

# ***ISDB-T Transmission Technologies and Emergency Warning System***

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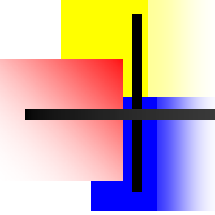


## *What is ISDB-T ?*

### *ISDB-T is ...*

- *One of the DTTB systems in the world*
  - There are 3 systems recommended in ITU-R BT1306.
    - ISDB-T, DVB-T and ATSC
- *The most flexible system*
  - HDTV, multi-SDTV, EPG, data-casting, internet-access, mobile reception, Cellular phone TV, etc.
- *The most robust system*
  - OFDM, time-interleaving, etc.
  - Brazilian comparison test results proved it.

## ***2. ISDB-T transmission system***

- 
- Requirements of DTTB
  - Transmission key technologies
  - Technical features of ISDB-T
  - ISDB-T standard

***DTTB** (Digital Terrestrial Television Broadcasting)*

***ISDB-T** (Integrated Services Digital Broadcasting - Terrestrial)*

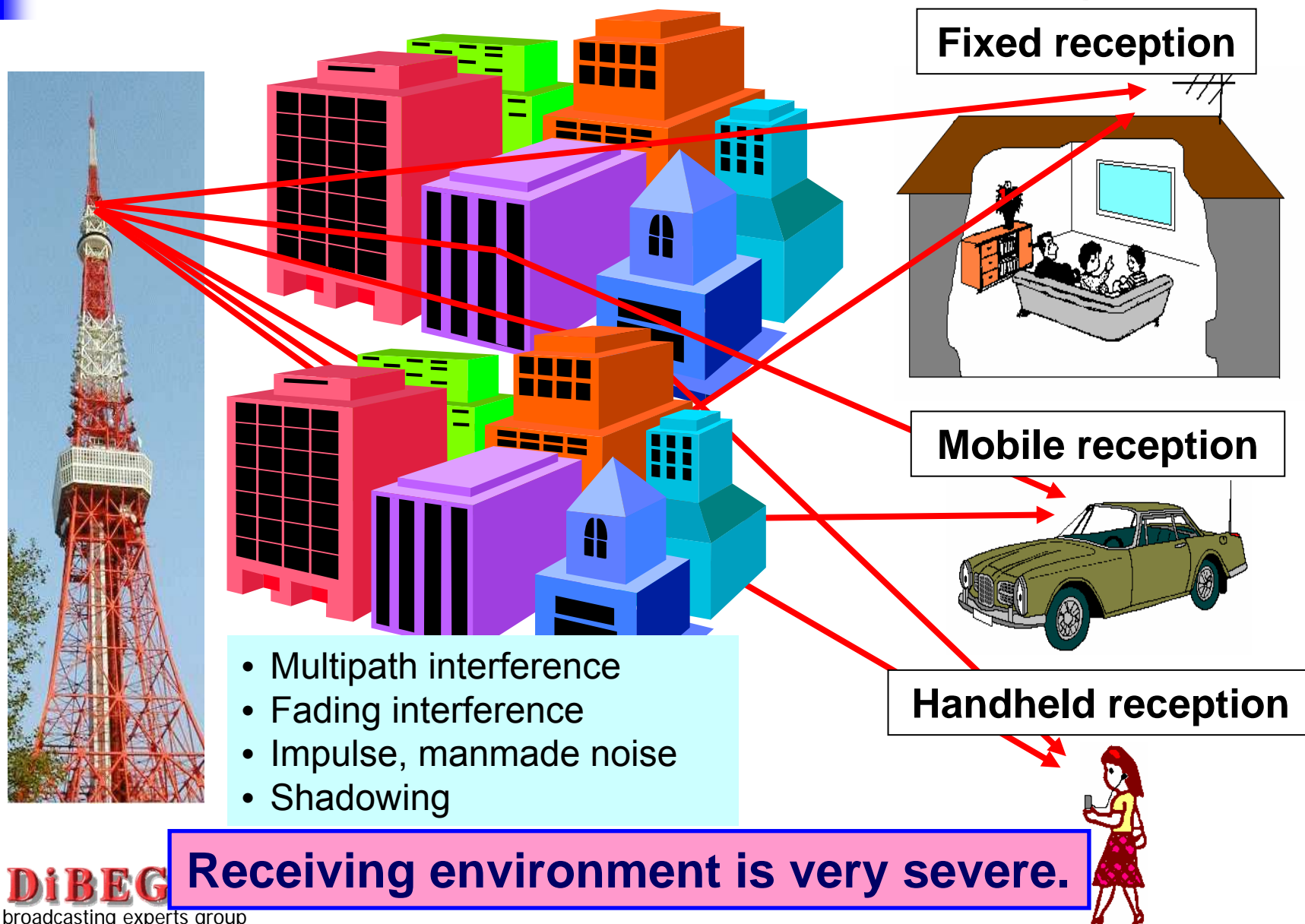


## *Requirements for DTTB*

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- ***Attractive broadcasting service***
  - High quality pictures & sound(HDTV, 5.1 surround)
  - Anytime information access (Data, Internet)
  - Robustness against interference
- ***Mobile and portable reception***
  - Anytime, anywhere TV service
- ***Effective Frequency Utilization***
  - Frequency congestion in VHF/UHF TV bands
  - OFDM, SFN (Single Frequency Network)

# Receiving environment for terrestrial TV broadcasting





## *Key technologies for ISDB-T*

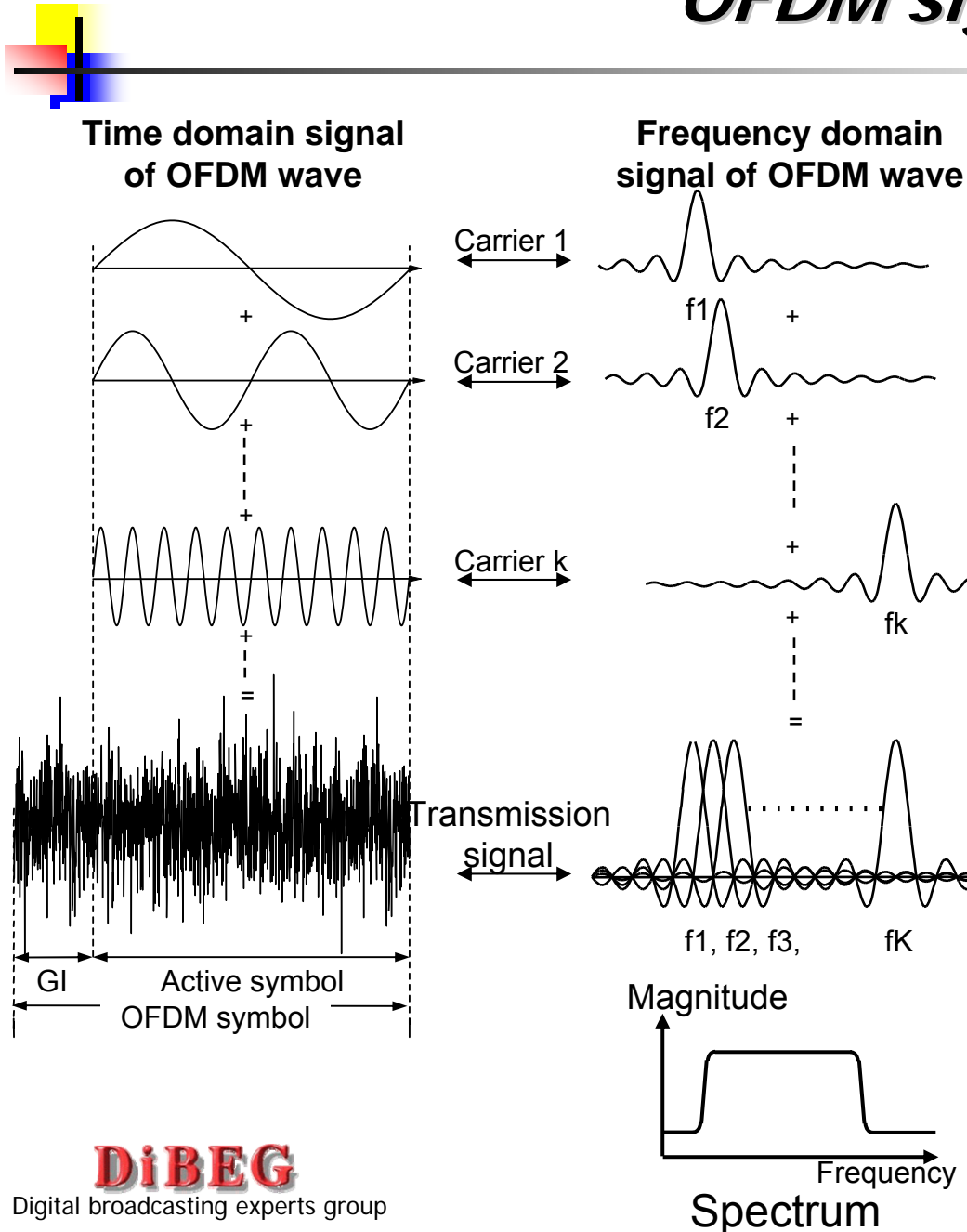
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### Key technologies adopted in ISDB-T



