DiBEG
Digital Broadcasting Experts Group

Presentation 4

Research and development for digital broadcasting in NHK STRL / Japan

Digital Broadcasting Expert Group (DiBEG)

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NHK Science and Technical Research Laboratories (STRL)

Contents

1. Research and development relate to Digital Terrestrial Television Broadcasting transmission technologies

2. Video on HDTV mobile reception (3 minute)

3. New technologies for broadcasting systems and devices under development in STRL

4. Video on STRL Open House 2004 (26 minute)

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1. Research and development relate to Digital Terrestrial Television Broadcasting transmission technologies

2. Video on HDTV mobile reception (3 minute)

3. New technologies for broadcasting systems and devices under development in STRL

4. Video on STRL Open House 2004 (26 minute)

1. R&D relate to DTTB transmission technologies

- Transmitter side
  - Coupling loop interference canceller at broadcast-wave relay station for single frequency network
- Receiver side
  - Fixed reception
    - Long delay multipath equalizer
  - Mobile reception
    - HDTV mobile reception
  - Handheld/portable reception
    - Study on prediction of service area

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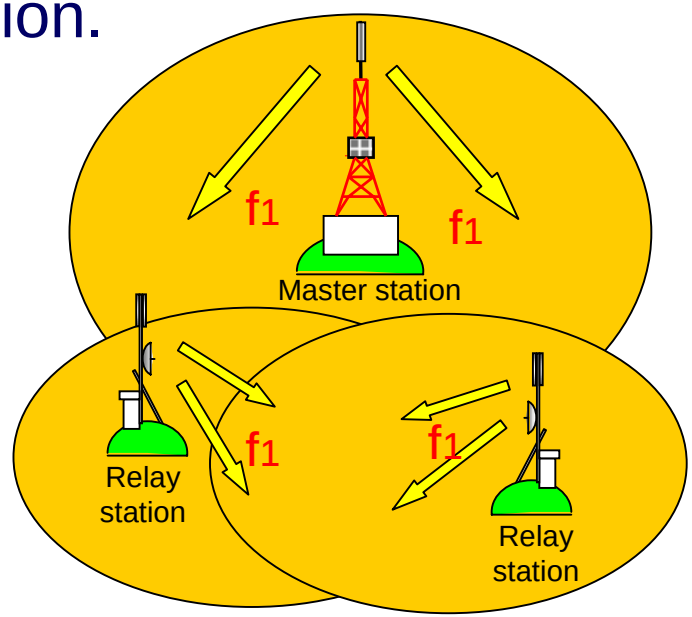
Countrywide transmitter networks

- To cover the service area all over the country, Broadcasters have to construct relay stations.
- DTTB has an ability of constructing SFN.
- There are 3 delivery methods of DTTB signal from master station to relay station.
  - Microwave Link
    - More frequency bands (limited frequency band)
  - Optical Fiber
    - Construction and running cost (expensive)
  - Broadcast-wave relay system (On air relay from master station)
    - Coupling loop interference

    Merit : low cost



SFN : Single Frequency Networks

CLI canceller for broadcast-wave relay system

-Toward the construction of countrywide digital terrestrial broadcasting networks -

- Constructing stable and cost-effective relay networks is important.
- Broadcast-wave relay system is the most cost-effective signal delivery system.
- Remaining problem was stability. But we developed Coupling loop interference (CLI) canceller.
- CLI cancellers can eliminate distortion when signals are relayed in a single frequency network (SFN).

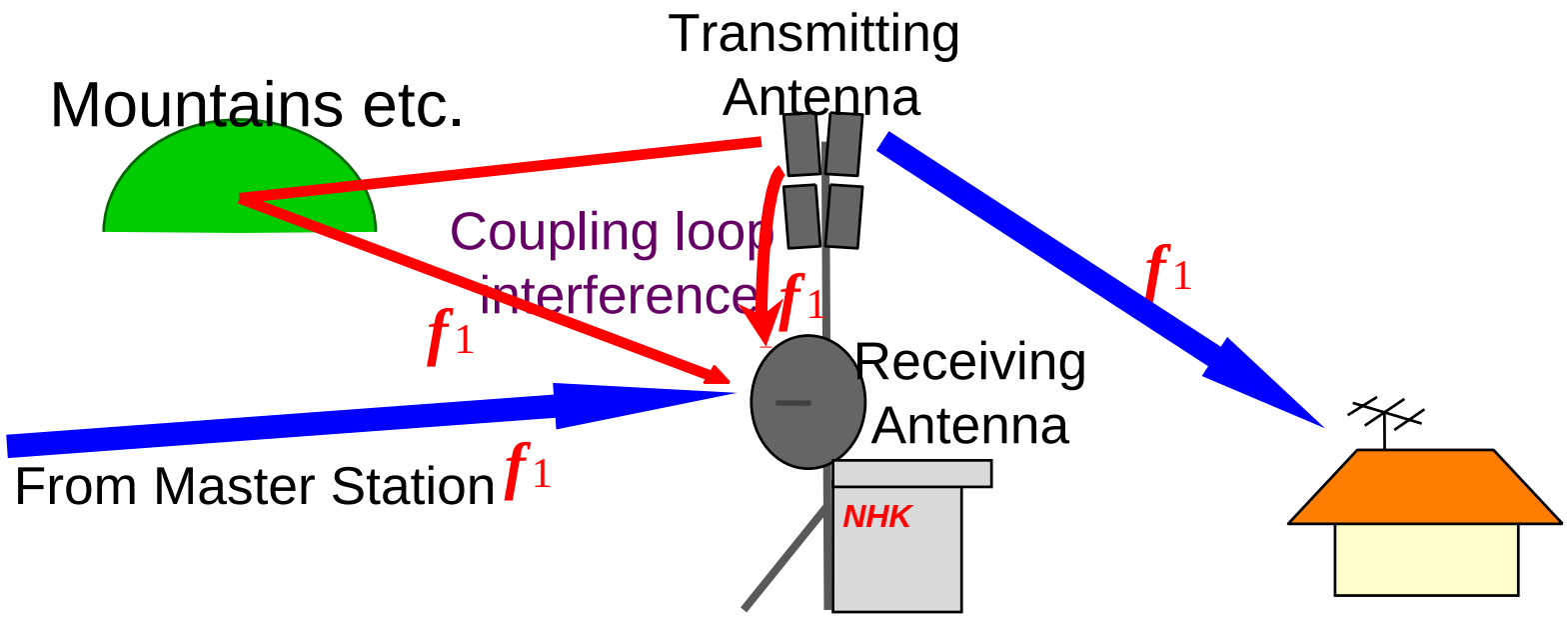
Broadcast-wave relay stations

Transmitting Antenna

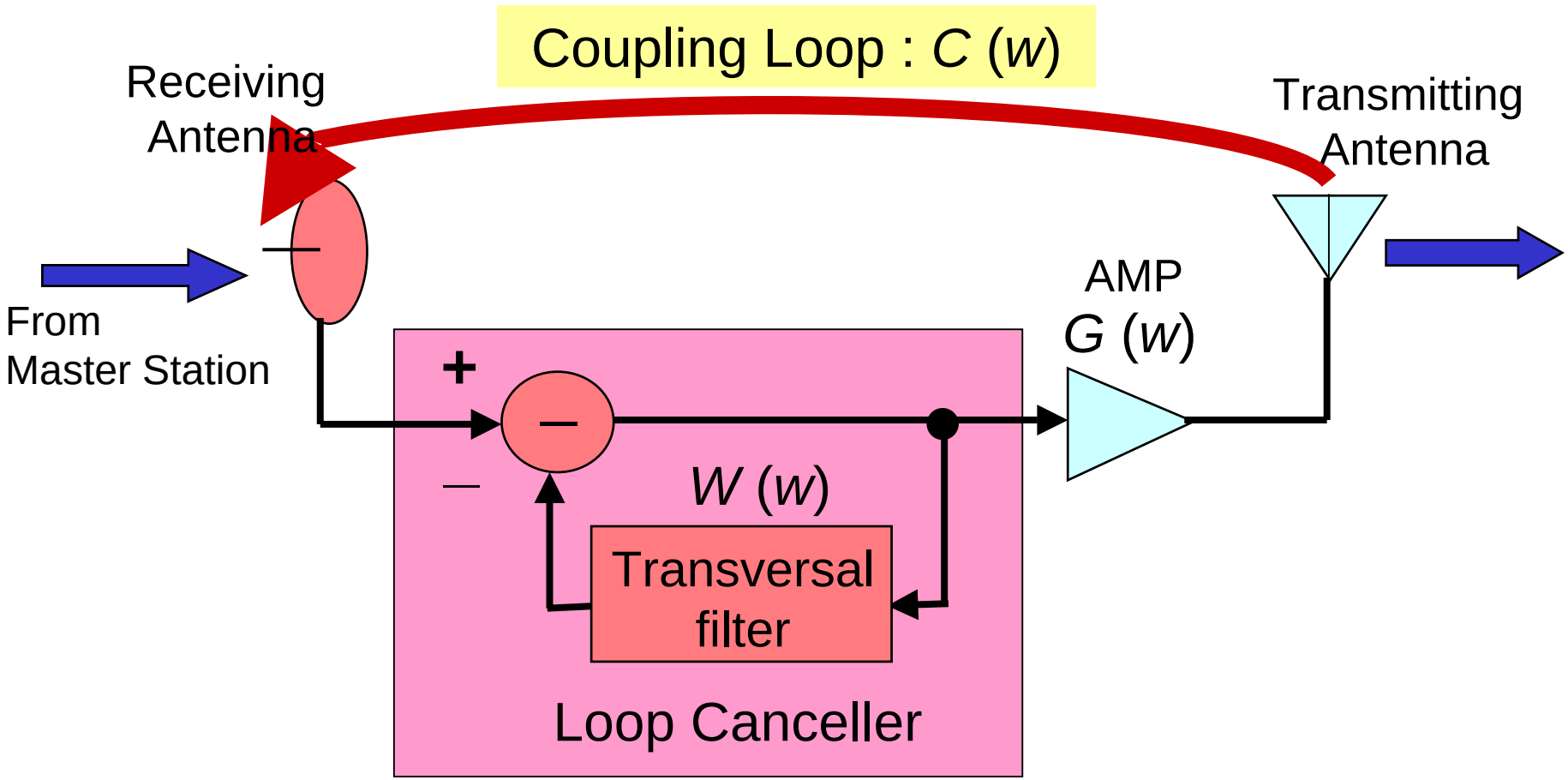
Receiving Antenna

What is CLI (coupling loop interference) ?

- Frequency of transmitting signal is the same as frequency of receiving signal.
- If the output of transmitting signal comes to the input receiving antenna, receiving signal is interfered. This is CLI.
- It is generally said that more than 90dB isolation is needed between transmitting antenna and receiving antenna.

