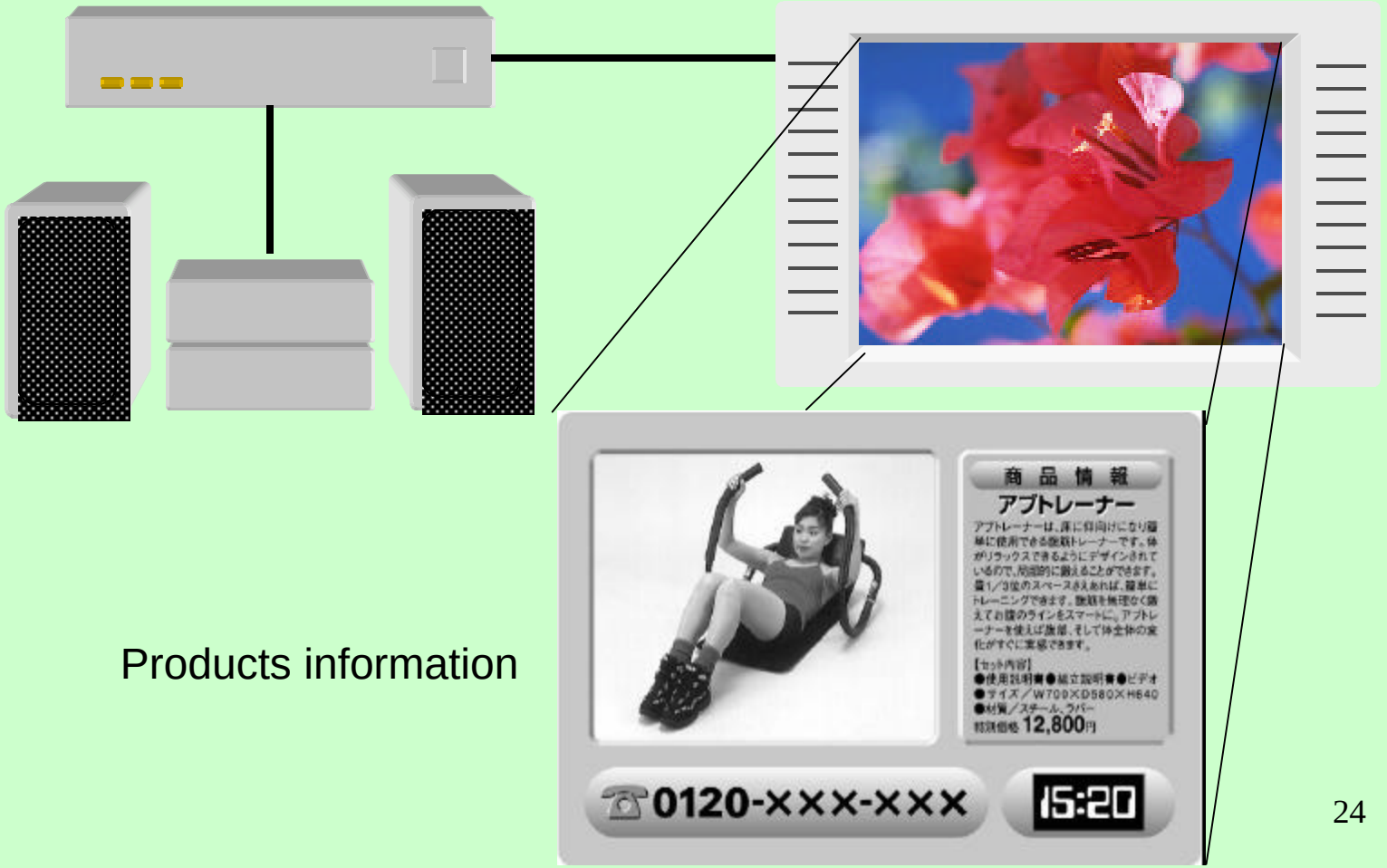
(c) Personal phone type receiver

DiBEG
Digital Broadcasting Experts Group

Data broadcasting (2)

Fixed-type receiver

TV display (still picture)



Products information

Service content examples (3/3)

(continued)