- To overcome severe receiving environment of DTTB service
  - **OFDM**
  - **Time-interleaving** (*Freq.&Time interleave*)
- To achieve effective and smart transmission
  - **Hierarchical transmission** by segmented OFDM
    - HDTV / multi-channel SDTV service for fixed and mobile
    - One-Seg service for handheld

# OFDM signal



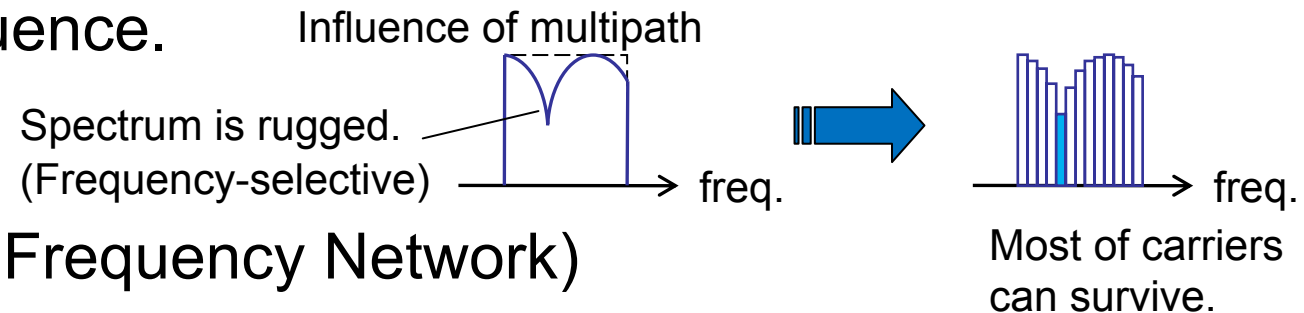
## OFDM is

- Multi-carrier modulation
  - More than 2,000 carriers in a 6MHz TV channel
  - Long symbol duration compare to single-carrier transmission system
- Multipath proof modulation
  - by adding guard interval
- Modulation/demodulation can be processed by **IFFT/FFT.**



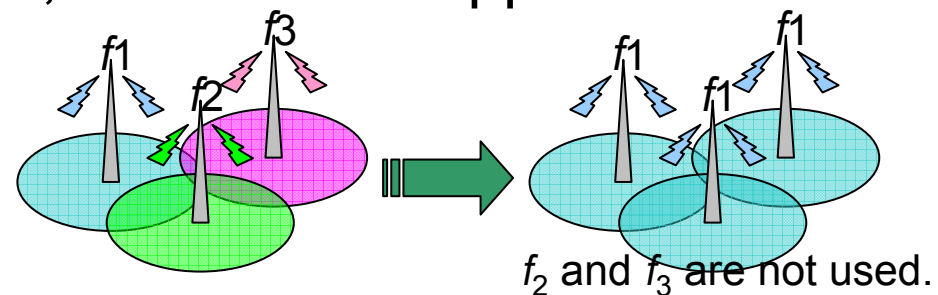
# Features of OFDM signal

- Robustness against **multipath interference** and **frequency-selective fading**
  - The band is divided by its component carriers.
  - ✓ Carrier-by-carrier degradations
  - ✓ Longer symbol duration and **guard interval** mitigates the influence.



- **SFN** (Single Frequency Network)

- Thanks to guard interval, SFN can be applied.
- Same as multipath



# Interleaving and Error correction

- Digital transmission

- Forward Error Correction (FEC) is applied.

➔ *Lower required C/N*

- ✓ Convolutional coding, Reed-Solomon coding

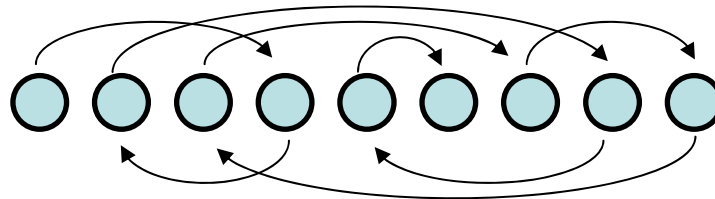
- ✓ Error distribution affects the correction performances

- Random error ? or burst error ?

- **Interleaving**

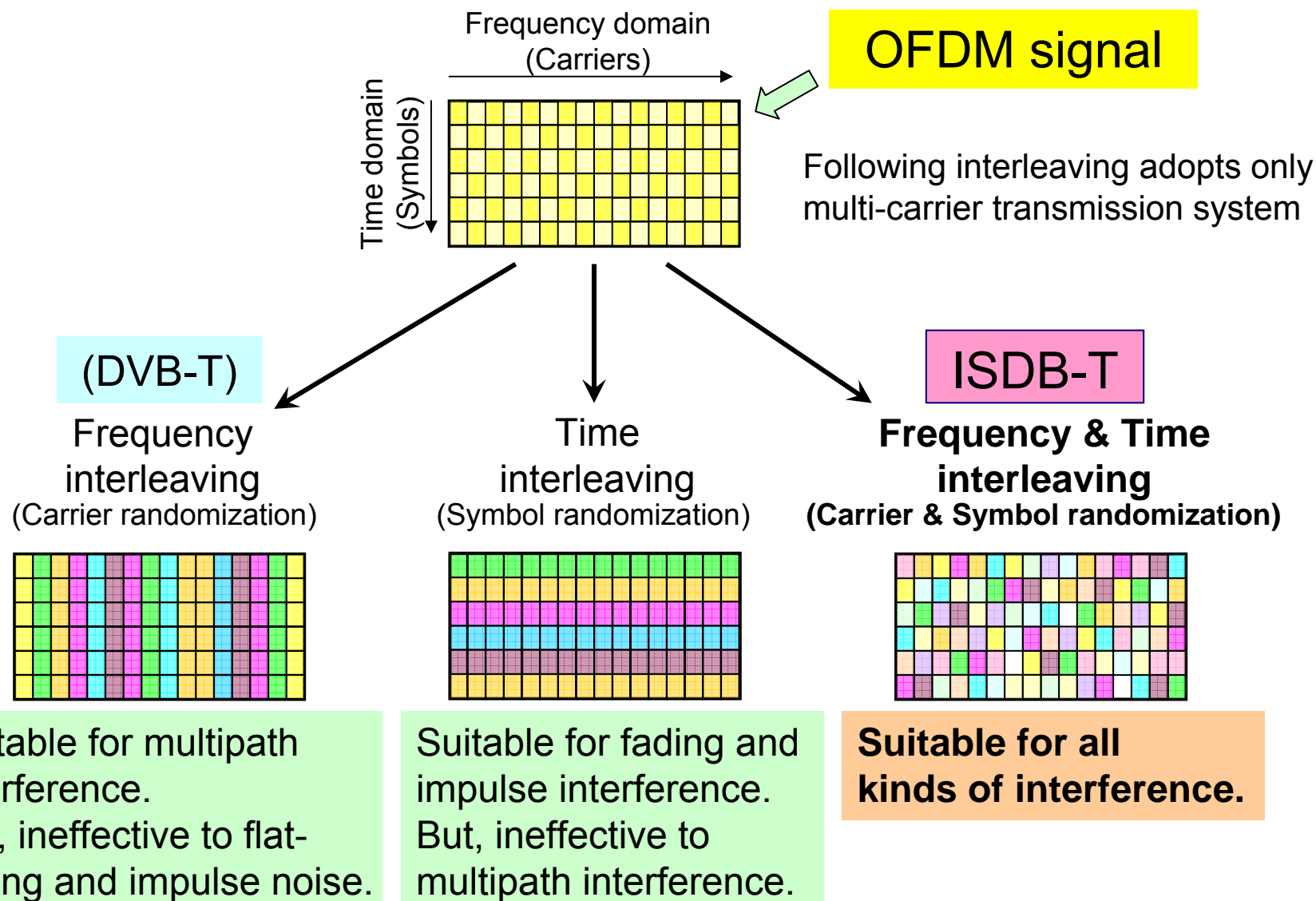
- Randomization of error distribution

- ✓ Carrier arrangement, time-sequence of symbols



An order is randomly changed.