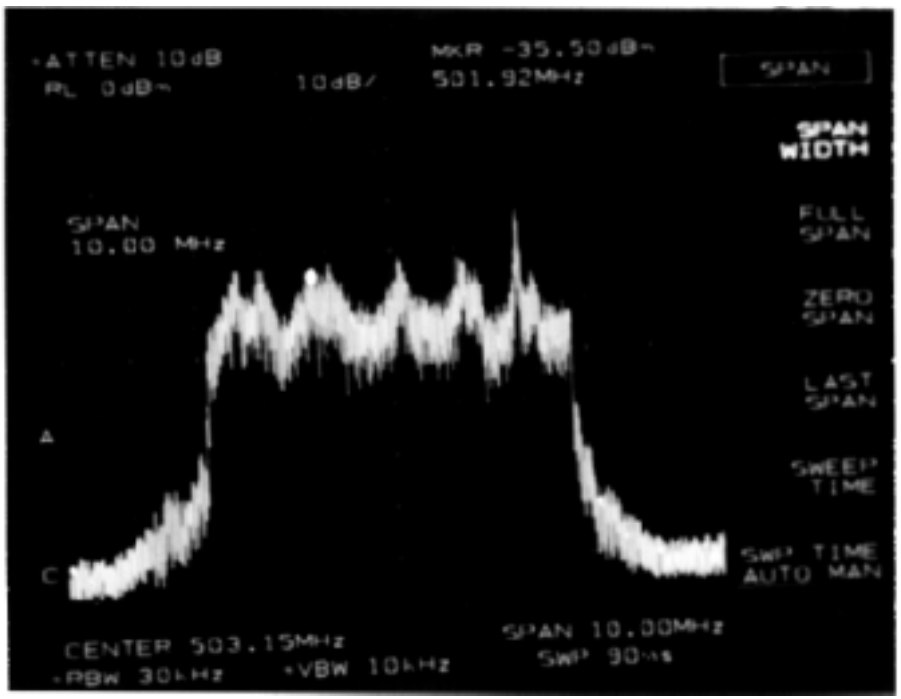


Principle of CLI canceller

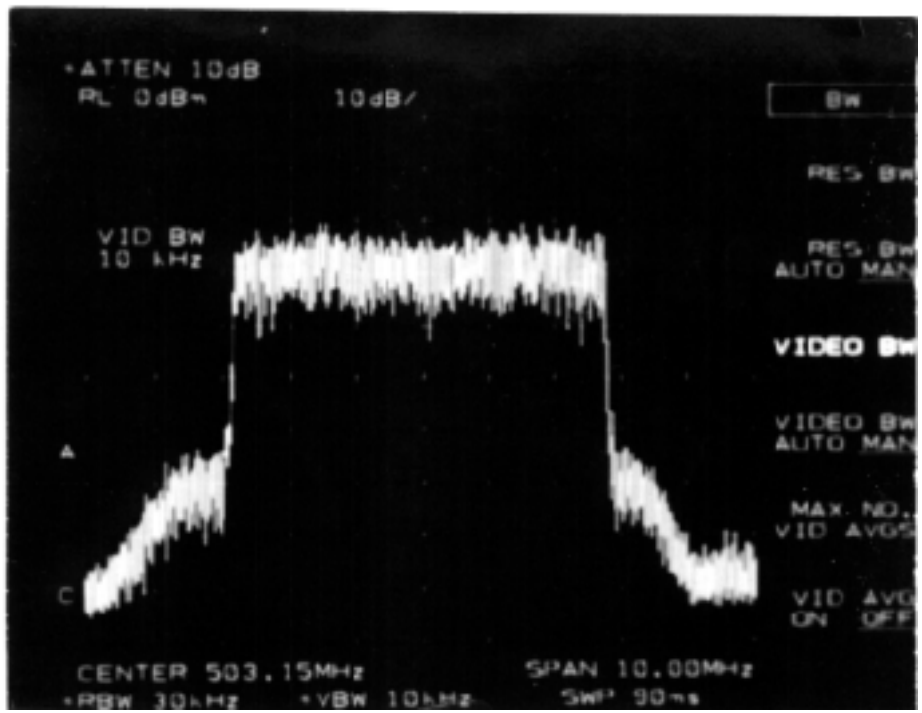


Condition for canceling : $W(w) = G(w)\,C(w)$

Effect of CLI canceller

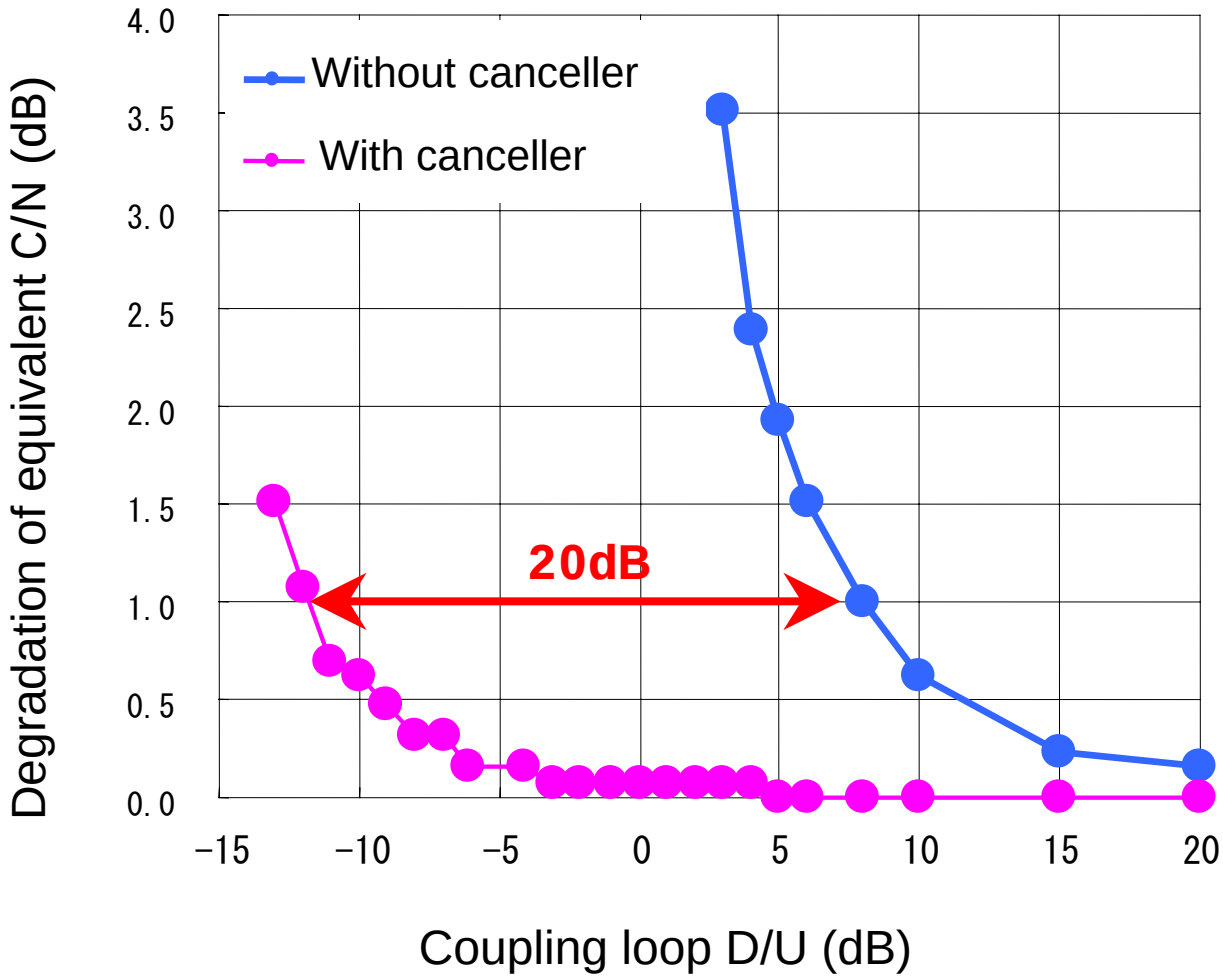


Transmission signal
without CLI canceller



Transmission signal
with CLI canceller

Performance of CLI canceller (Experimental data)



Equipment of CLI canceller (small type)

RF/IF, IF/RF freq. transform

Loop canceller

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Merits / demerits of SFN

- Merits of SFN
  - Frequency effective use (Frequency is limited)
- Demerits of SFN
  - CLI at broadcast-wave relay station
    - solve by CLI canceller
  - Appearance of long delay multipath
    - solve by guard interval of OFDM

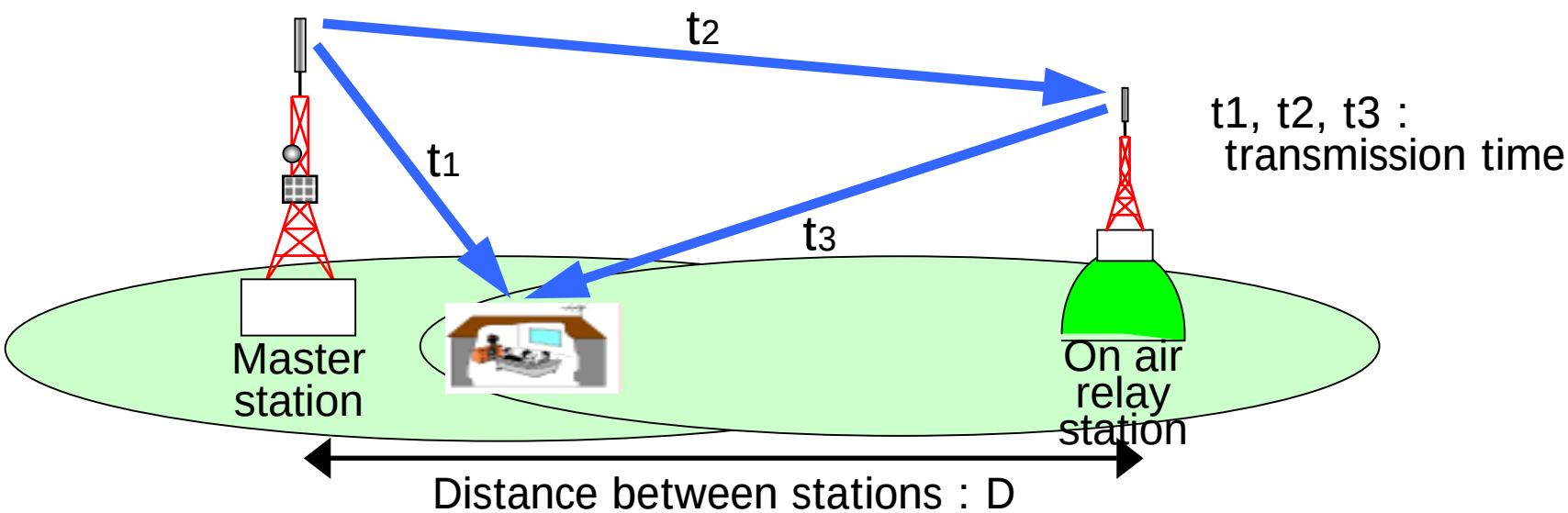
How about long delay multipath over guard interval

