Field Trial of A Space-Time Equalizer

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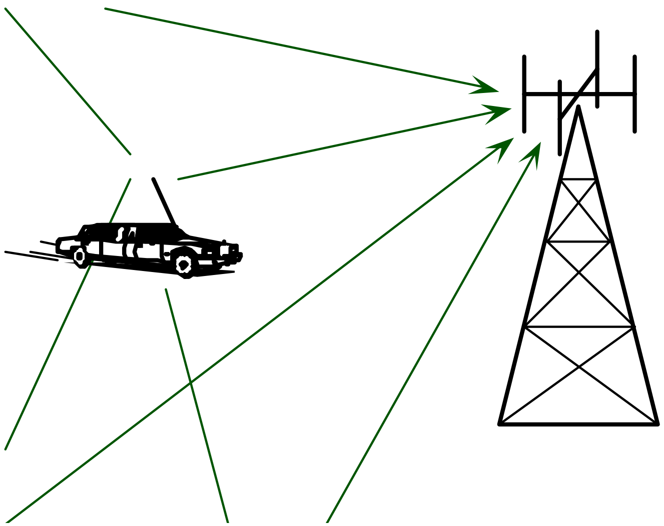
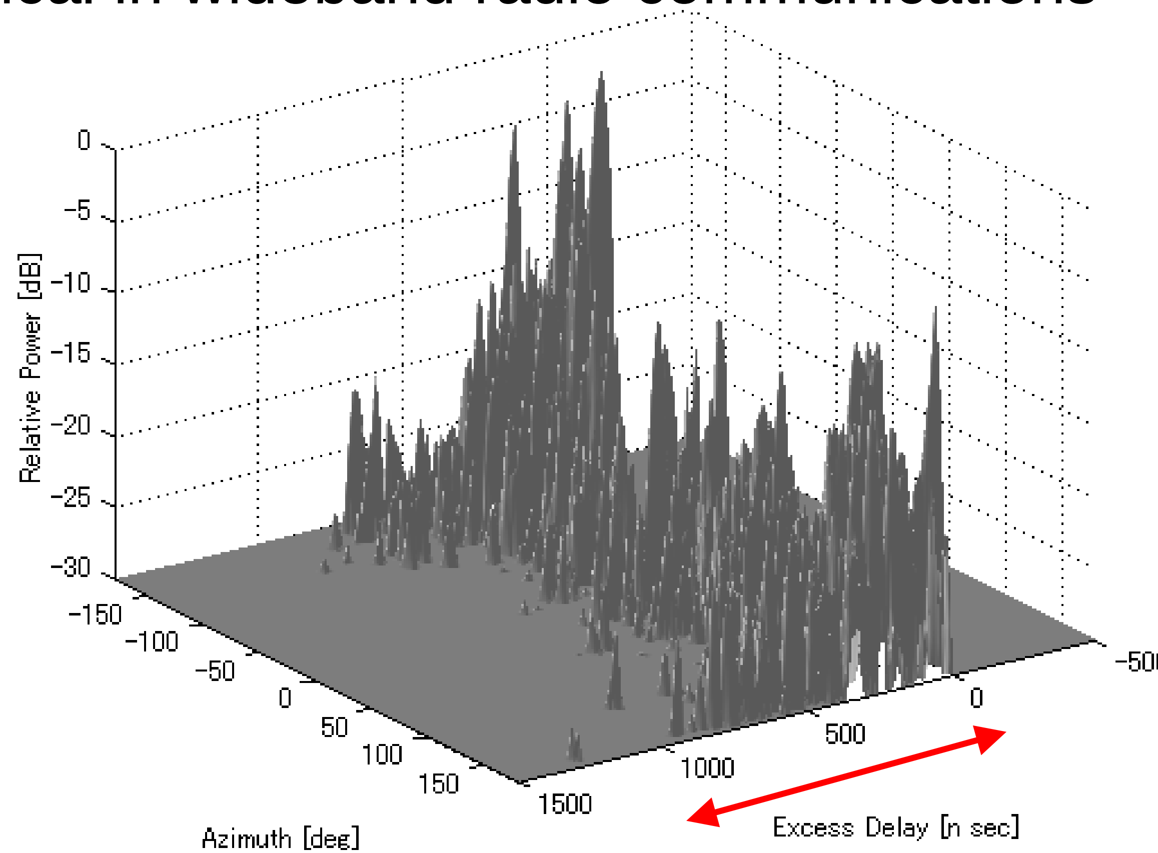
Contents