# Frequency and time interleaving (1)

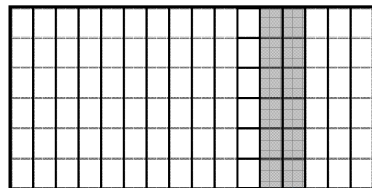


# Frequency and time interleaving (2)

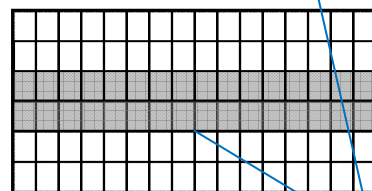


## Transmission

Multipath interference  
(Frequency selective interference)

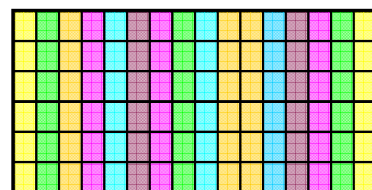


Flat fading or impulse noise

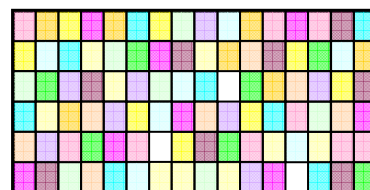


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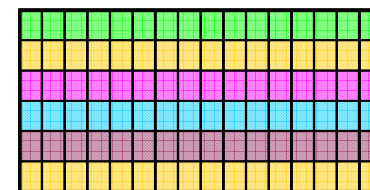
Frequency interleaving



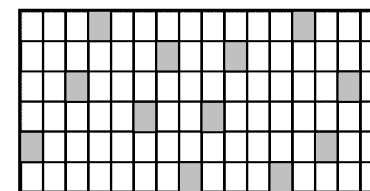
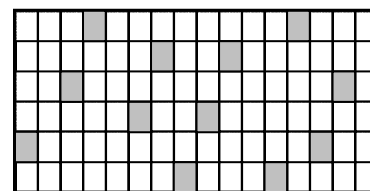
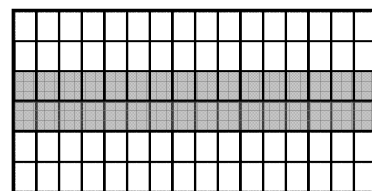
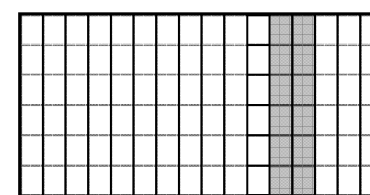
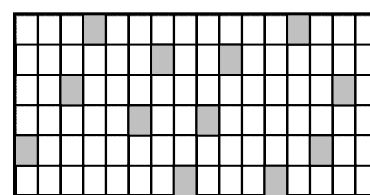
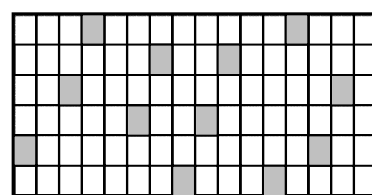
Frequency & Time interleaving



Time interleaving



De-interleave



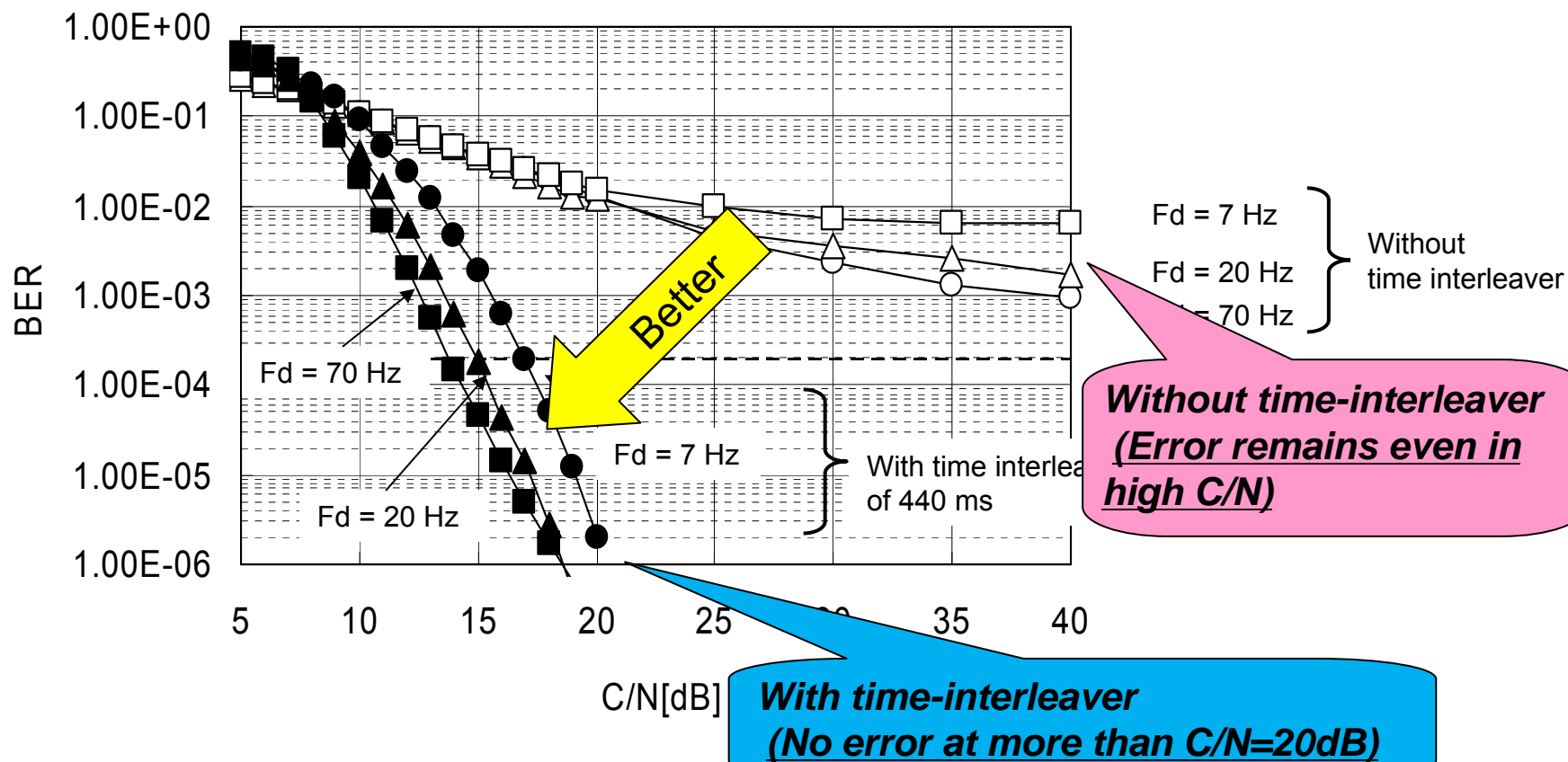
2-dimensional Random error

Suitable for Viterbi and Reed-Solomon error corrections

# Effect of frequency and time interleaving

## Laboratory test results

flat fading, DQPSK, Mode=1, GI=1/8, FEC=1/2, RS=OFF



# Hierarchical transmission

ISDB-T adopts hierarchical transmission system

- by **FDM (frequency division multiplexing) of Segment**

Hierarchical transmission is realized by changing following parameters

- Modulation** : QPSK, 16QAM, 64QAM, (DQPSK)

QPSK	16QAM	64QAM
<div> <div>More robust</div> <div>Higher capacity</div> </div>		

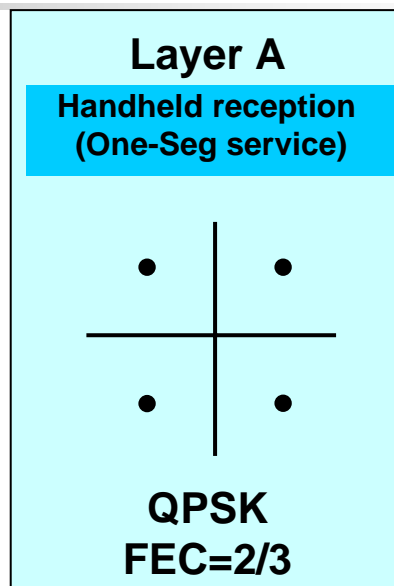
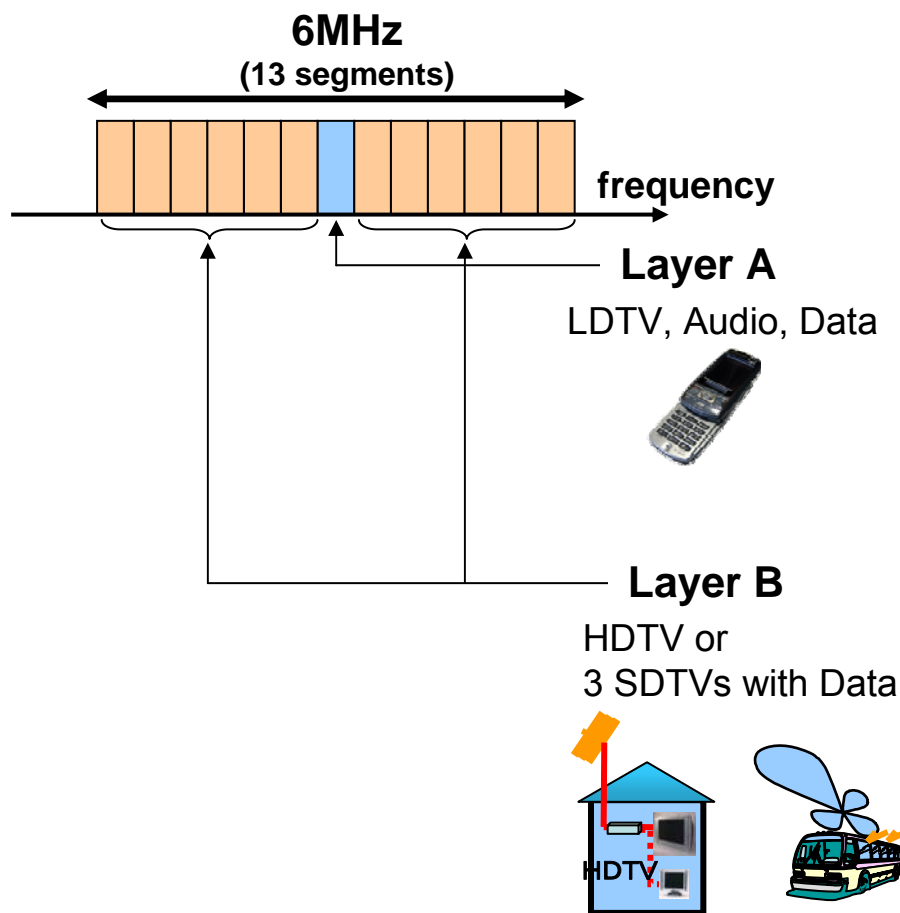
- Error correction** : Coding rate of convolutional code (1/2 - 7/8)