(3)Low quality video(MPEG-4) is on investigation

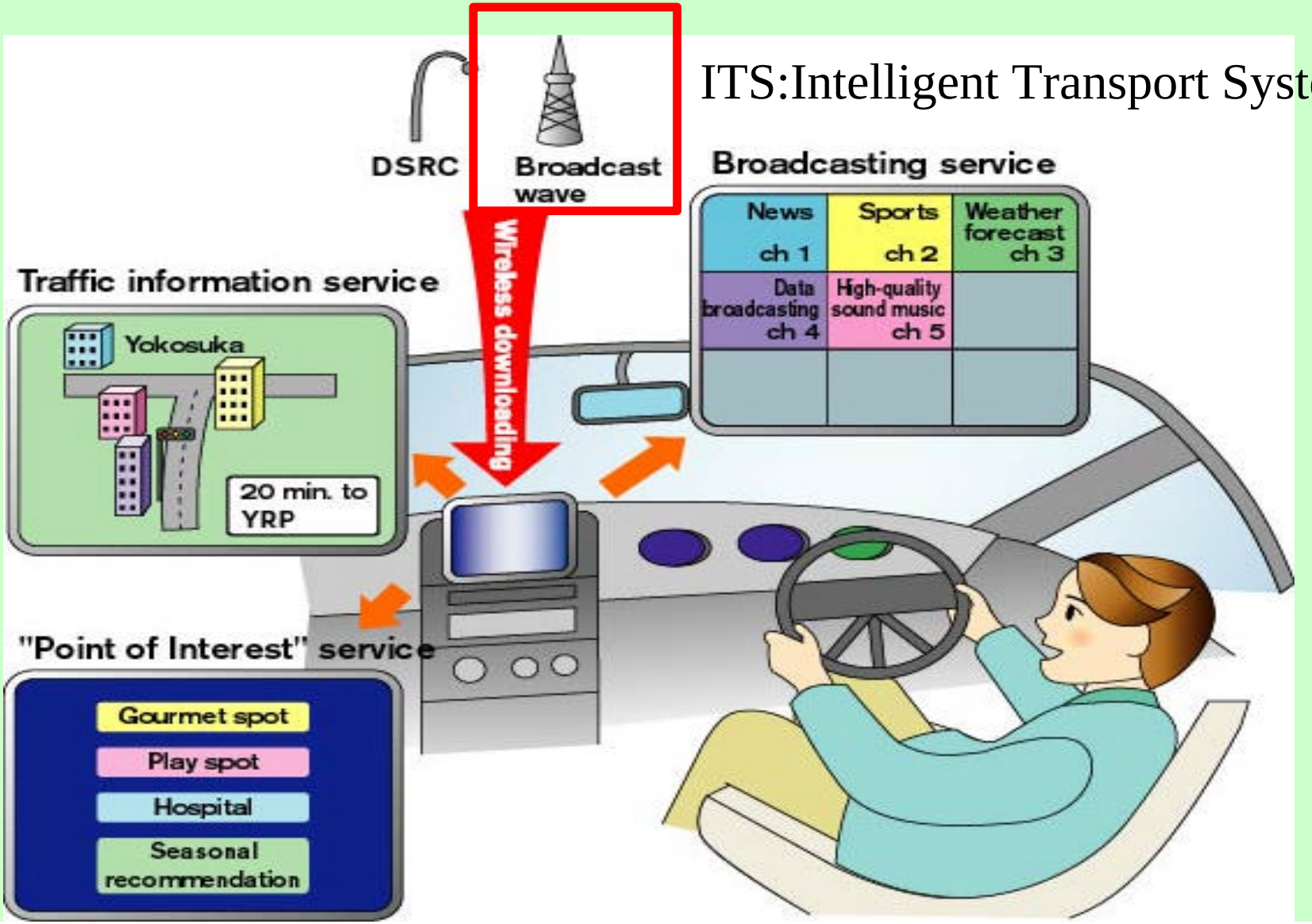
- small size display receiver

- Considering the bit rates sharing
  - Keep the lower bit rate than transmission bit rate
  - Share the bit rates to several services,