⇒ Long delay mutipath equalizer

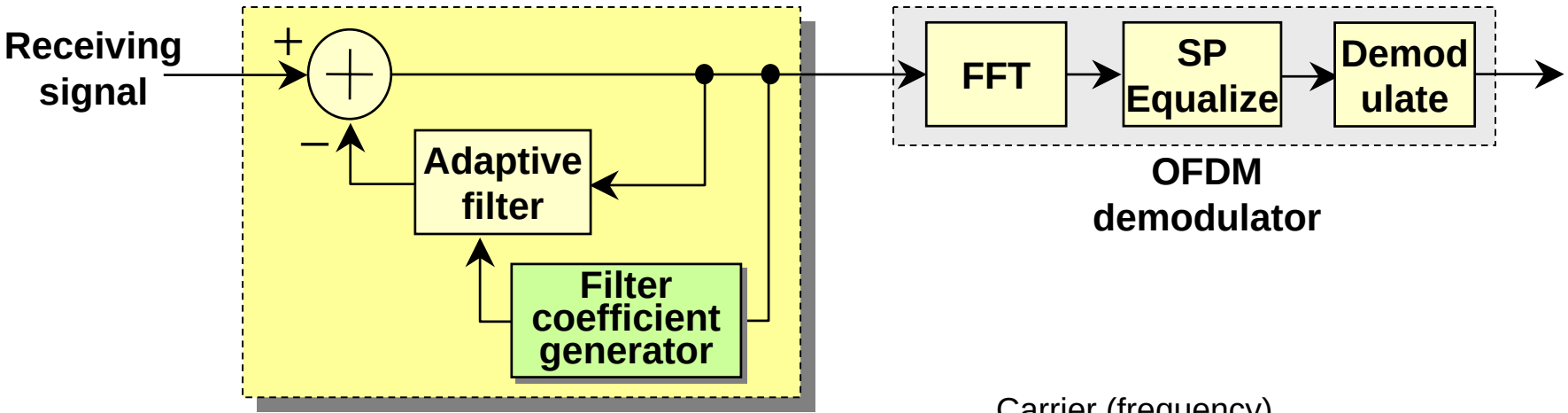
Long delay multipath situation

- Transmission time of desired signal : t_1
- Transmission time of delayed (undesired) signal : t_2+t_3
- Delay time of undesired signal $\tau_x = (t_2+t_3) - t_1$
- Guard Interval : τ_{GI} (for example τ_{GI} = 126 usec)
- Long delay multipath over guard interval $\tau_x > \tau_{GI}$
- IF D>37.8km, t_2>126usec, there is possibility to be $\tau_x > \tau_{GI}$

→ Development of long delay multipath equalizer is important.



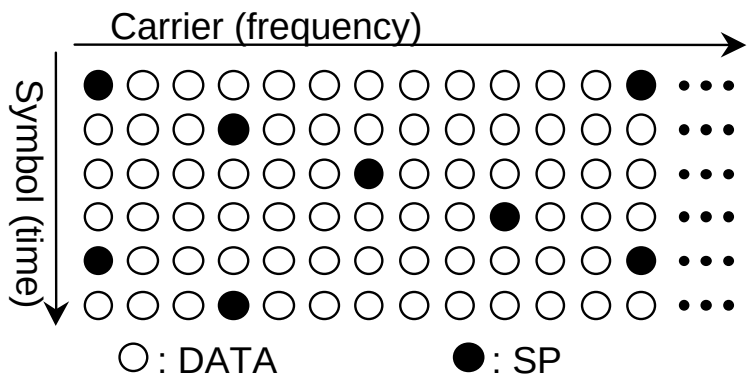
Receiver improvement
Principle of long delay mutipath equalizer



Equalizer adapted with long echo over guard interval
(Equalizer in time domain)

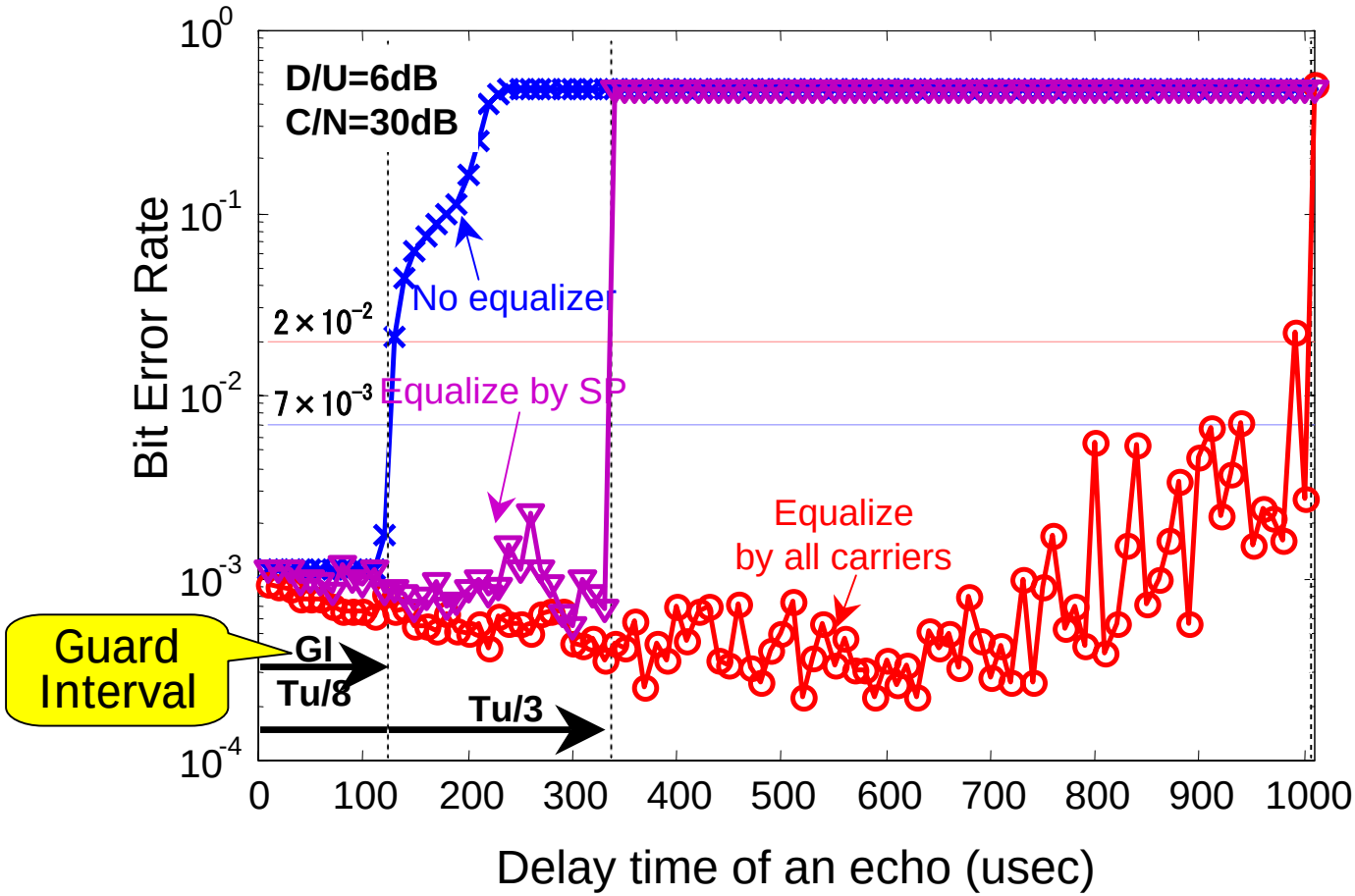
Update of filter coefficient ;

- SP : 4 symbol interval
- All carrier : 1 symbol



Distribution of Scattered Pilot symbol

Performance of long delay multipath equalizer



Mode	3
GI	1/8
Mod	64QAM

Useful symbol duration (Tu) : 1008usec

Guard interval (GI = Tu/8) : 126usec

Equipment of long delay multipath equalizer

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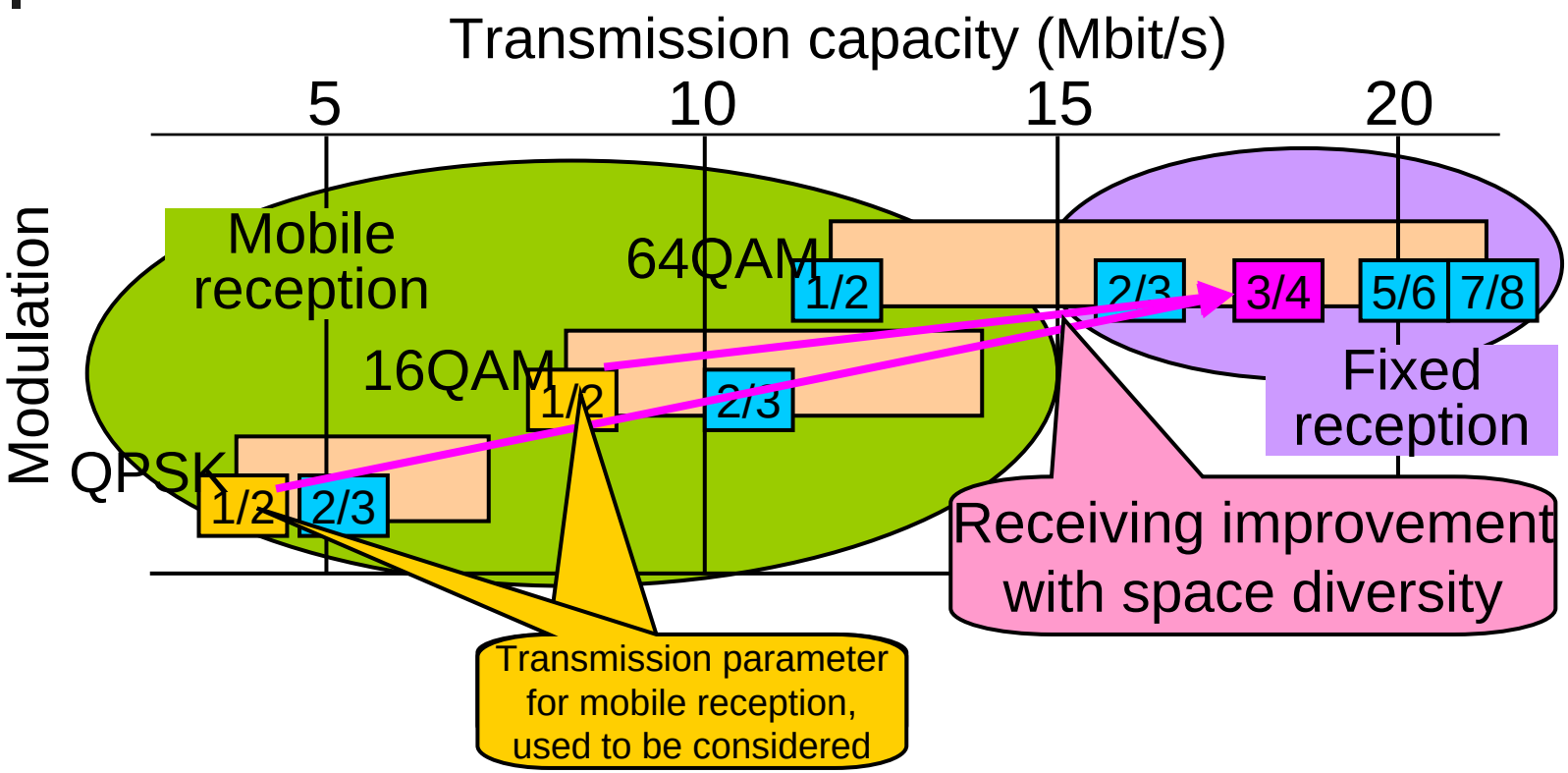
HDTV mobile reception
- background -



DTTB replaces analog TV. Analog TV is mainly for fixed reception service.
So, in Japan, main service of DTTB is decided to be HDTV.
DTTB has ability to transmit STDV service for mobile reception using QPSK or 16QAM, however, there is no TV channel to be assigned for mobile reception.