1/2	2/3	3/4	5/6	7/8
<div> <div>More robust</div> <div>Higher capacity</div> </div>				

# Example of hierarchical transmission

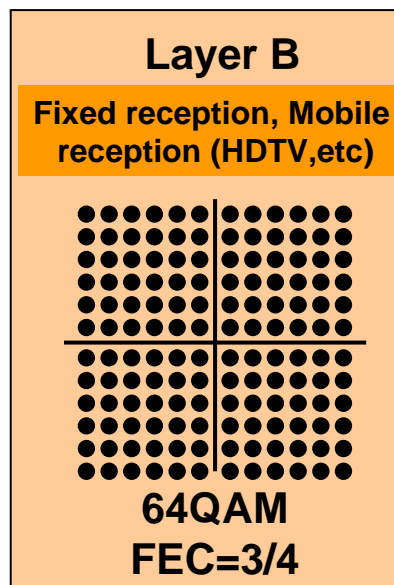
## Example

(2 layers transmission)



For handheld service

Robust transmission mode



For HDTV service

High capacity transmission mode



# *Features of ISDB-T transmission system*

## 1. Robustness against interference

- (1) OFDM transmission system
- (2) Time interleaving; very effective for various kinds of interference
- (3) Concatenated error correction with plural interleaver

## 2. Fixed and mobile (handheld) service can be achieved in one transmission channel

- (1) Hierarchical transmission by segmented OFDM
- (2) Partial reception of center one-segment for handheld service, “One-Seg.”

## 3. Efficient frequency utilization

- (1) OFDM transmission system; SFN operation
- (2) Hierarchical transmission; service for different type of reception in one frequency channel

## 4. Flexibility for several type of service/reception style



# Transmission parameters of ISDB-T (6MHz Bandwidth)

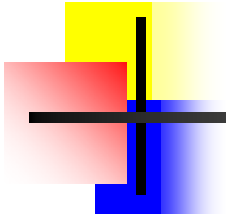


<b>ISDB-T mode</b>	<b>Mode 1 (2k)</b>	<b>Mode 2 (4k)</b>	<b>Mode 3 (8k)</b>
<b>Number of OFDM segment</b>	<b>13</b>		
<b>Useful bandwidth</b>	<b>5.575MHz</b>	<b>5.573MHz</b>	<b>5.572MHz</b>
<b>Carrier spacing</b>	<b>3.968kHz</b>	<b>1.984kHz</b>	<b>0.992kHz</b>
<b>Total carriers</b>	<b>1405</b>	<b>2809</b>	<b>5617</b>
<b>Modulation</b>	<b>QPSK , 16QAM , 64QAM , DQPSK</b>		
<b>Number of symbols / frame</b>	<b>204</b>		
<b>Active symbol duration</b>	<b>252 <math>\mu</math> s</b>	<b>504 <math>\mu</math> s</b>	<b>1.008ms</b>
<b>Guard interval duration</b>	<b>1/4 , 1/8 , 1/16 , 1/32 of active symbol duration</b>		
<b>Inner code</b>	<b>Convolutional code (1/2, 2/3, 3/4, 5/6, 7/8)</b>		
<b>Outer code</b>	<b>RS (204,188)</b>		
<b>Time interleave</b>	<b>0 -- 0.5s</b>		
<b>Useful bit rate</b>	<b>3.651Mbps -- 23.234Mbps</b>		

# ***ARIB standards and ITU-R recommendations for ISDB-T***

<b>Items</b>	<b>Contents</b>	<b>ARIB Standards</b>	<b>ITU-R Recommendations</b>
<b>Video coding</b>	<b>MPEG-2 Video (ISO/IEC 13818-2)</b>	<b>STD-B32</b>	<b>BT.1208</b>
<b>Audio coding</b>	<b>MPEG-2 AAC (ISO/IEC 13818-7)</b>	<b>STD-B32</b>	<b>BS.1115</b>
<b>Data broadcasting</b>	<b>BML (XHTML), ECMA Script</b>	<b>STD-B24</b>	<b>BT.1699</b>
<b>Multiplex</b>	<b>MPEG-2 Systems (ISO/IEC 13818-1)</b>	<b>STD-B10, STD-B32</b>	<b>BT.1300, BT.1209</b>
<b>Conditional access</b>	<b>Multi 2</b>	<b>STD-B25</b>	<b>—</b>
<b>Transmission</b>	<b>ISDB-T transmission</b>	<b>STD-B31</b>	<b>BT.1306 System C</b>
<b>Receiver</b>	<b>ISDB-T receiver</b>	<b>STD-B21</b>	<b>—</b>
<b>Operational guideline</b>	<b>ISDB-T broadcasting operation</b>	<b>TR-B14</b>	<b>—</b>

### ***3. Comparison of 3 DTTB systems***



- Comparison of 3 DTTB systems
- Results of comparison test in Brazil
- Summary of comparison

# Technical features of DTTB Systems

System		ATSC	DVB-T	ISDB-T
Modulation		8VSB	<b>OFDM</b> (QPSK, 16QAM, 64QAM)	<b>Segmented OFDM</b> (DQPSK, QPSK, 16QAM, 64QAM)
Inter-leaving	Bit/Symbol	Yes	Yes	Yes
	Frequency	-	Yes	Yes
	time	-	-	<b>0s, 0.1s, 0.2s, 0.4s</b>
Excess Bandwidth/ Guard Interval		11.5%	1/4, 1/8, 1/16, 1/32	1/4, 1/8, 1/16, 1/32
Configuration		-	TPS	TMCC
Information bit rate		19.39 Mbps	3.69 -23.5Mbps	3.65 -23.2 Mbps
Channel bandwidth		6 / 7 / 8 MHz	6 / 7 / 8 MHz	6 / 7 / 8 MHz

# Results of Brazilian Tests

- **Comparison tests for three DTTB systems**
  - ATSC, DVB-T, ISDB-T
- **Carried out from Aug. 1999 to April 2000**
- **Laboratories tests**
  - AWGN, impulse noise, multipath, Doppler effect
- **Field tests**
  - Coverage, gap-filler, indoor reception, etc.