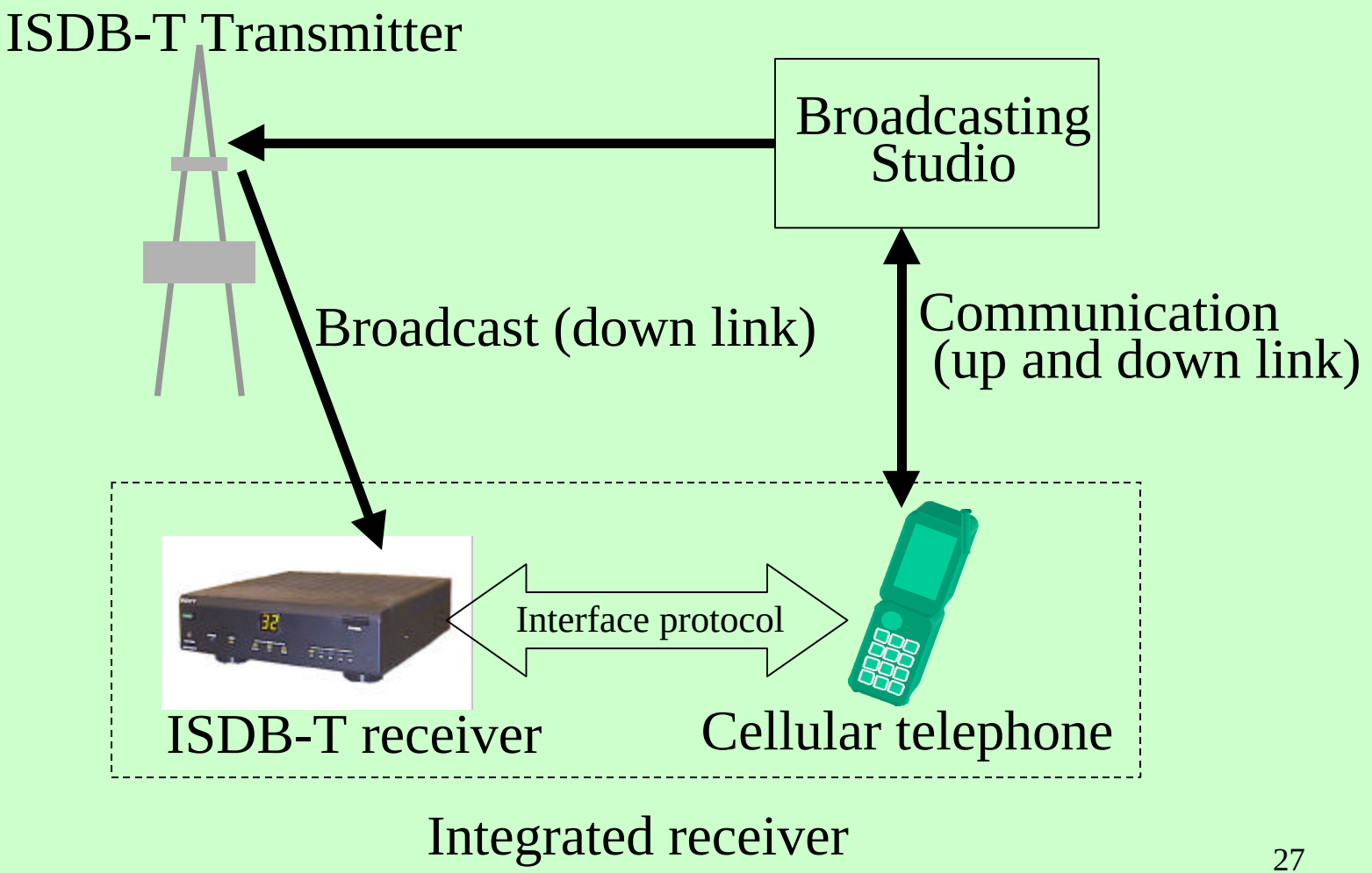
    such as,MPEG2 control(PSI,PCR,etc),program guide(SI/EPG), sound, text,still picture and others

ISDB-T_N service development with ITS

ITS:Intelligent Transport Systems



ISDB-T service development with cellular telephone



System Confirmation Tests

- Carried out by ARIB from June to September in1999
- Field experiments
  - Wide-area mobile reception trials
  - Urban-area mobile reception trials

Experimental Transmitting Station

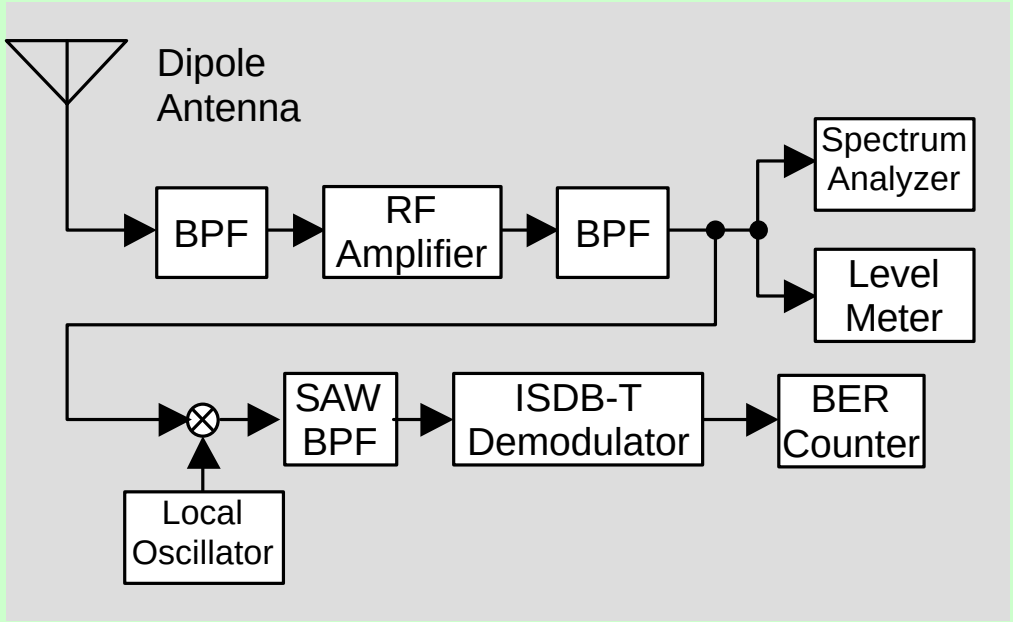
Tokyo Tower

- Mounted on Tokyo Tower
- Specifications

Antenna height	247.5 m
Frequency	190.0 MHz (VHF 7ch)
Transmitter power	100 W
ERP	800 W
Polarization	Linear-Vertical