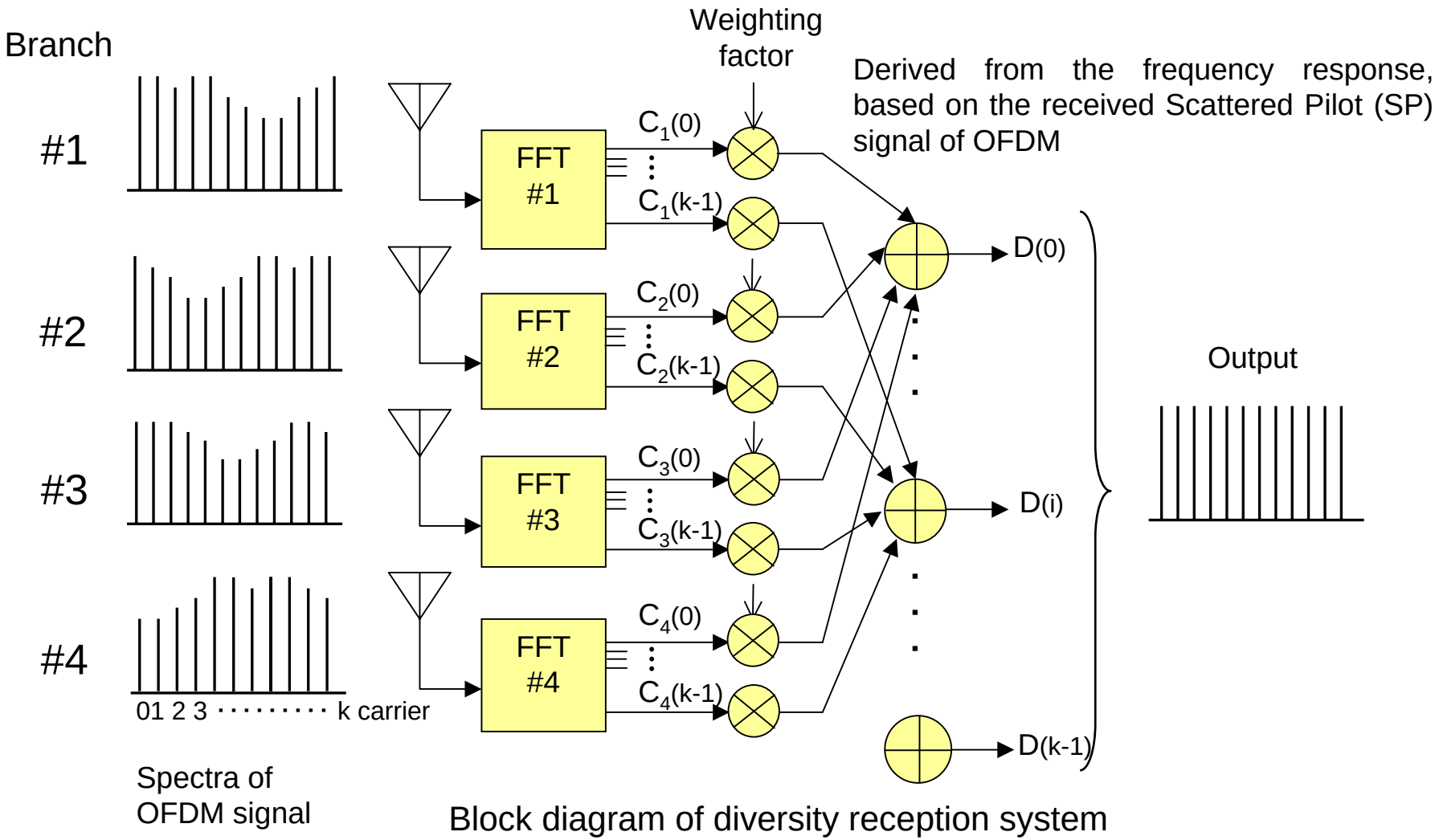
⇒ It is hopeful that HDTV service for fixed reception can be received by mobile.

Prototype 4-branch space diversity
for HDTV mobile reception

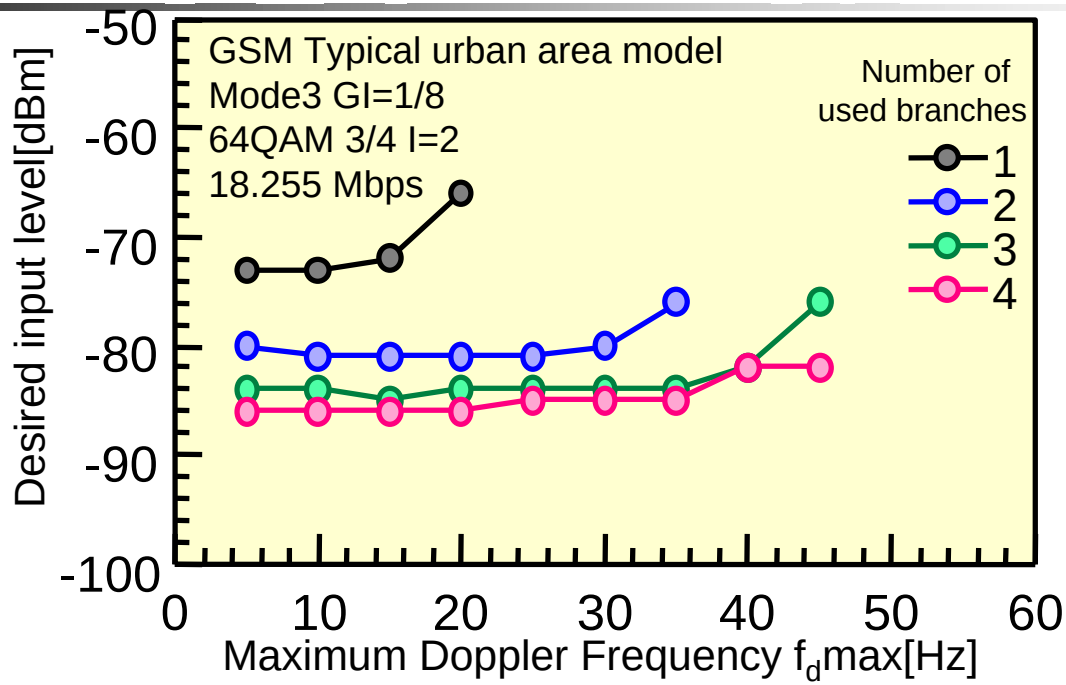
- NHK's prototype diversity reception system for HDTV mobile reception
  - Signal : 6MHz BW 64QAM-OFDM (ISDB-T)
  - Application : HDTV (18.3 Mbps) in a mobile car
  - Diversity : 4-branch space diversity

- Implementation and performance evaluation
  - Laboratory test
    - Maximum Doppler frequency in fading environment
  - Field trial in Tokyo suburban area

Principle of 4-branch space diversity for OFDM signal under mobile reception



Results of lab test on 4-branch diversity reception system



Number of Branch	$f_d$max	Velocity@19ch ($v = f_d\text{max} \times \lambda$)	Velocity@62ch ($v = f_d\text{max} \times \lambda$)	Desired input level (@ $f_d$max =20Hz)
1	20Hz	42 km/h	28 km/h	-66 dBm
2	35Hz	74 km/h	49 k	-81 dBm
3	45Hz	95 km/h	63 k	-84 dBm
4	45Hz	95 km/h	63 km/h	-86 dBm

35km/h improved

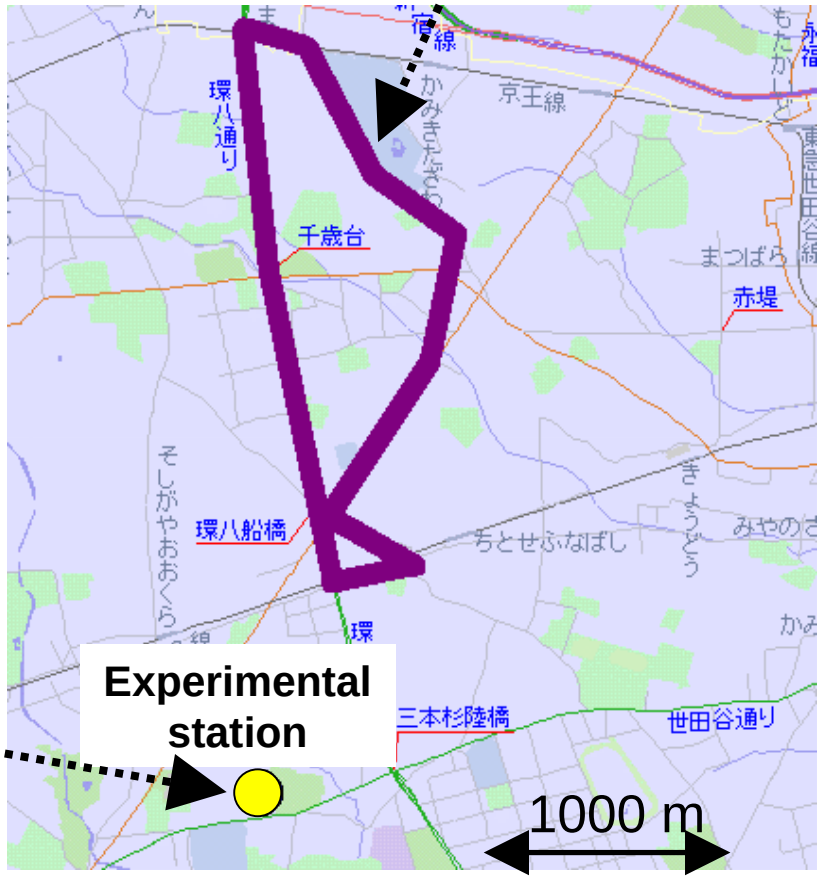
20dB improved

Field trial in Tokyo (suburban area)

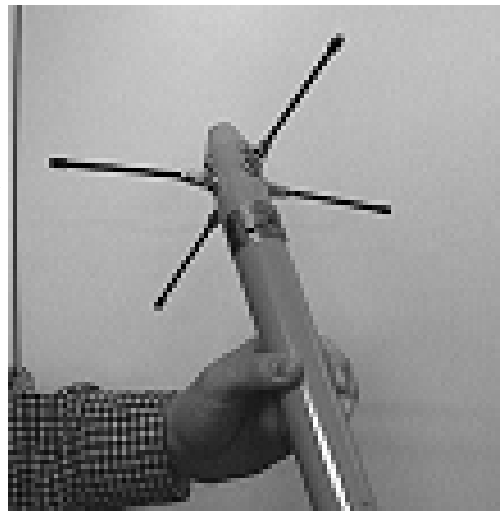
Frequency	UHF 19ch 509 MHz
Tx power	30 W (45dBm)
Polarization	Horizontal