ISDB-T shows superior performances especially for following items

- (1) Robustness against impulse noise (urban noise)
- (2) Coverage; robustness of ISDB-T system leads wide cover area
- (3) Indoor reception; Robustness against impulse noise and fading leads good performance of indoor reception

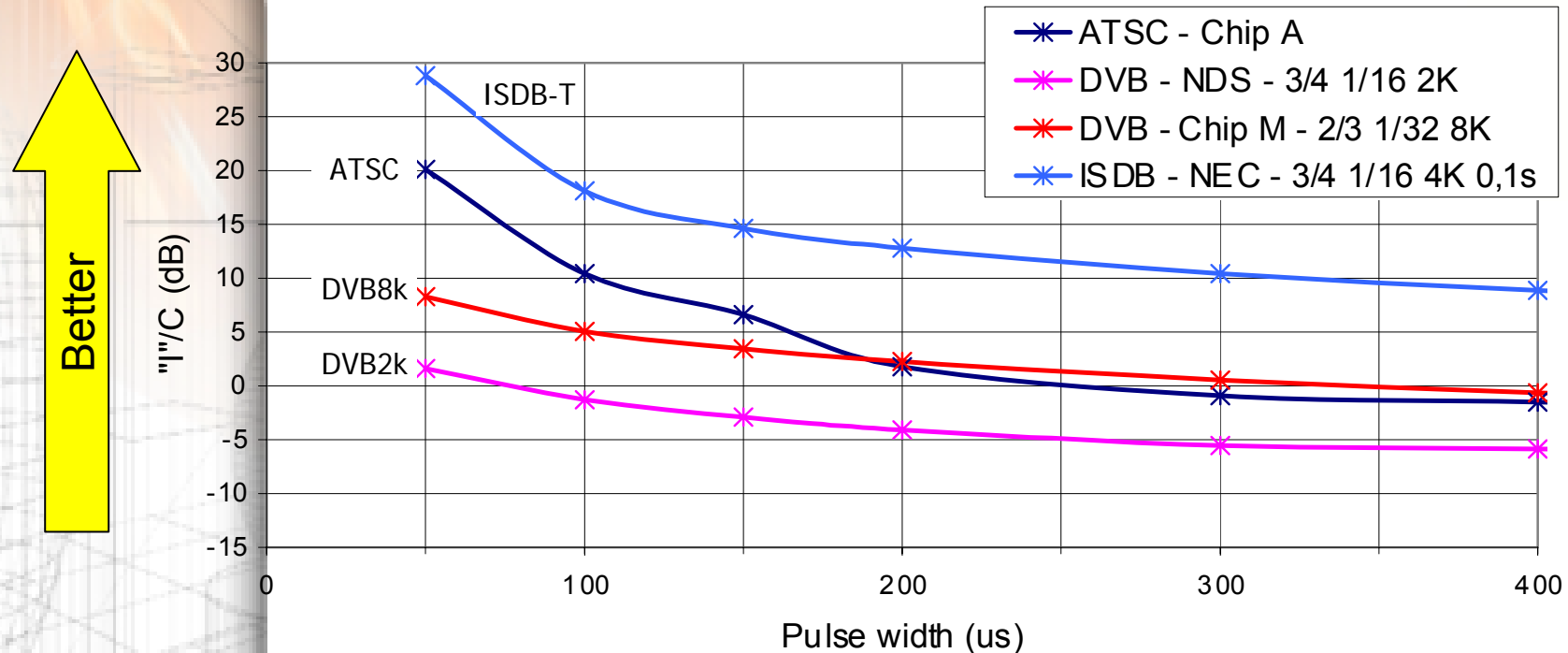
# Selected transmission parameters

- Transmission parameter : almost same bit rate
- ATSC
  - Fixed, 8VSB FEC=2/3 (19,39 Mbit/s)
- DVB-T
  - DVB-2K : 64QAM FEC=3/4 GI=1/16 2K (19,75 Mbit/s)
  - DVB-8K : 64QAM FEC=2/3 GI=1/32 8K (18,09 Mbit/s)
- ISDB-T
  - ISDB-4k : 64QAM FEC=3/4 GI=1/16 4K 0,1s (19,33 Mbit/s)

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)

# Impulse Noise

Relation between the noise pulse width & interference to signal ratio

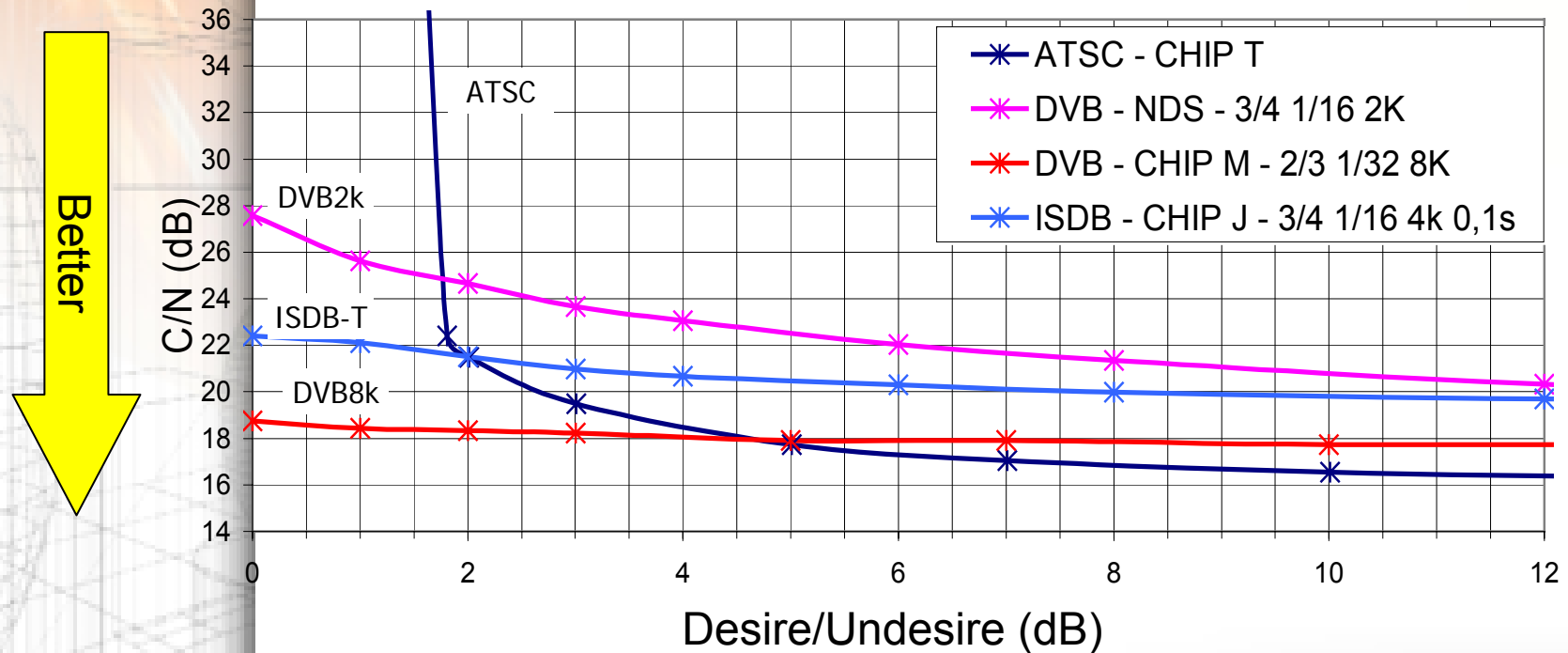


- Better performance of the ISDB-T system, by introducing time interleaving

(From the presentation of the Brazilian SET/ABERT study group at NAB2000)

# Static Multipath

Carrier to noise ratio as a function of carrier to echo ratio  
Comparison at post-echo = 8us

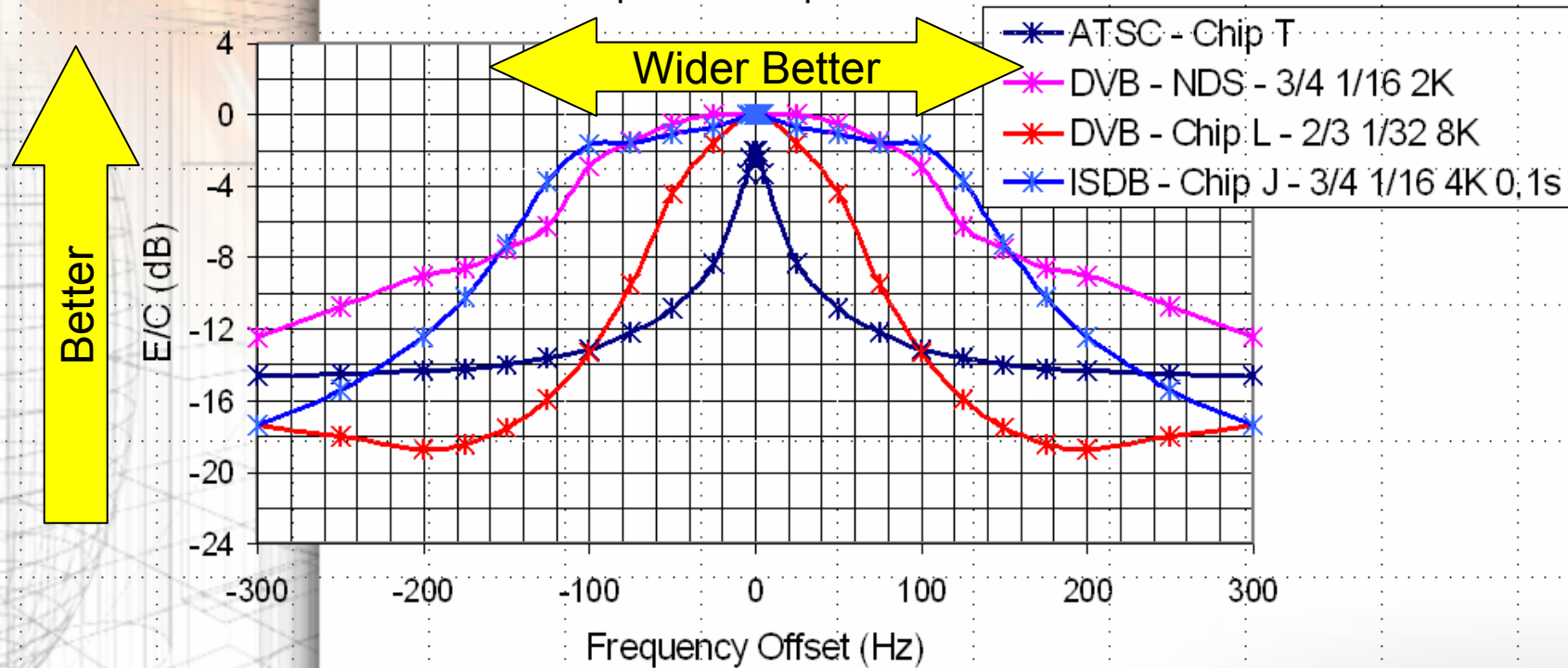


(From the presentation of the Brazilian SET/ABERT study group at NAB2000)