- Background
- Space-Time (ST) equalizer
- Measured results
- ST equalizer w/ delayed diversity transmission (DDT)
- Measured results
- Conclusions
- Future works

Intersymbol Interference (ISI)

Combating ISI is critical in wideband radio communications

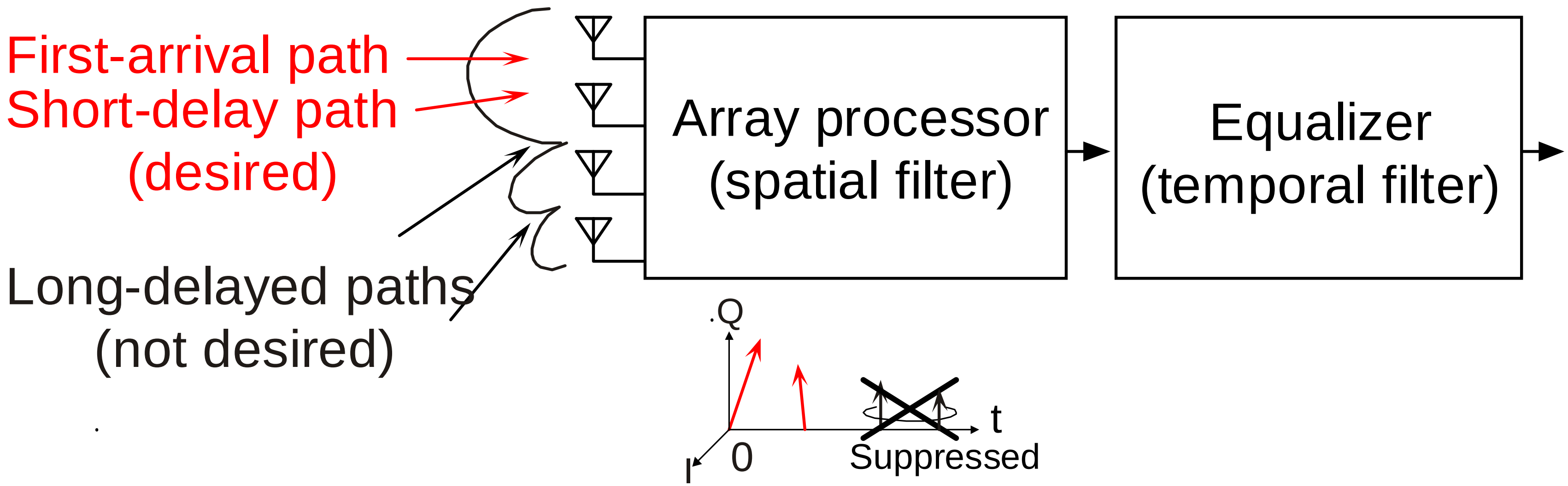