TX antenna

Measured route



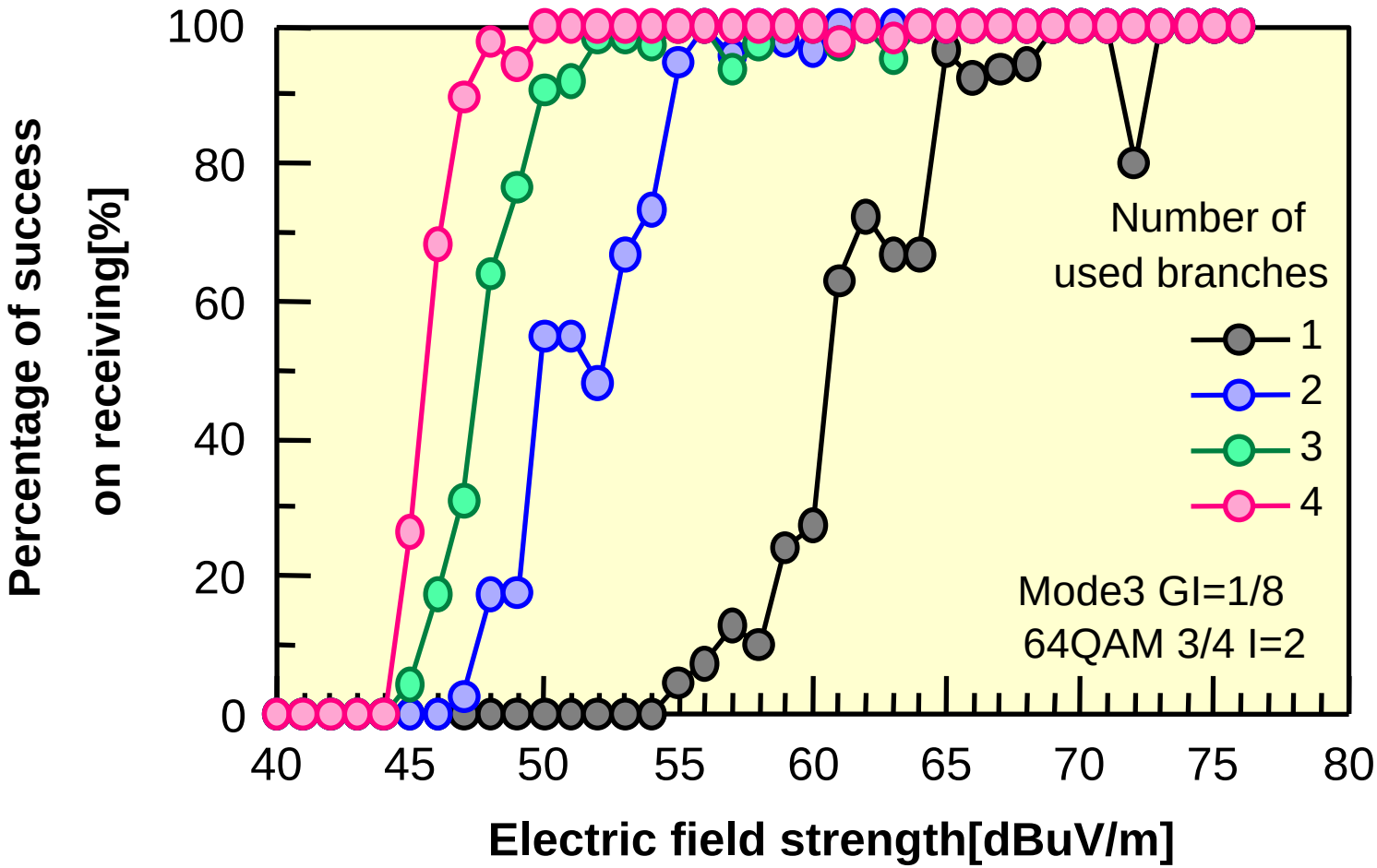
Receiving antennas
for DTTB mobile reception



Cross dipole antenna
Gain = 0 dB

4 antennas are mounted on the car roof.
Height is 2 m above the ground.

Results of field experiment



Effectiveness of diversity reception

Required field strength
for 50 % and 90 % correct reception rate.

Number of branch	1	2	3	4
E_{min} at CRR of 50 %	61	50	48	46
E_{min} at CRR of 90 %	65	55	50	48

E_{min} : Minimum usable field strength [dBμV/m]
CRR: Correct Reception Rate

✓At CRR of 90 %,
E_{min} of 17dB can be reduced
by using 4-branch diversity reception.

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Transmitting station (Tokyo tower)

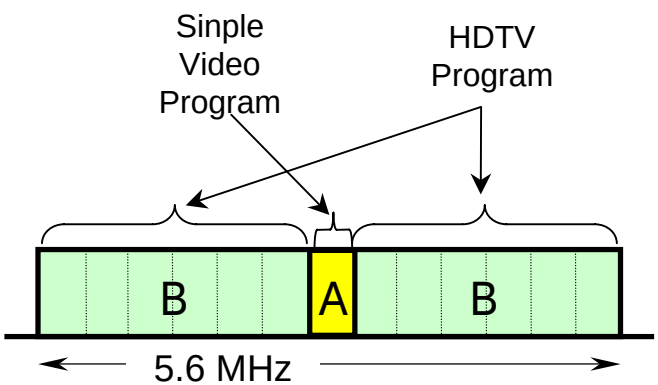
Tokyo tower digital transmitter
1st stage (NHK Digital GTV)

Channel	UHF 27ch (557MHz)
Transmission power	300 W
ERP (Effective radiation power)	570 W
Antenna height	267 m
Polarization	Horizontal

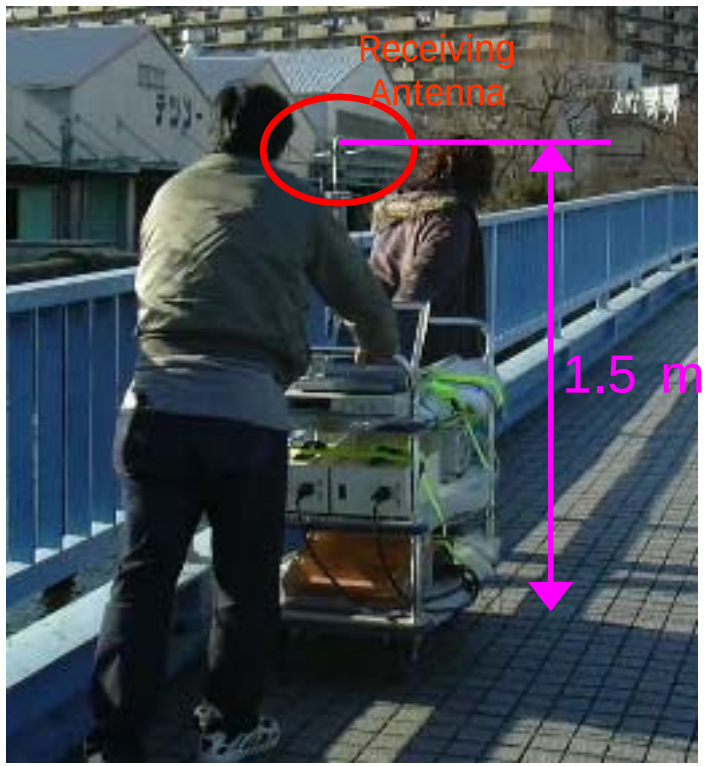
Transmission parameters and receiving scenery

Transmission parameters of NHK Digital GTV

Mode	3 (5617 carriers)	
GI (Guard Interval)	1/8 (126usec)	
Hierarchical transmission	2 layers	
	A	B
Number of segments	1	12
Carrier modulation	QPSK	64QAM
FEC coding rate	1/2	3/4
Time interleaving	215ms	215ms