Measuring Equipment

DiBEG
Digital Broadcasting Experts Group



- Measurements
  - Field strength
  - BER (bit error rate)
  - Positions of measuring points (by GPS)
- Measurements taken once every second

DiBEG
Digital Broadcasting Experts Group

Wide-area mobile reception trials

- *Purpose of the trials*
  - To investigate the mobile reception characteristics
    - fast-moving
    - over highways and main arterial roads
    - under actual environmental conditions
- *Transmission parameters*

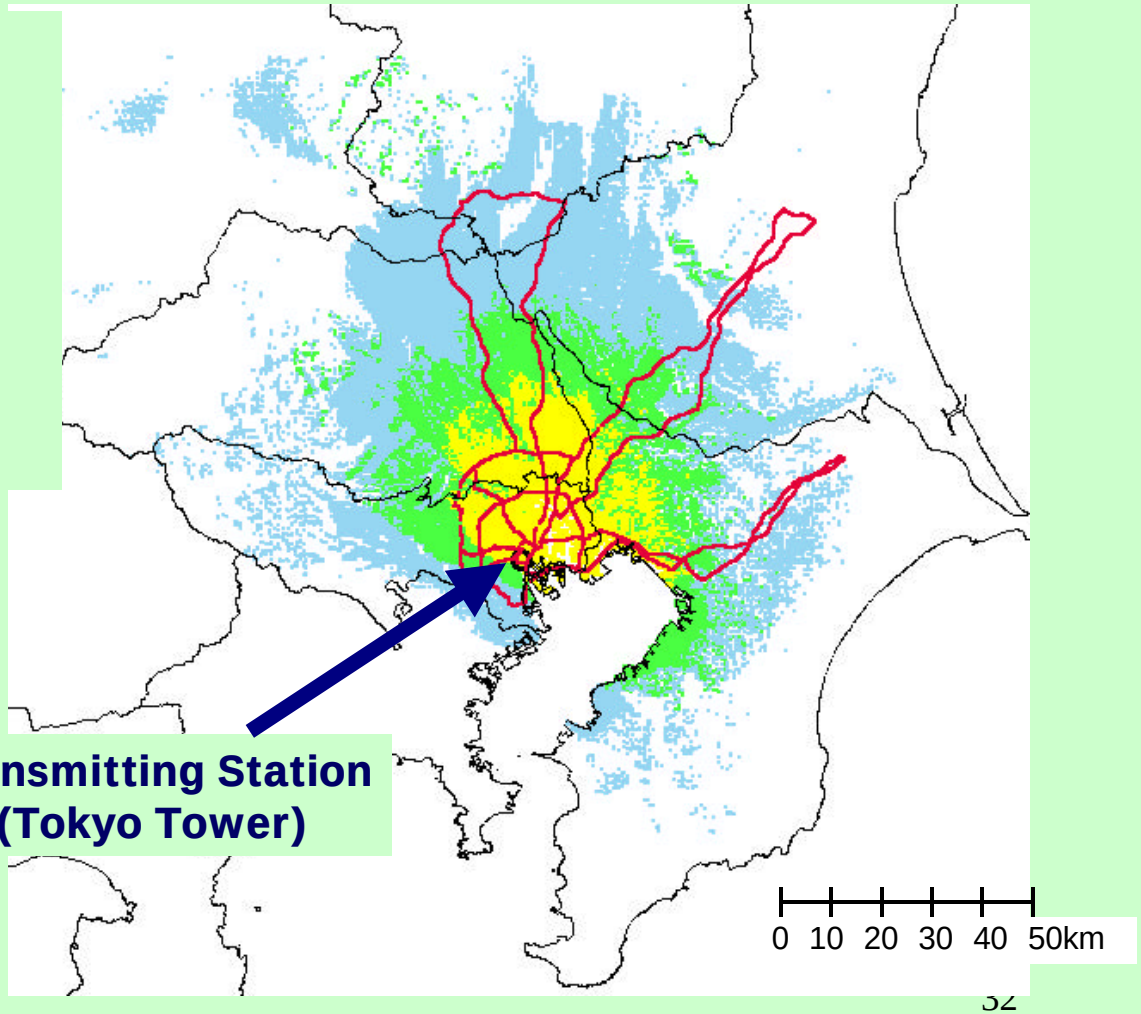
Mode	Guard Interval Ratio	Time-interleave	Carrier Modulation	Error Correction	Information Bit Rate
3	1/16	407ms	DQPSK	1/2 + RS	330.42
3	1/16	407ms	16QAM	1/2 + RS	660.84