ISI spans several symbol periods

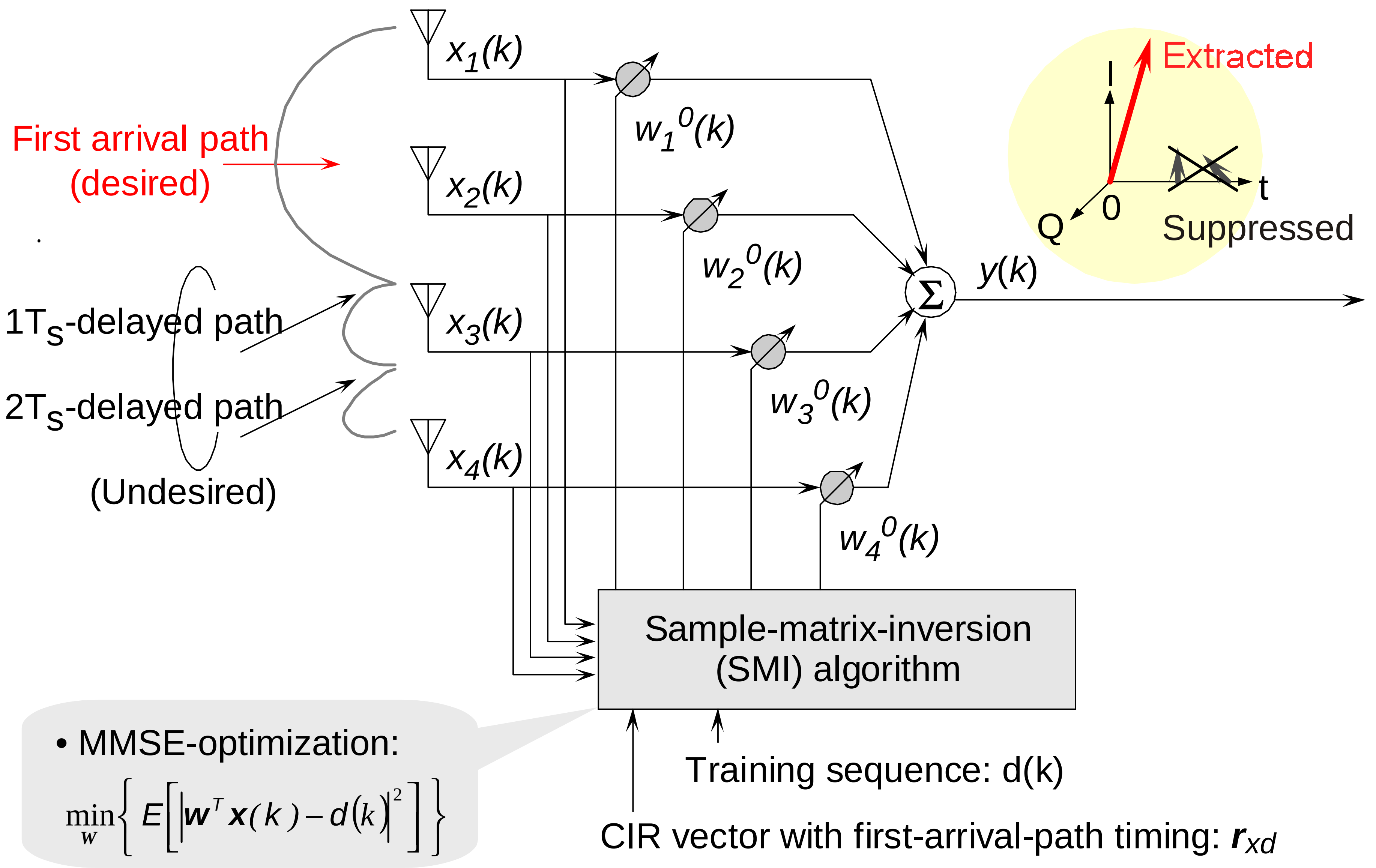
Reference: M. Mizuno, S. Sekizawa, and K. Taira, “Measurement of Spatiotemporal Propagation Characteristics in Urban Microcellular Environment,” in *Proc. IEEE Vehicular Technology Conf.*, Amsterdam, Sep. 1999.