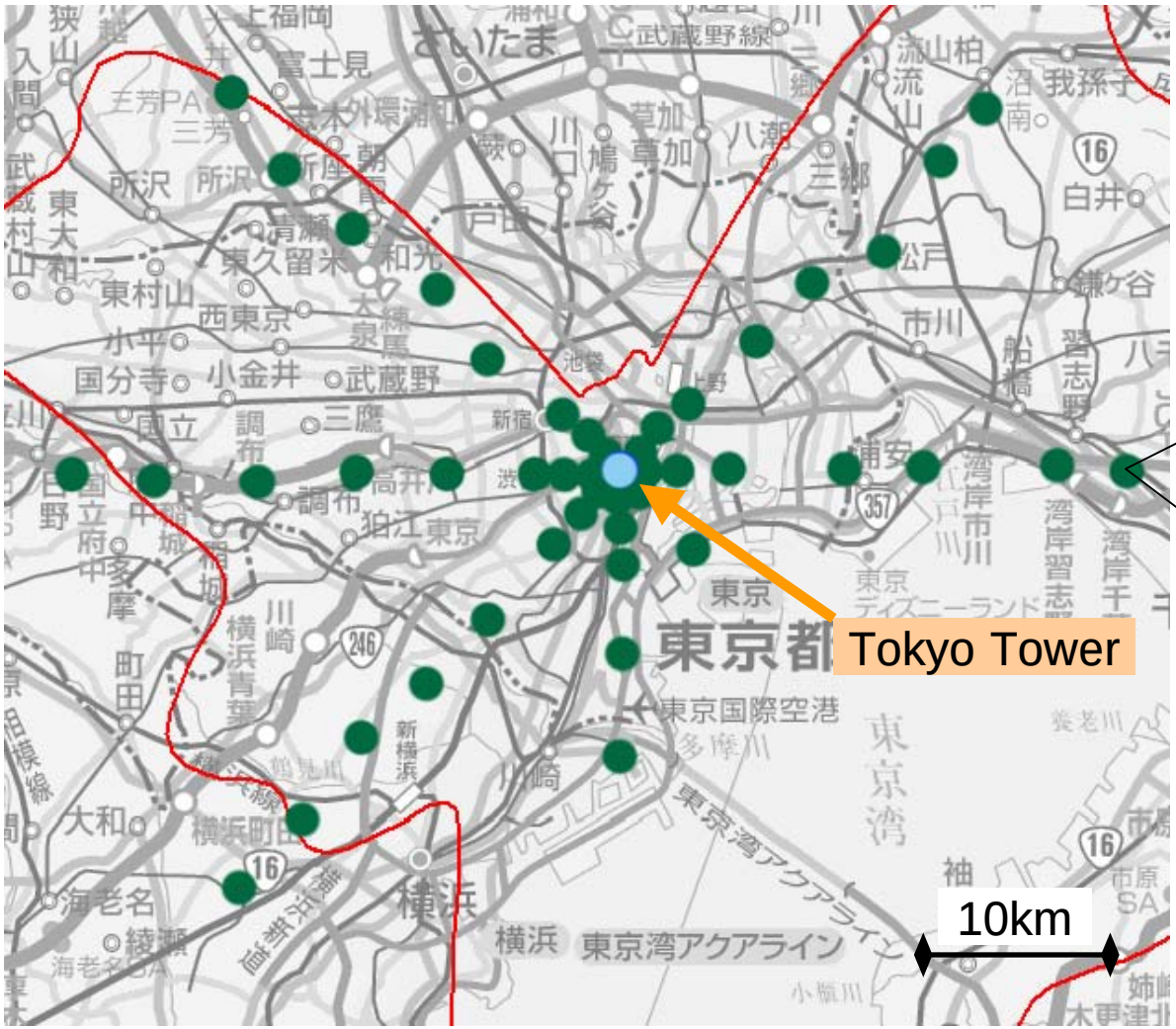


Receiving scenery

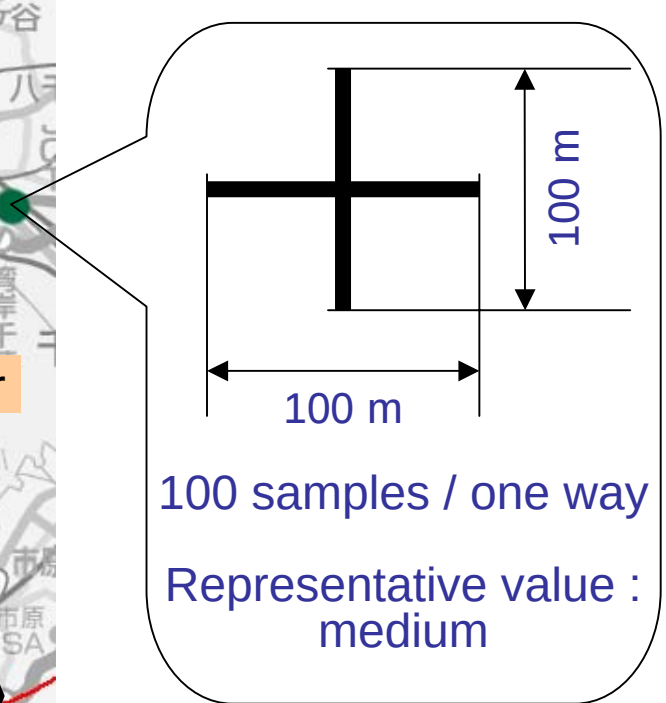


Receiving antenna height : 1.5m
Receiving antenna : Cross dipole antenna

Measured points for handheld reception



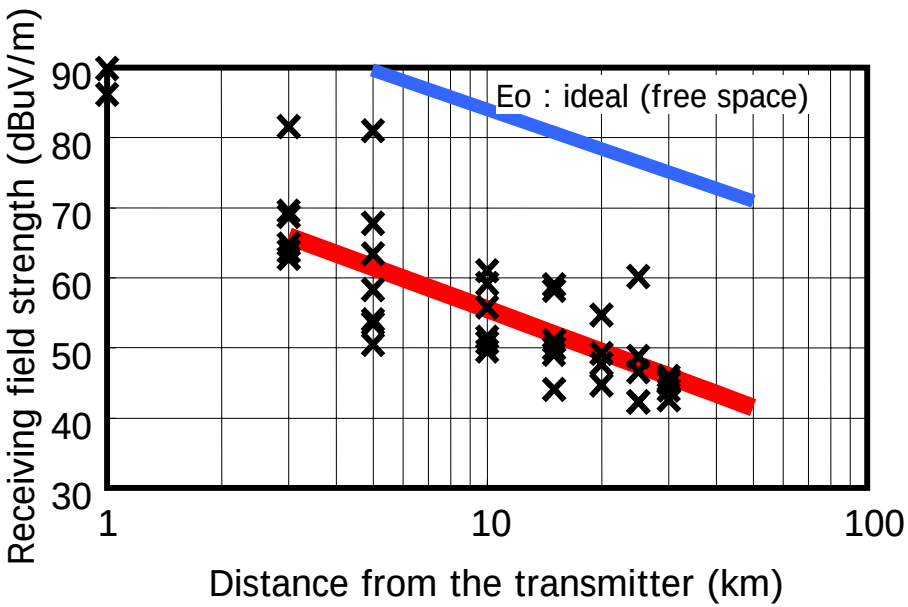
- 7 directions (spokewise)
- 1,3,5,10,15,20,25,30 km

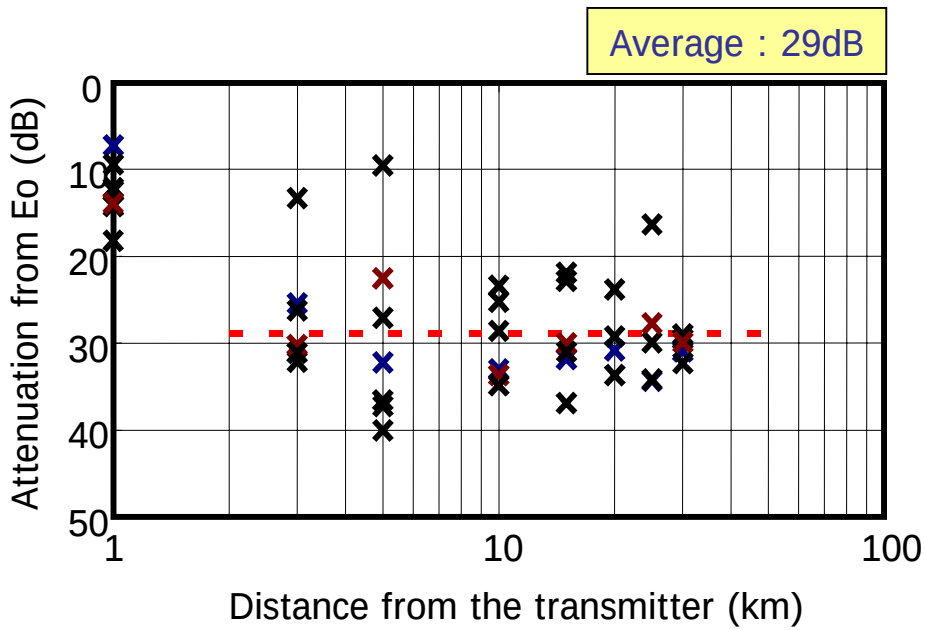


100 samples / one way

Representative value : medium

Distribution of measured field strength





Average attenuation from Eo (free space electric field strength) = 29dB

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NHK STRL

- NHK (Japan Broadcasting Cooperation)
  - Established in 1925
  - Non-profit public broadcasting organization
  - 2 AM radio, 1 FM radio, 2 terrestrial TV, 3 satellite TV
- NHK STRL (Science & Technical Research Labs.)
  - Established in 1930

    (5 years later science radio broadcasting started)
  - Research department of NHK
  - Major research themes
    - Television, Color television, HDTV, PDP, Broadcasting satellite, Digital broadcasting (ISDB), etc.

3rd generation research complex

- Opened in April 2002
  - 14 stories high
    (office tower)
  - 6 stories high
    (experiment building)
- STRL area
  - B2 – 5th floors
- STRL employees ('04,3/31)
  - 286 personnel
    (260 research engineers)
- Researches based on "Middle and long term research vision(MLRV) of STRL" are conducted

Organization of STRL (9 research labs.)

- Wireless systems
  - Terrestrial/satellite digital broadcasting, wireless LAN
- Networked broadcasting systems
  - Networked program production broadcasting systems and services
- Advanced television systems
  - Ultra high definition video (super hi-vision), 3D visual systems
- Acoustics and audio signal processing
  - High definition audio systems, acoustic signal analysis and coding
- Visual information technologies
  - Video compression and image expression
- Intelligent information processing
  - Metadata production and applications, image recognition, media processing
- Human science
  - Services for visual or hearing impaired, software agents, speech processing
- Advanced broadcasting devices
  - Ultrahigh-sensitivity imaging devices, ultrahigh-density recording
- Materials science
  - Materials for displays and recording devices

STRL Open House 2004

- 58th Open House
  from May 27 to May 30, 2004.
- 40 exhibits presented research results under the catch phrase
  "Dreams On Air. Welcome to the Future Fantastic."
- These included technologies categorized into three groups.
  1. Vision exhibits
  2. Fun exhibits
  3. Technical exhibits
- More than 28,000 attendance visited

Specific research themes

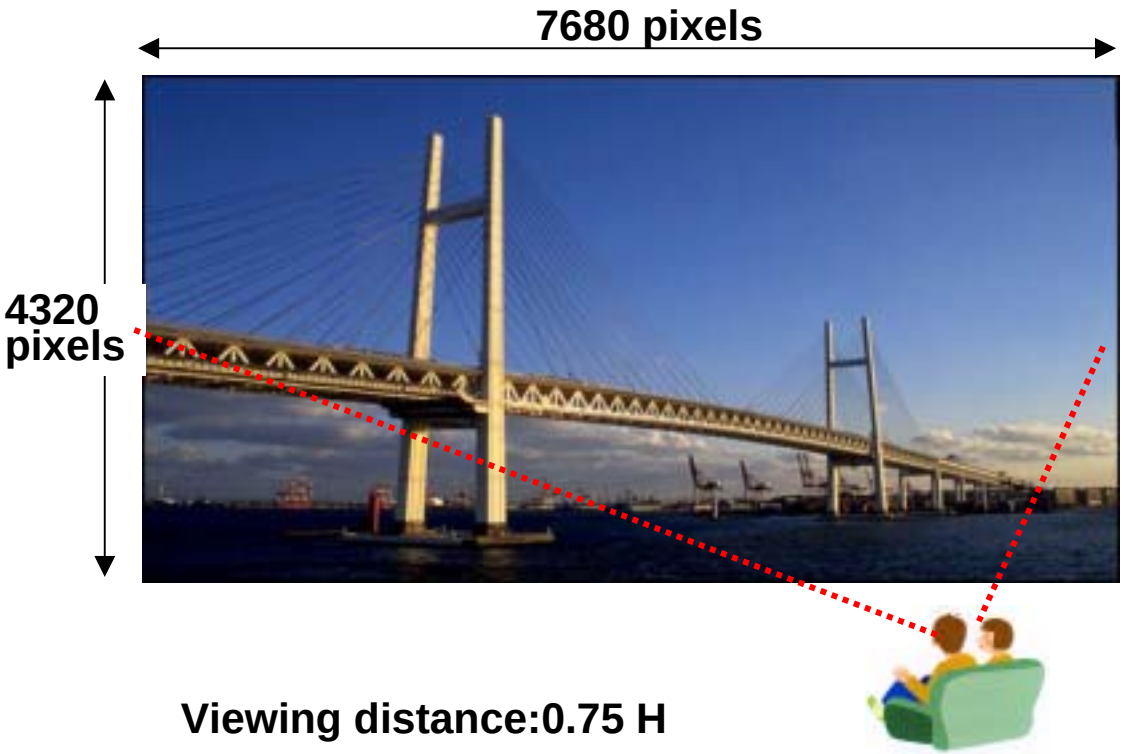
- Super Hi-Vision
  - Ultrahigh-definition, wide-screen system with 4000 scanning line
- 3-Dimentional Audio System
  - for Super Hi-Vision
- Human-friendly Digital TV
  - for people with visual and hearing impairments