Wide-area mobile reception trial

Measurement course

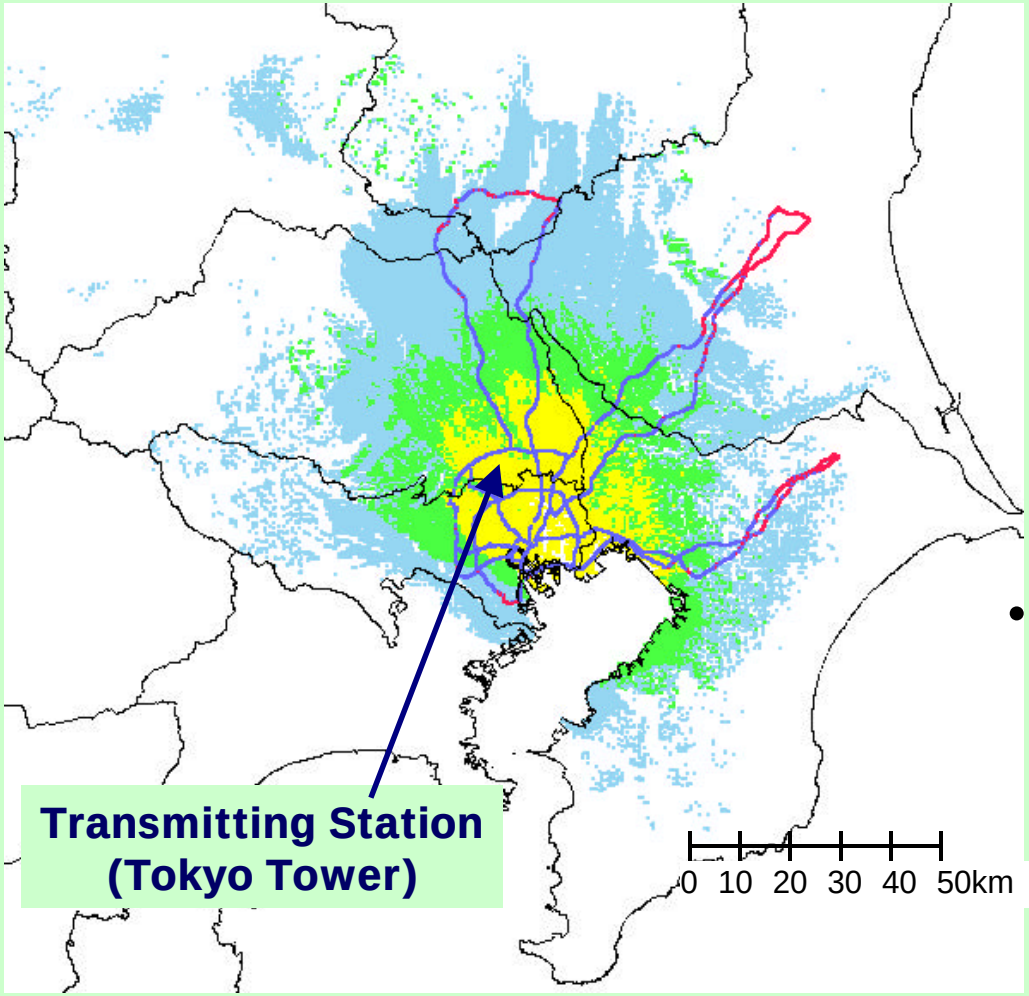
DiBEG
Digital Broadcasting Experts Group

- highways and main arterial roads
- 80 km radius of the transmitting station
- 700 km in length



Wide-area mobile reception trial
Experimental Result (DQPSK)

DiBEG
Digital Broadcasting Experts Group



DQPSK 1/2+RS

- Error free
- Error occurred

Field strength (calculated)