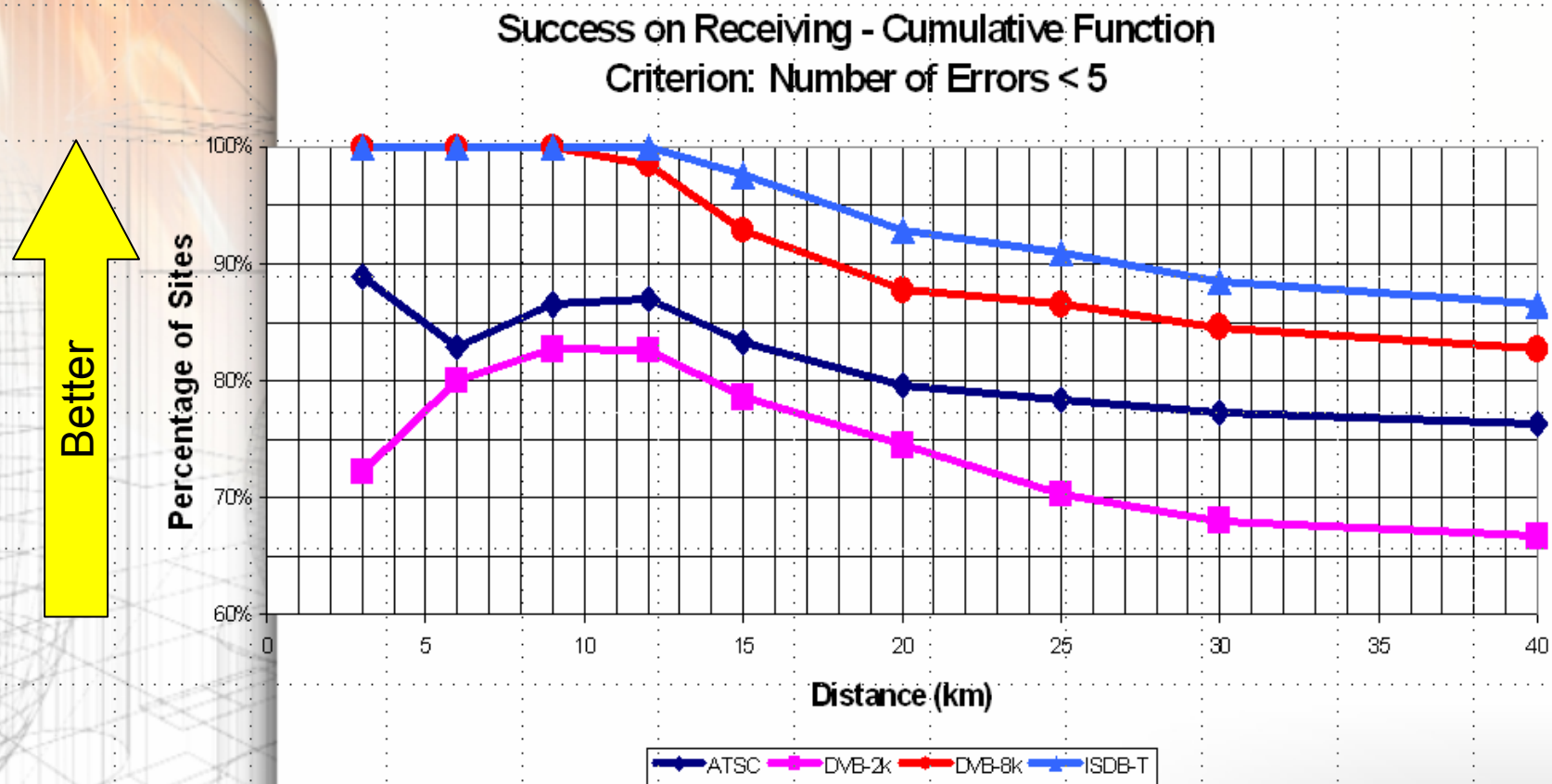
# Doppler Effect

Echo to carrier ratio as a function of frequency offset  
Comparison at post-echo = 8 us



(From the presentation of the Brazilian SET/ABERT study group at NAB2000)

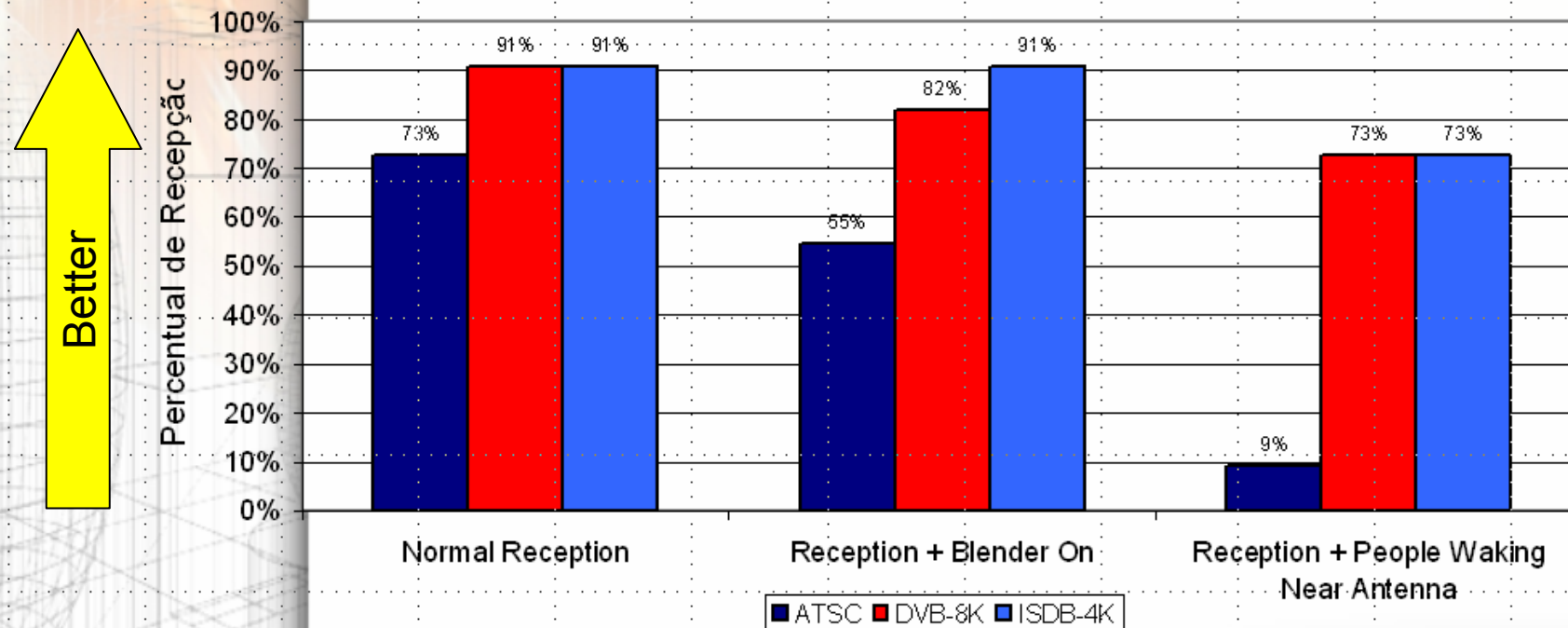
# Outdoor: Coverage



(From the presentation of the Brazilian SET/ABERT study group at NAB2000)

# Indoor Reception

Indoor Reception: Sites Where the Three Systems Were Tested  
in the Same Condition



(From the presentation of the Brazilian SET/ABERT study group at NAB2000)