- Ultrahigh-sensitivity HDTV handheld camera
- Ultra-small silicon microphone
- Flexible ultra-thin displays

Super Hi-Vision

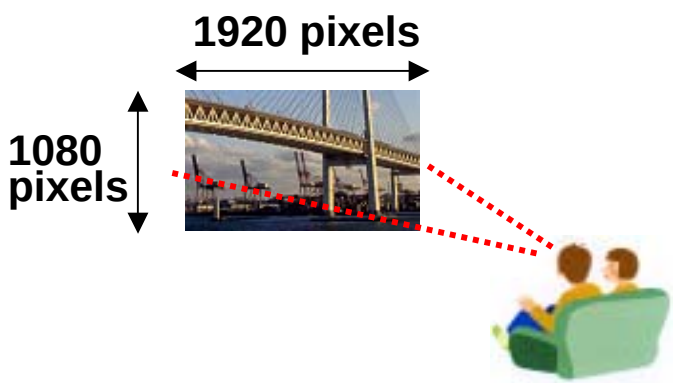
Ultrahigh-definition, wide-screen system with 4000 scanning lines

< 4000 scanning lines >
Get sensation of immersion



Viewing distance:0.75 H
Visual angle: 100 degree

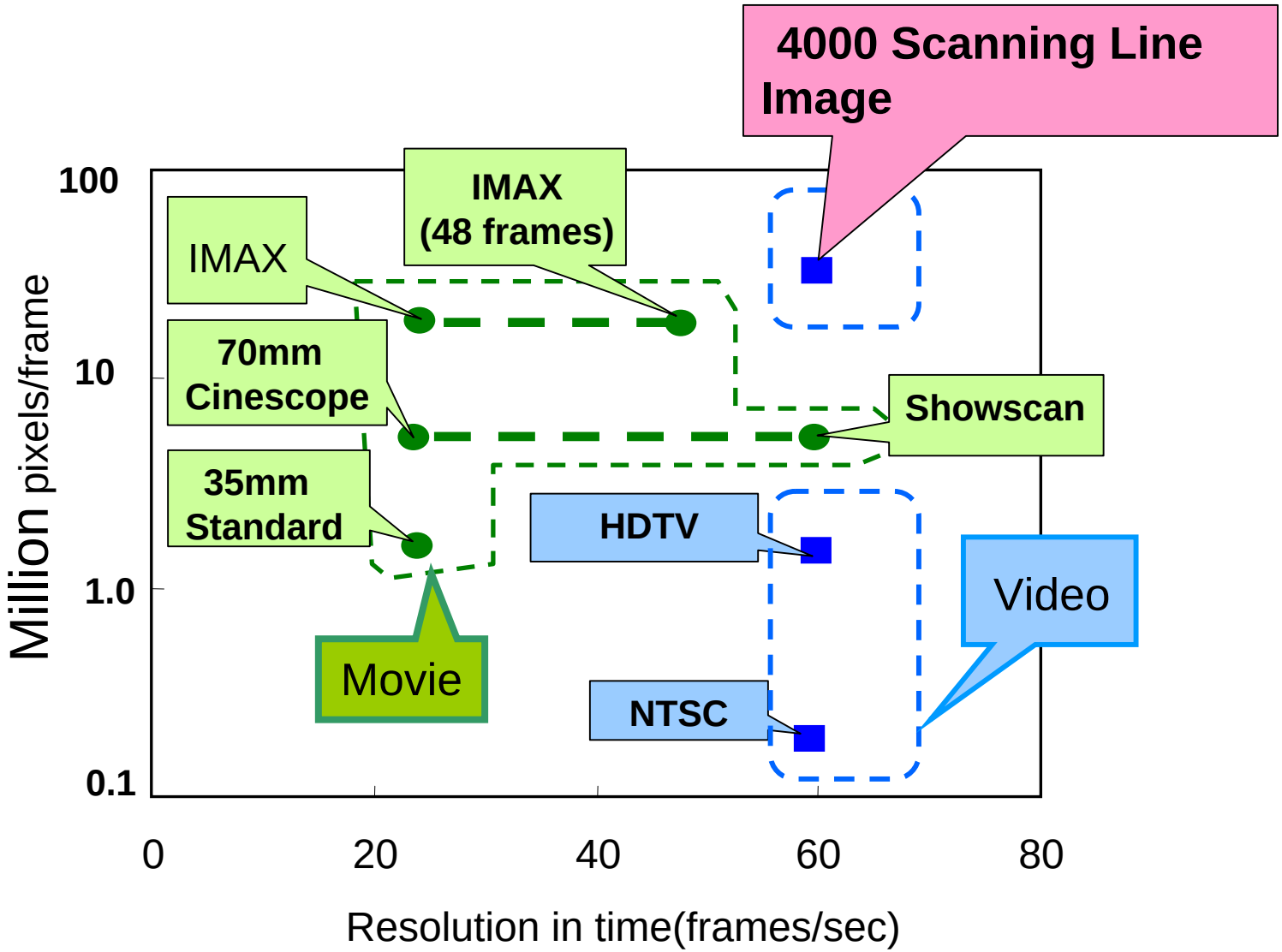
< HDTV >
Get sensation of presence



Viewing distance: 3H
Visual angle: 30 degree

H:screen height

Comparison of resolution



Ultrahigh-definition camera and projector

- NHK developed an experimental system made up of a camera, display, and recording device.
- The system uses 4 CCD imaging devices and 4 LC (liquid crystal) panel display devices (8 million pixels each). This four-panel color system, in which two panels are for green, has 32 mega pixels.