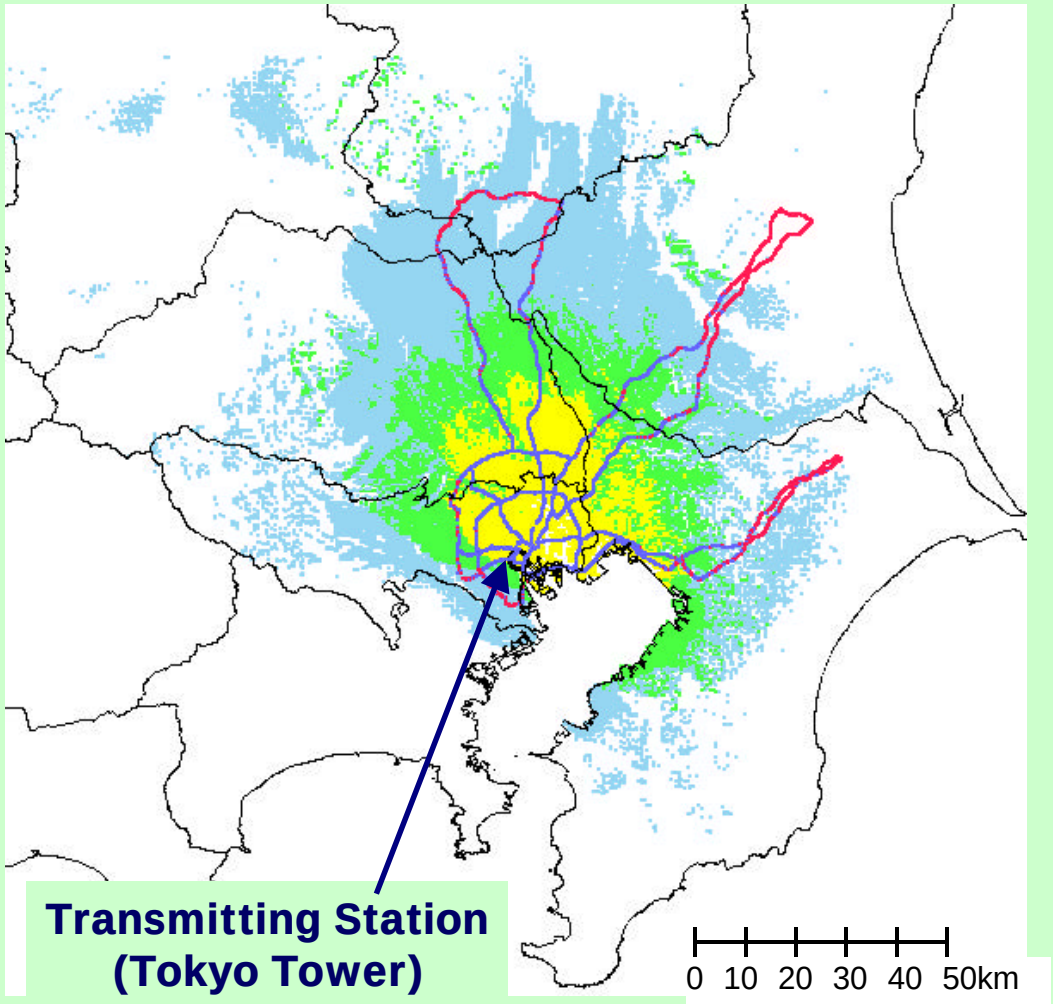
- > 70 dBμV/m
- > 60 dBμV/m
- > 50 dBμV/m

- Correct receiving:
  about 60 km radius

Wide-area mobile reception trial

Experimental Result (16QAM)

DiBEG
Digital Broadcasting Experts Group



16QAM 1/2+RS

Error free

Error occurred

Field strength (calculated)

> 70 dBμV/m

> 60 dBμV/m

> 50 dBμV/m

- Correct receiving:
  about 40 km radius

Correct reception time rate

- *definition*
  - Proportion of samples measured in a 1-second interval
  - Correct received time:

    the measured sample of which the BER = 0

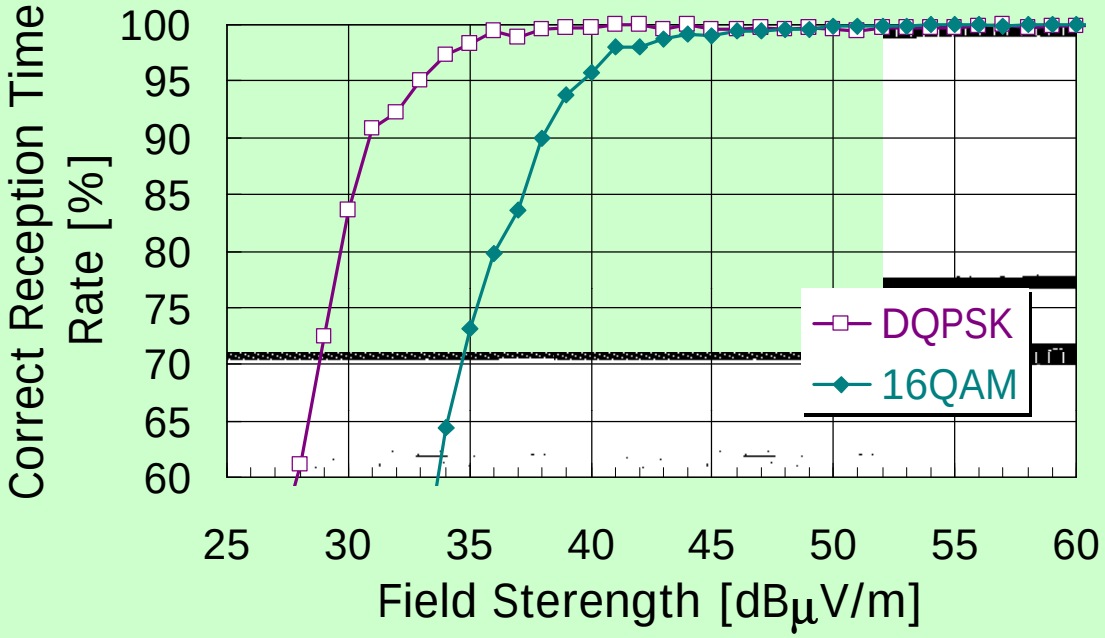
    after Reed-Solomon decoding
  - Correct reception time rate

$$= \frac{\text{(Number of correct received time)}}{\text{(Number of samples)}}$$