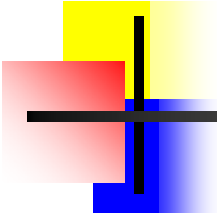


## *Essence of comparison test results*

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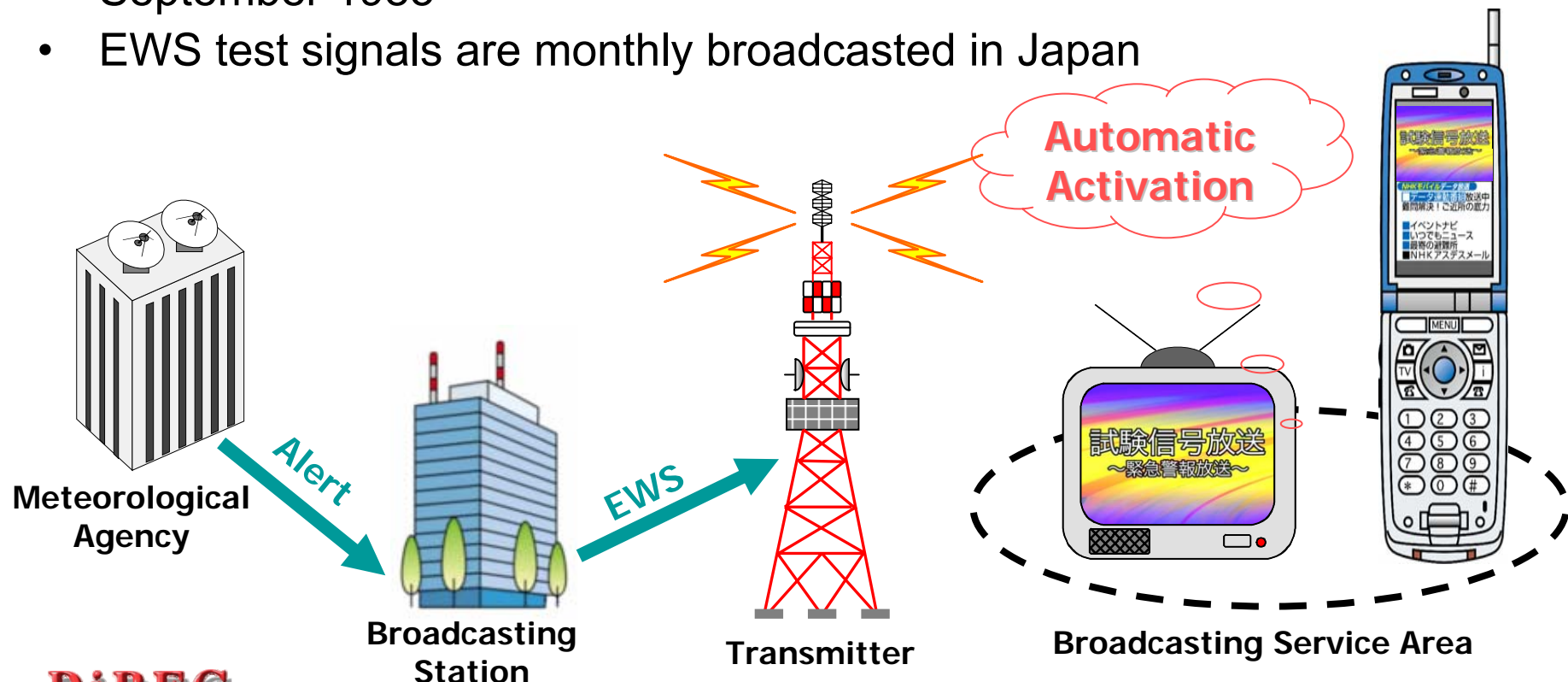
- The **OFDM** modulation scheme is suitable for DTTB in real broadcast circumstances.
- **Time interleaving** scheme, adopted in ISDB-T, is a key technology for mobile digital transmission and is also effective to cope with impulse noise degradation.
- **ISDB-T showed the best results** in Brazil's comparison tests.

## ***4. Emergency Warning Broadcasting System***

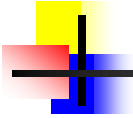
- 
- A decorative graphic on the left side of the slide, featuring a yellow square, a red square, and a blue square, with a black crosshair-like structure overlaid.
- Emergency Warning Broadcasting System (EWS)
  - Service image of EWS
  - EWS for One-Seg
  - Key technology for power saving

# Emergency Warning Broadcasting System

- Remote activation of Radio & TV ready for EWS
  - AM, FM Radio & TV : Control signal and Alert Sound
  - Digital Broadcasting (ISDB-T) : Emergency Warning Control Flag
- In Japan, EWS for analog broadcasting has been operated since September 1985
- EWS test signals are monthly broadcasted in Japan



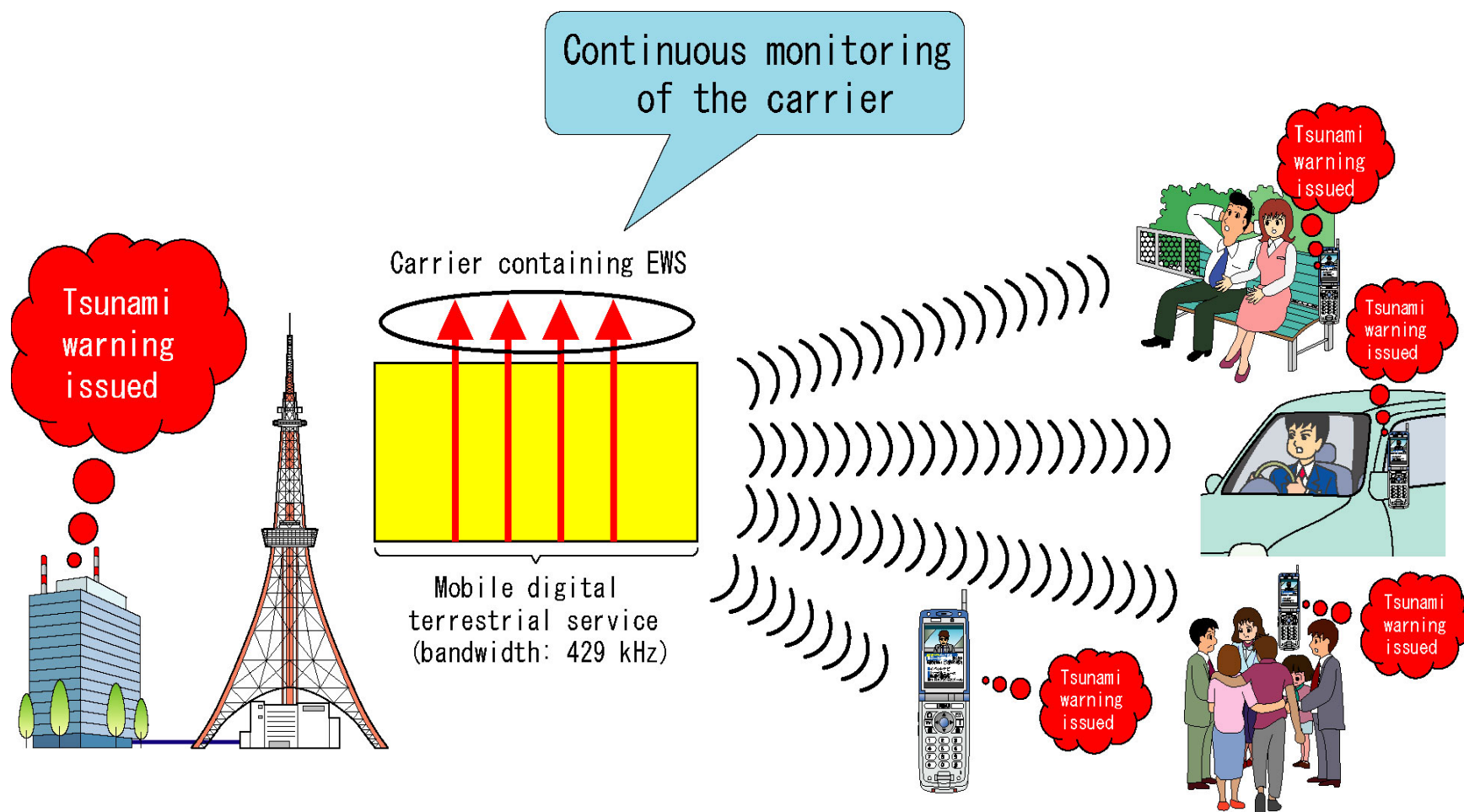
# *Functions of broadcasting in disaster management*



1. Gathering/receiving disaster information from administrative organizations
  2. Filtering information
  3. Delivering disaster information to the general public
  4. Broadcasting offers reliable information  
There is no “spam” information in broadcasting
  5. Broadcasting is always connected to everybody  
There are no congestions like in communication
  6. Broadcasting is always active : 24 hour operation
- Broadcasting is an ideal media to deliver disaster information to the general public