A Space-Time Equalizer



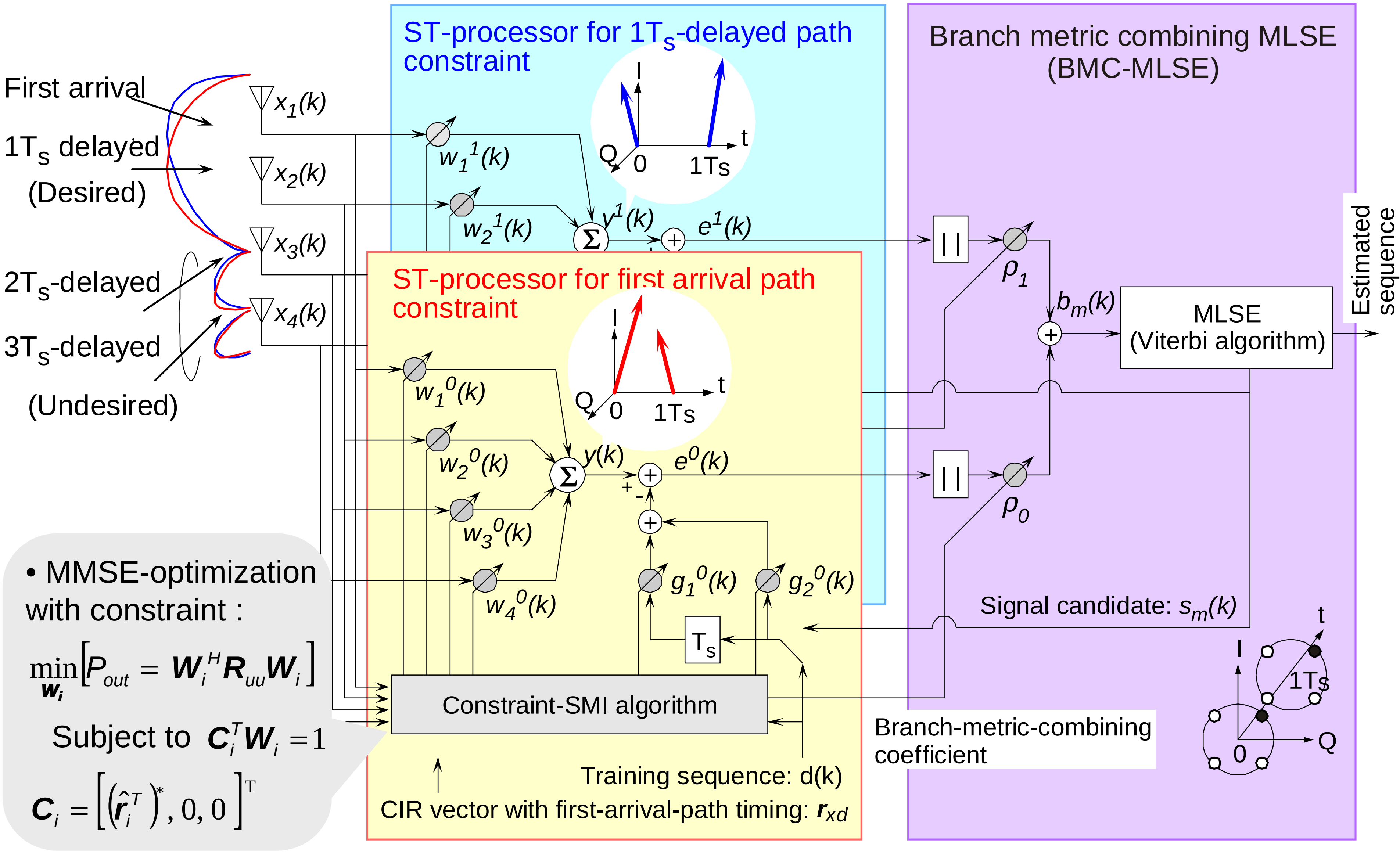
	Array	Equalizer	Array + Equalizer (ST equalizer)
Maximum delay-time	○	×	○
Path diversity	×	○	○