Ultrahigh-definition camera

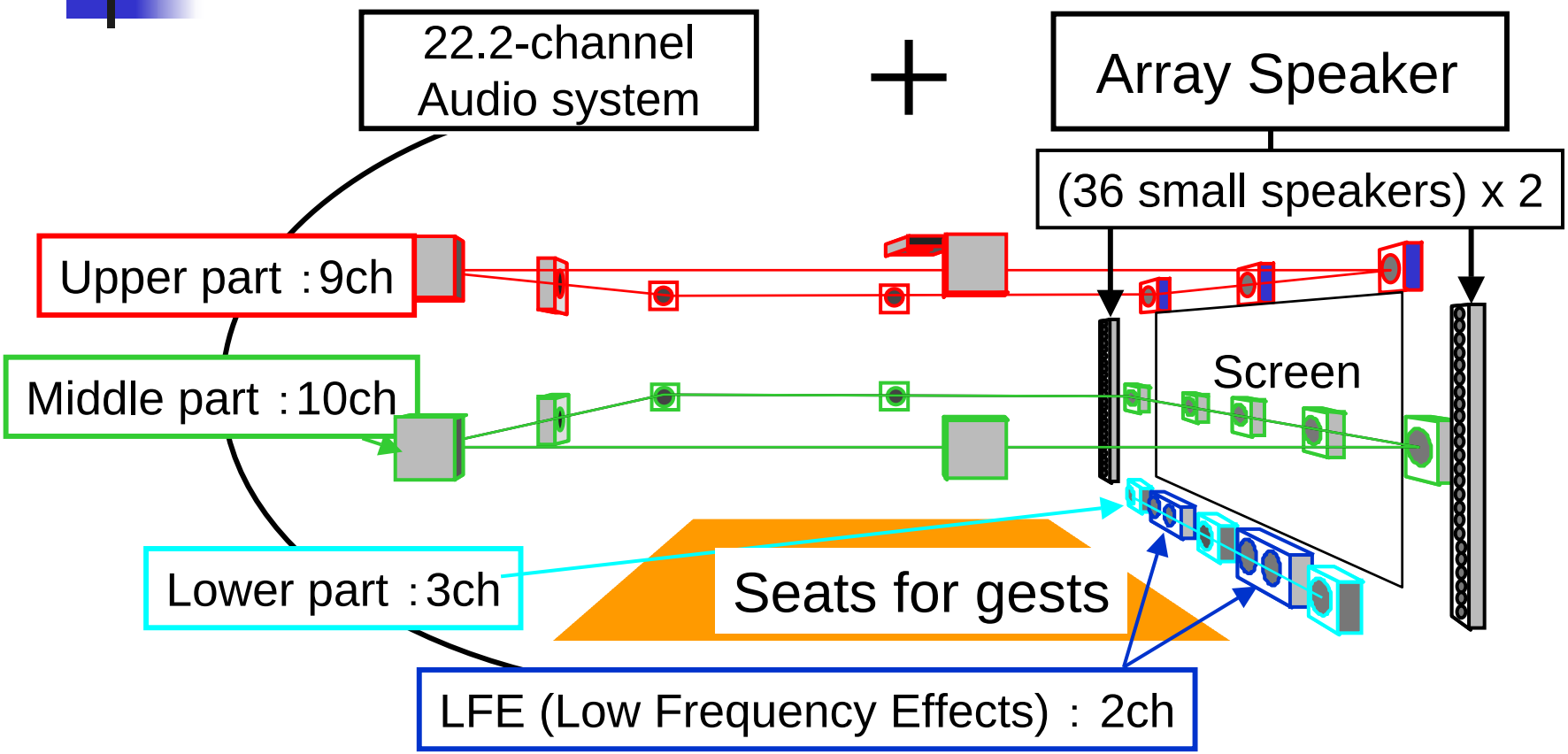
Ultrahigh-definition projector

New camera with 4000 scanning lines

Ultrahigh-definition, wide-screen display

3-Dimentinal Audio System

for 4000 scanning line system

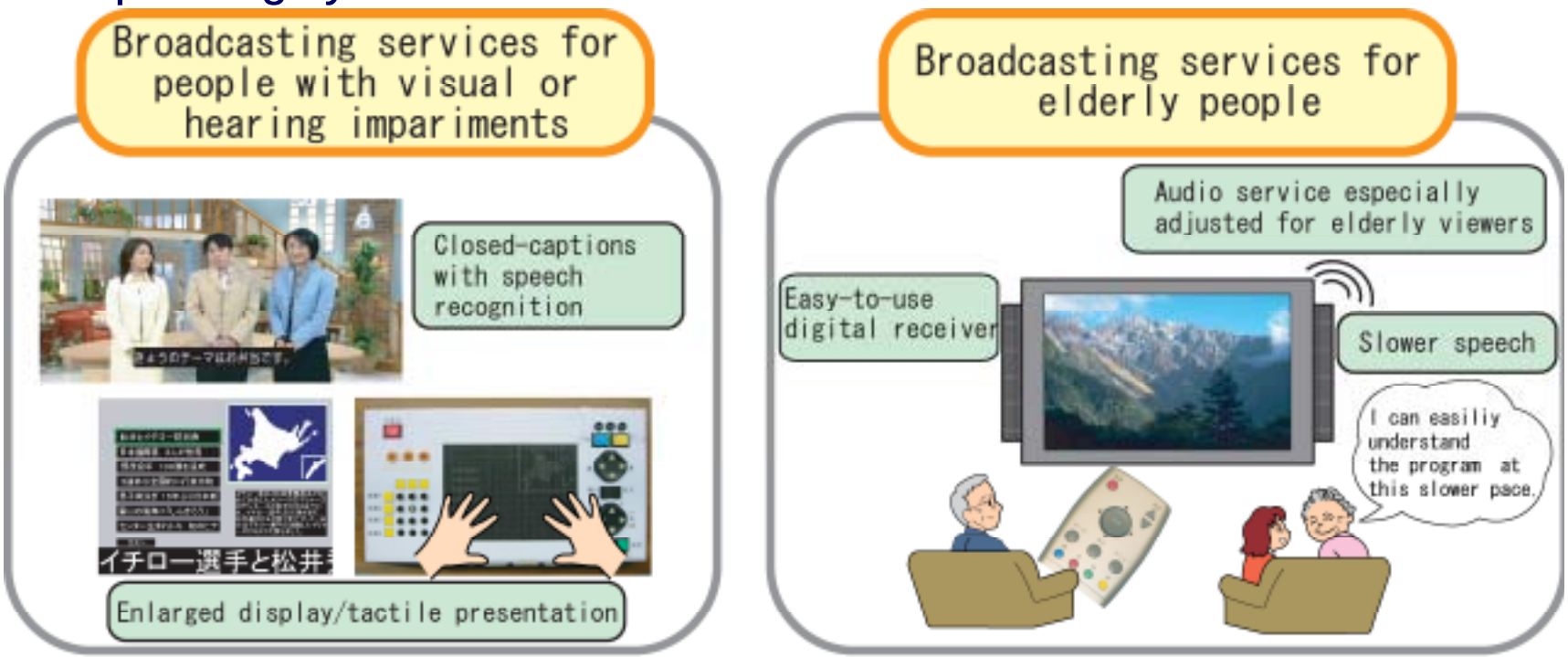


Features

- **Recreation of various sound fields**
- **Sound in synchronization with a picture on a large screen**
- **The arrayed loudspeakers help create a sound that a listener perceives popping up from a 3D video image**

Human-friendly Digital TV

- Combines a simple-operation remote control and a menu display.
- Visually impaired people can “VIEW” data services through tactile presentation and synthesized voice.
- Hearing impaired people can “READ” the announcer’s voice by closed captioning system.



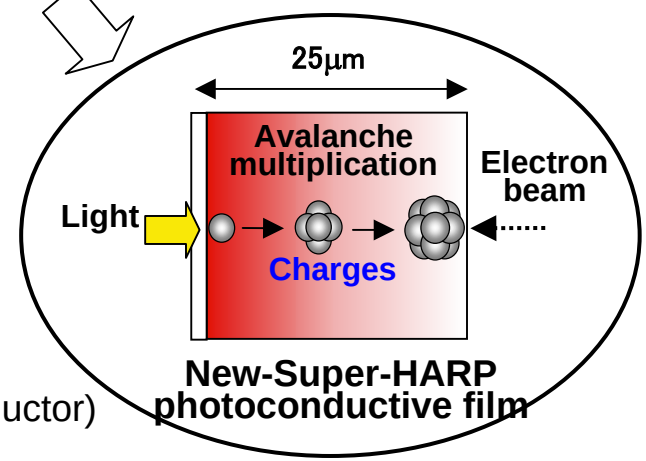
Human-friendly digital broadcasting

Ultrahigh-sensitivity HDTV new Super-HARP handheld camera

- Developed for applications such as emergency reporting at night
- Clear Hi-Vision picture obtained even under moonlit conditions
- 100 times the sensitivity of a CCD camera, 50,000 times for still pictures

Ultrahigh sensitivity HDTV handheld camera

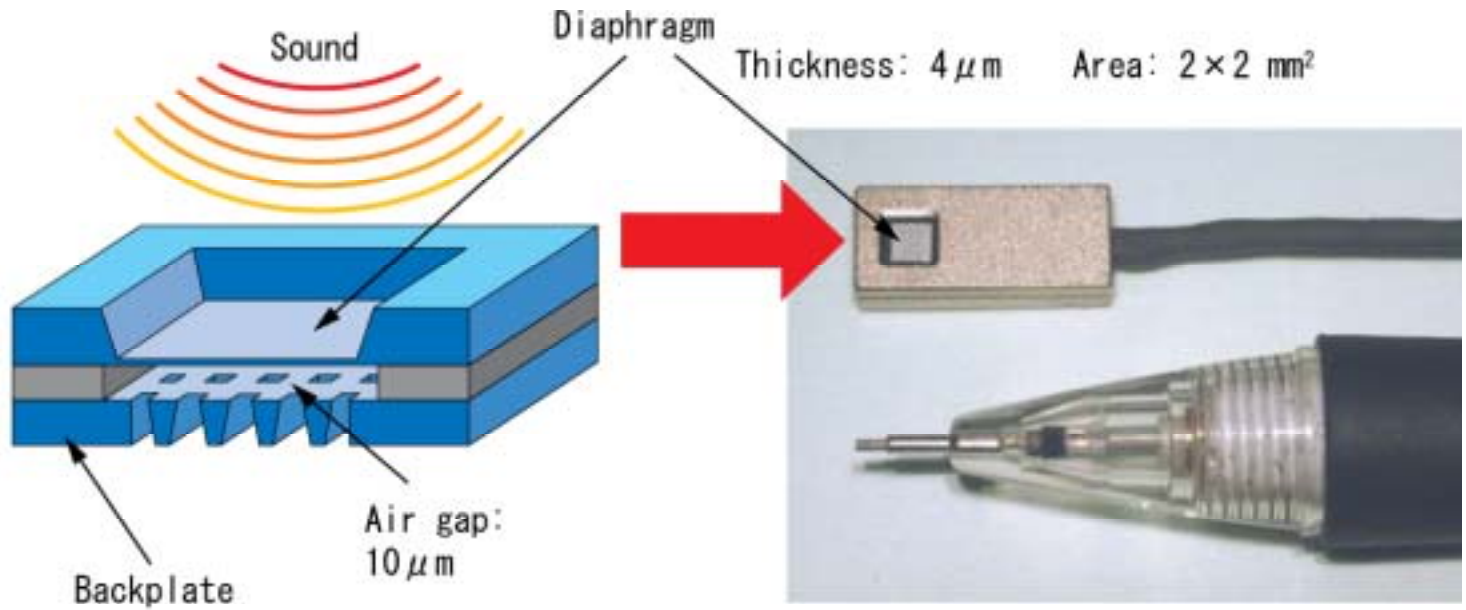
New-Super-HARP image pickup tube



HARP (High-gain Avalanche Rushing amorphous Photoconductor)

Ultra-small silicon microphone

- First fabrication of single-crystalline silicon microphone with an integrated structure
  - Ultra-small, Superior acoustic characteristics, Highly reliable (robust, thermal resistance)
  - Mass producible, Applicable to low-voltage operation, broadcasting or consumer use



Microphone element cross-sectional view

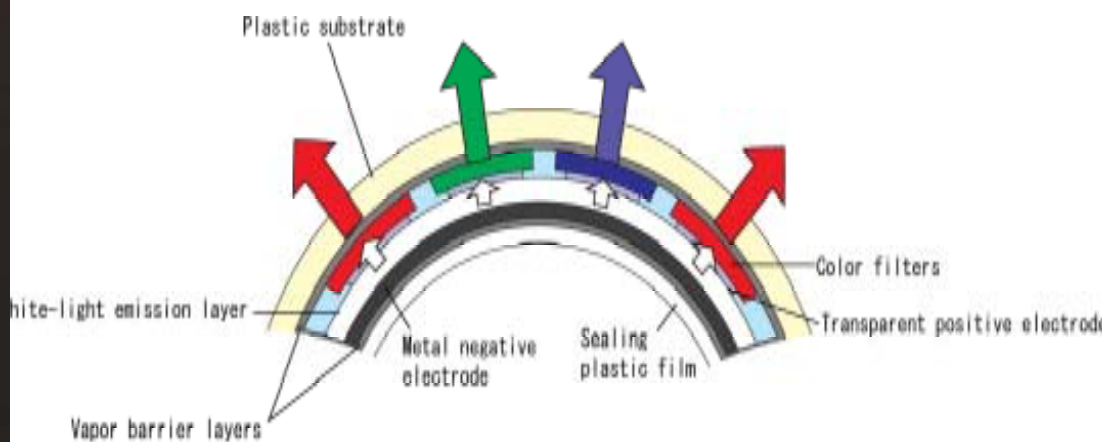
Silicon microphone

Flexible ultra-thin displays (1)

Organic EL (electroluminescence) display

- An organic EL device using polymer material.
- A new light-emission mechanism, phosphorescence, may achieve a quantum efficiency that is four times that of conventional (fluorescence) light-emission.

Organic EL display
(moving picture)



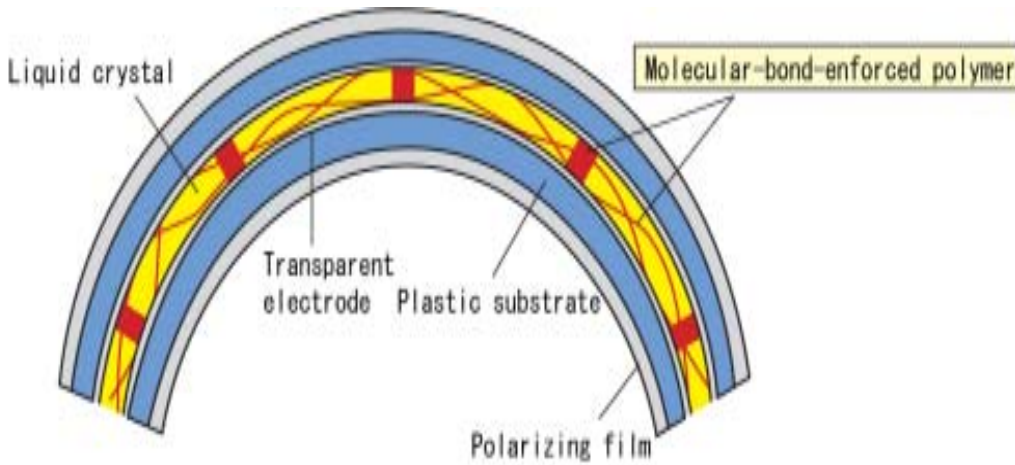
Flexible organic EL display cross-sectional structure

Flexible ultra-thin displays (2)

Film Liquid Crystal Display (LCD)

- A flexible liquid crystal display (LCD) using a film substrate and ferroelectric liquid crystal with a polymer network
  - A new film structure and fabrication technique that improve flexibility

Flexible LCD



Flexible liquid crystal display cross-sectional structure

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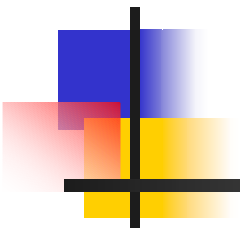

Thank you for your attention!

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(Digital Broadcasting Expert Group)
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