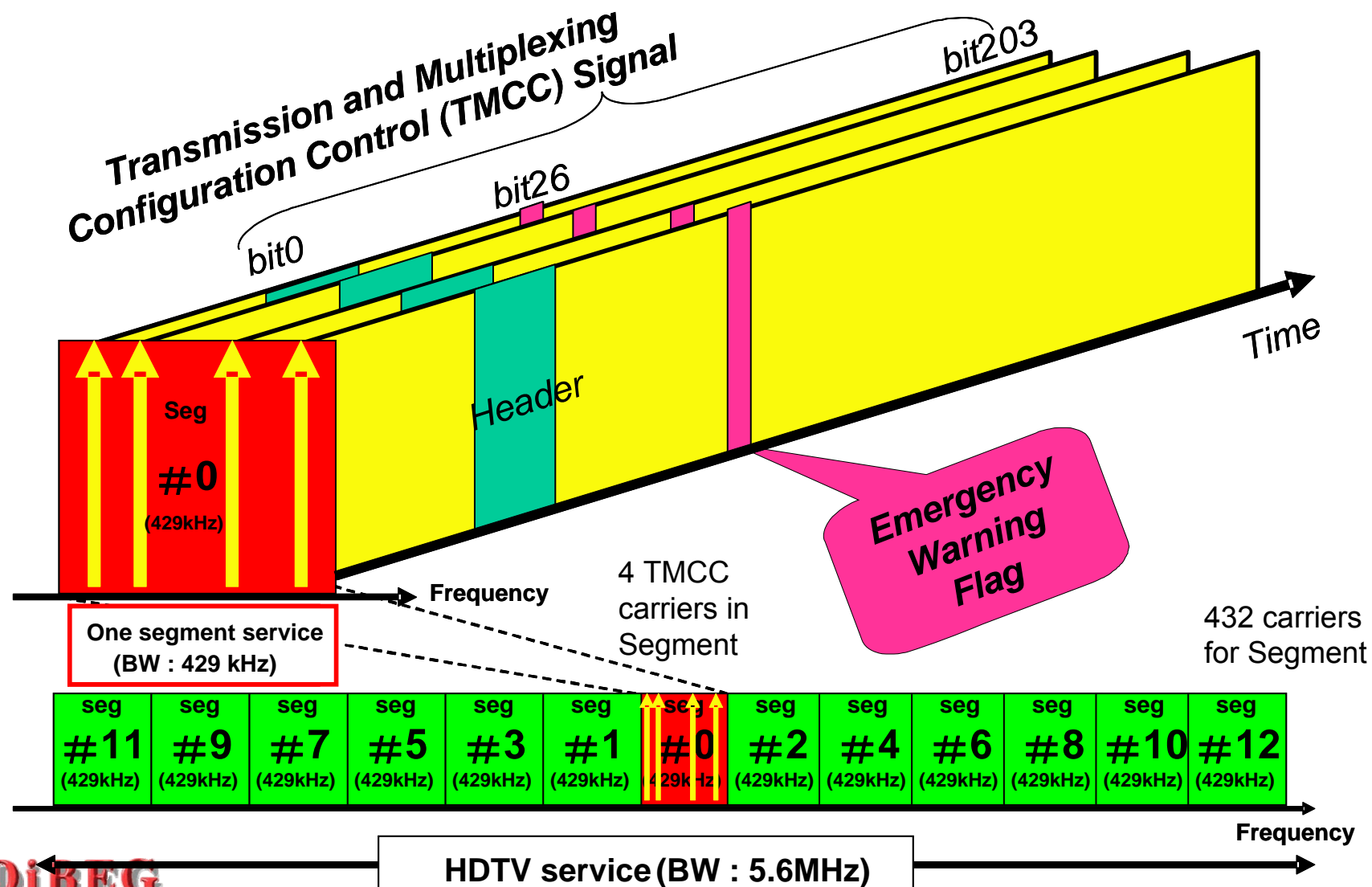


# Concurrent mobile receiver activation using EWS





# EWS signal allocation in ISDB-T



## *EWS for ISDB-T One-Seg services*

- EWS for ISDB systems have already been in operation in Japan as well as analog broadcasting
- Portable EWS receivers for One-Seg are now under development
- One-Seg receivers are expected to enlarge the opportunity to avoid disaster
- Key technology is power consumption saving in stand-by mode



## *ISDB-T One-Seg services & EWS*

- Remote activation of mobile terminals by EWS is very effective.
- EWS bits in TMCC have to be always watched in mobile terminals.



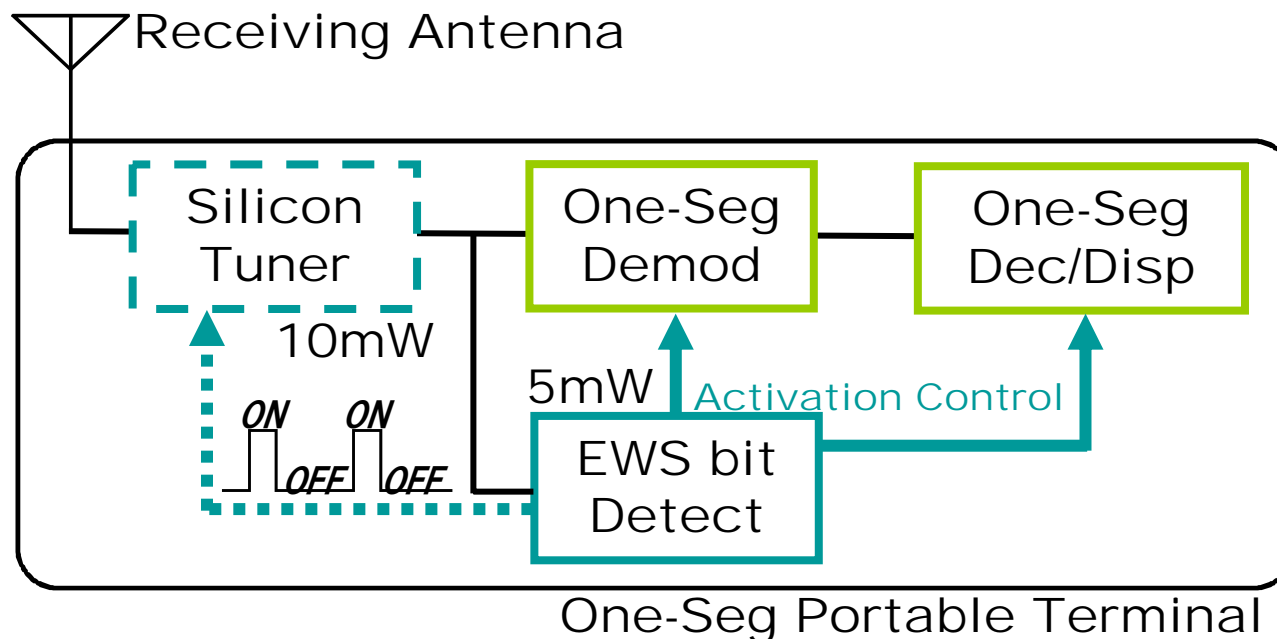
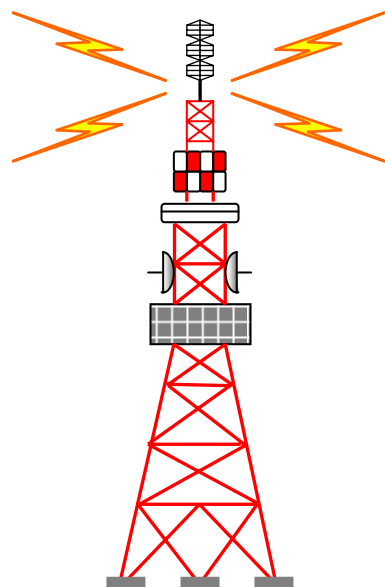
The problem is power consumption  
of mobile terminals



Power consumption saving is required  
during EWS stand-by mode

We developed the key technology

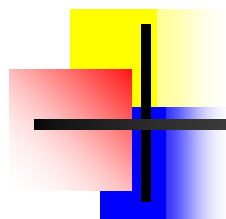
# Key technology for power saving while EWS stand-by mode



- NOT employ a FFT for EWS bit detect.
- Silicon Tuner(10mW) and EWS bit detector(5mW) are active only for necessary duration
- Life of a Battery(3.7V,800mAh $\div$ 3Wh) improved to 200h(8.3 days)

**More than 10 times improved**

## ***5. Conclusions***

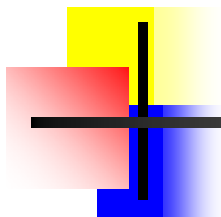




## Conclusions

- **ISDB-T** is the *most robust* transmission system
  - Adopting OFDM and time-interleaving
  - Brazilian comparison tests prove it.
- **HDTV** (or **SDTV multi-channel**) and **One-Seg** (handheld TV service) can be transmitted *simultaneously* in a single channel.
  - ISDB-T enables both digital TV service for fixed and mobile (handheld) by just one transmission facility
- **SFN** can be effective for frequency utilization
- Power saving of **One-Seg EWS** receiver in stand-by mode, which is a key technology, has been almost completed.

***Thank You for Your Attention!***



Digital Broadcasting Expert Group

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Digital broadcasting experts group