Array

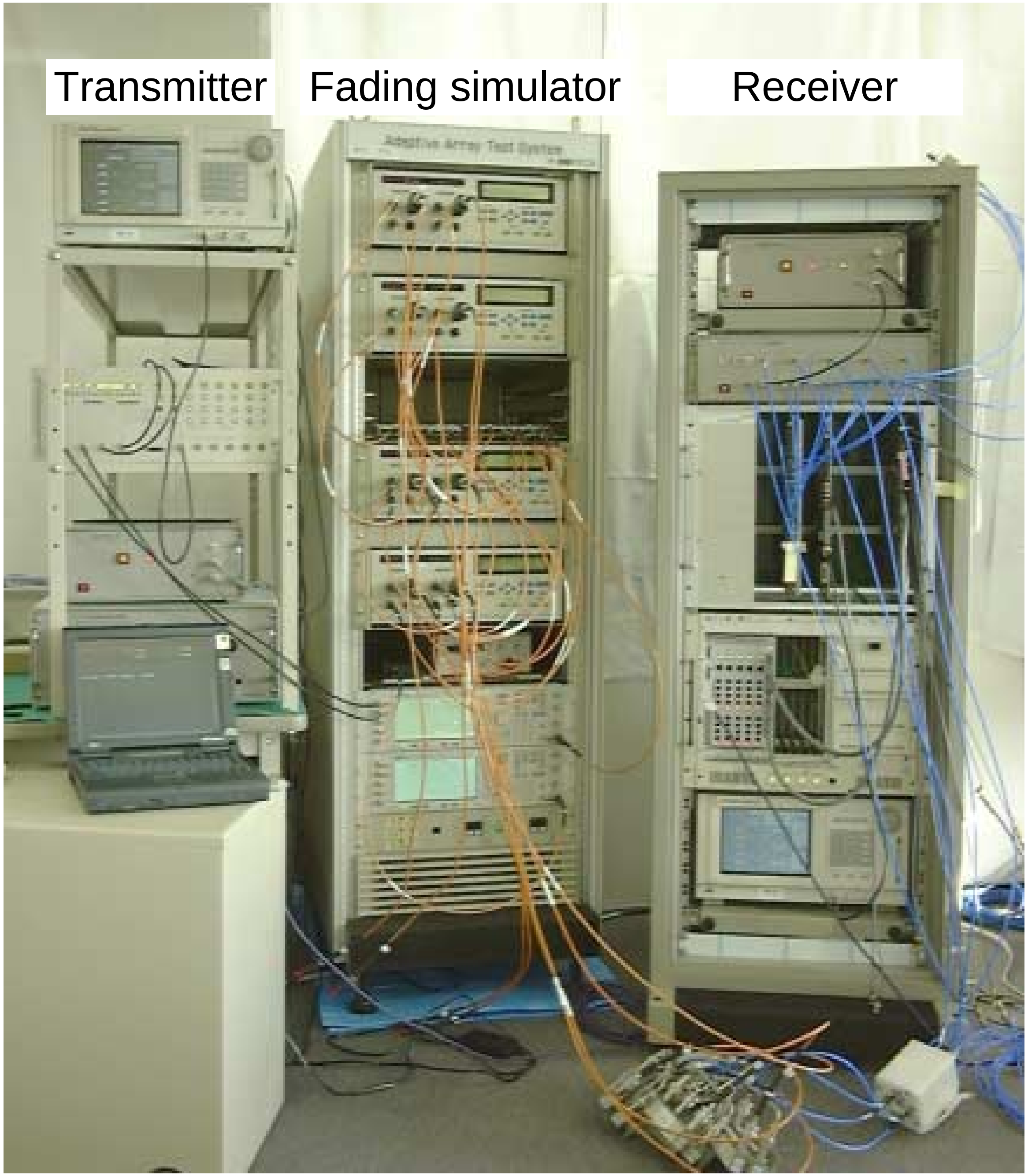


First arrival path
(desired)
1T_S-delayed path
2T_S-delayed path
(Undesired)
$x_1(k)$
$x_2(k)$
$x_3(k)$
$x_4(k)$
$w_1^0(k)$
$w_2^0(k)$
$w_3^0(k)$
$w_4^0(k)$
Σ
$y(k)$
Extracted
I
Q
0
t
Suppressed
Sample-matrix-inversion
(SMI) algorithm
• MMSE-optimization:
$$\min_{w}\left\{ E\left[\left|\boldsymbol{w}^T\boldsymbol{x}(k)-d(k)\right|^2\right]\right\}$$
Training sequence: d(k)
CIR vector with first-arrival-path timing: $\boldsymbol{r}_{xd}$