Wide-area mobile reception trial

DiBEG
Digital Broadcasting Experts Group

Field strength and correct reception rate



- *Field strengths to obtain correct reception time rates*

Correct Reception Time Rate	95%	98%	99%
DQPSK	**33** dBμV/m	**35** dBμV/m	**38** dBμV/m
16QAM	**40** dBμV/m	**41** dBμV/m	**44** dBμV/m

DiBEG
Digital Broadcasting Experts Group

Urban-area mobile reception trials

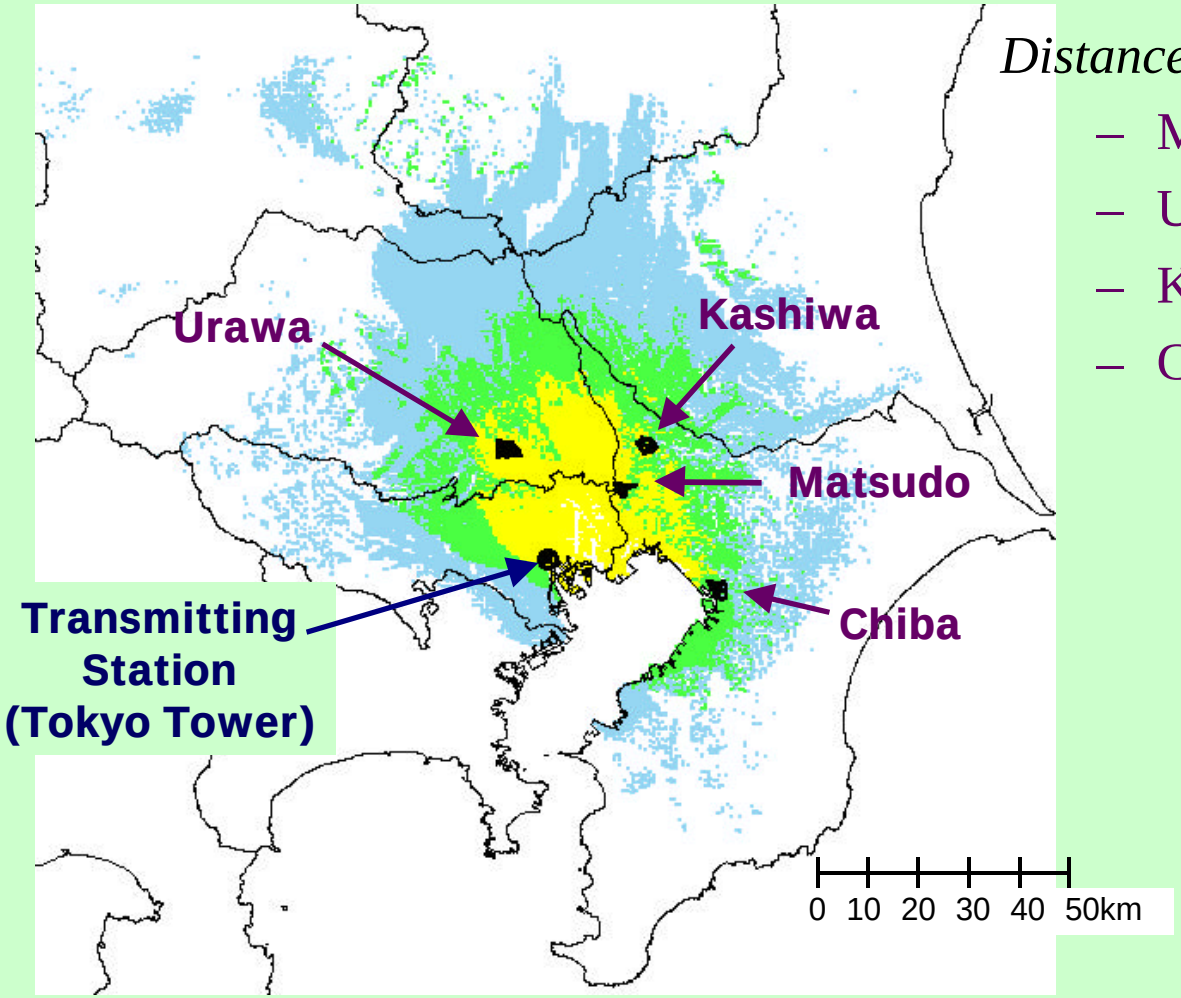
- *Purpose of the trials*
  - To confirm mobile reception characteristics
    - in medium-sized cities
      - located 20-30 km from the transmitting station
    - under typical traffic conditions
- *Transmission parameters*

Mode	Guard Interval Ratio	Time-interleave	Carrier Modulation	Error Correction	Information Bit Rate
3	1/16	407ms	DQPSK	1/2 + RS	330.42