Space-Time Equalizer



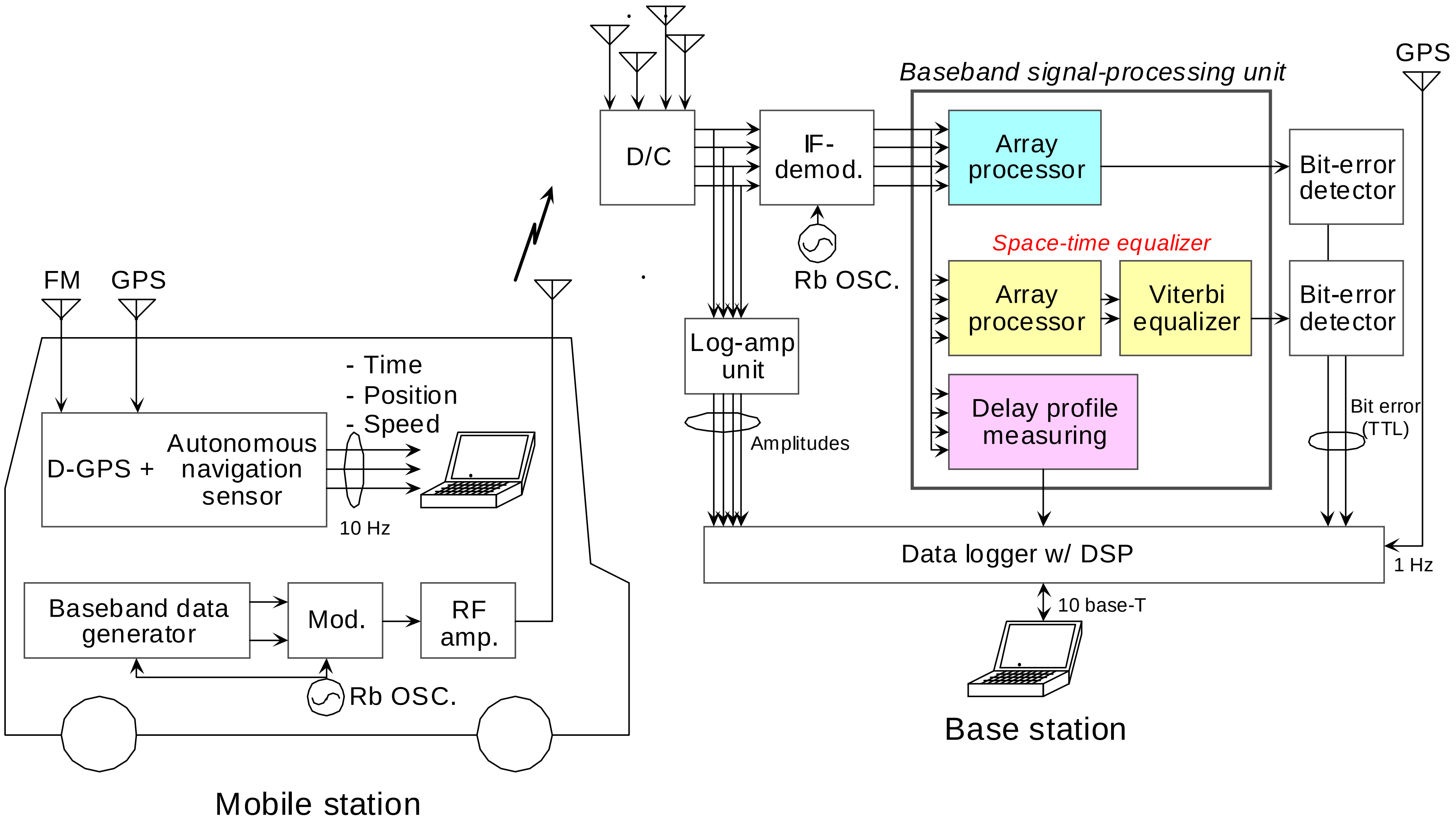
Photograph of Testbed



Field Trial Specifications

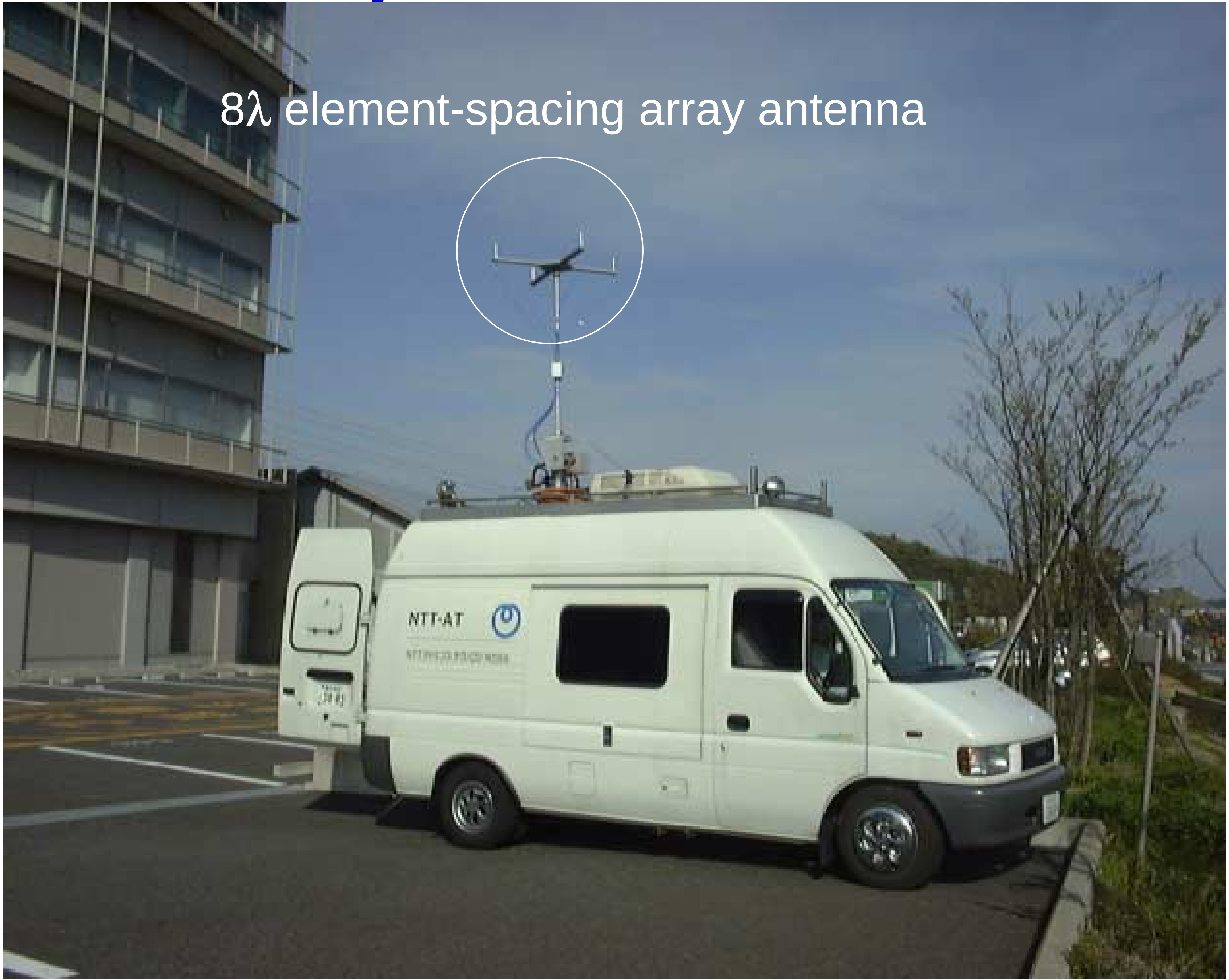
Radio frequency	3.35 GHz
Modulation	QPSK
Transmission rate	4.096 Mb/s
Frame format	TDM
Pulse shaping	Root rolloff filter (α=0.5)
Training/data length	48/208 symbols (32 symbols for training)
Tx. antenna	Omni-directional
Rx. Antenna array	Four-element circular (0.5, 8 λ element-spacing)