Urban-area mobile reception trials

DiBEG
Digital Broadcasting Experts Group

Cities where the trials were conducted



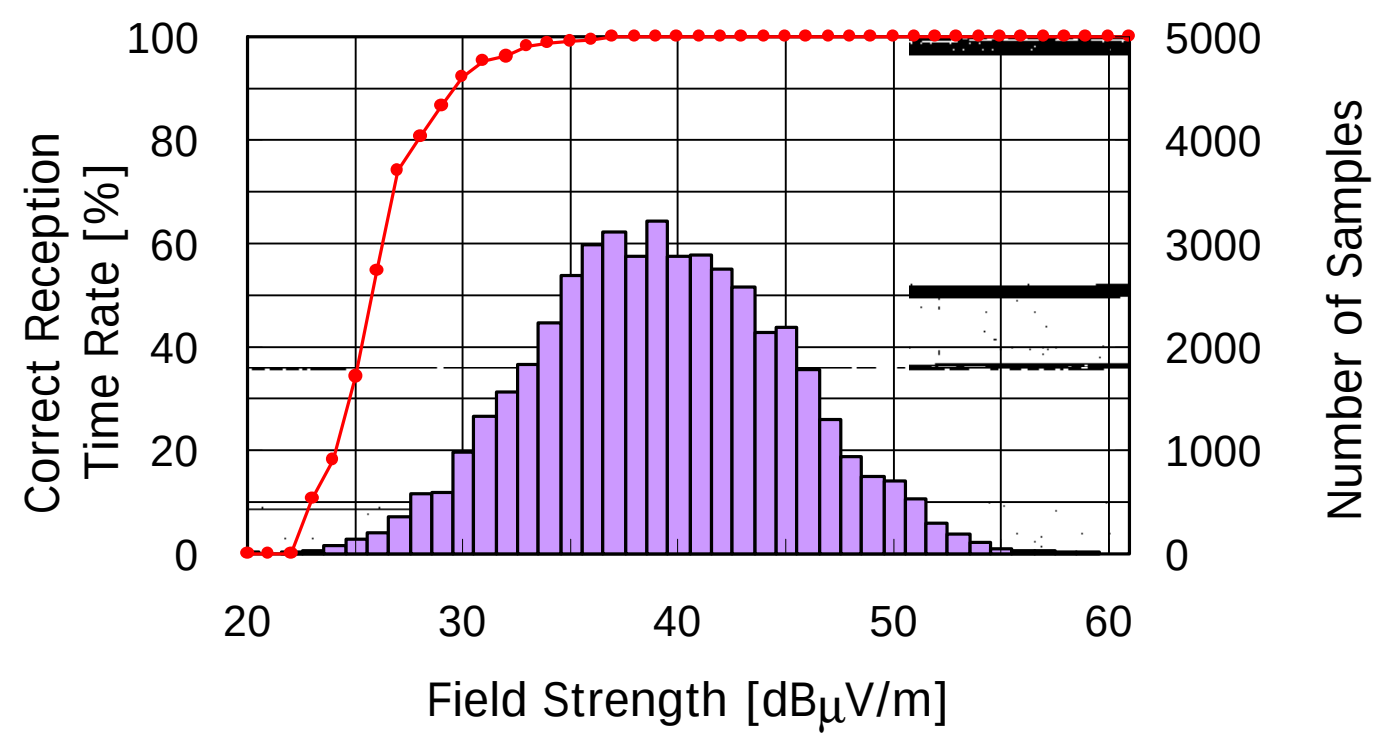
Distance from transmitting station

- Matsudo: 20 km
- Urawa: 23 km
- Kashiwa: 30 km
- Chiba: 33 km

Urban-area mobile reception trial

DiBEG
Digital Broadcasting Experts Group

Field strength distribution and correct reception time rate



- *Field strengths to obtain correct reception time rates*

Correct Reception Time Rate	95%	98%	99%
Field Strength	**31** dBμV/m	**33** dBμV/m	**35** dBμV/m

DiBEG
Digital Broadcasting Experts Group

Review of the features of ISDB-T_N

- Segment transmission format
  - Support the narrow band digital terrestrial broadcasting: 1 segment and 3 segment type
- Adopt the efficient audio coding(MPEG AAC)
  - High quality sound and low quality sound
- Adopt the MPEG2 systems for multiplexing
  - Flexibility and expandability for service multiplexing
- Robustness against multipath fading
  - Adopt the DQPSK and time interleave

DiBEG
Digital Broadcasting Experts Group

Conclusion

The ISDB-T_N provides following system merits;

- Interoperability of MPEG-2 systems
- High coding rate audio of AAC
- Powerful error correction of concatenated codes
- Transmission flexibility by BST-OFDM with a lot of transmission parameters
- Effective frequency utilization by BST-OFDM.

In the end of 2001, DSB starts in Japan