Experimental System



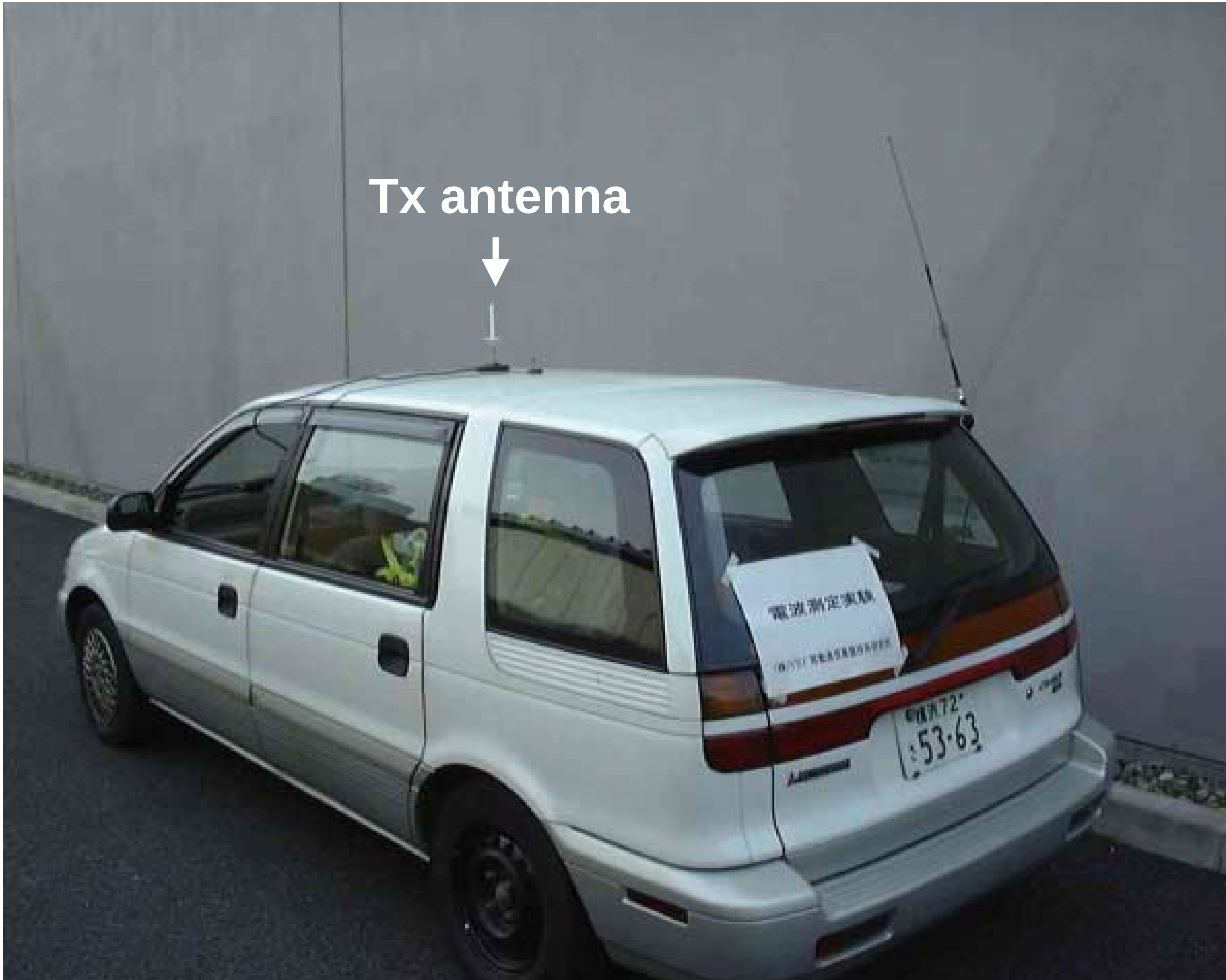
Base Station (Receiver)

Array Antenna for Base Station

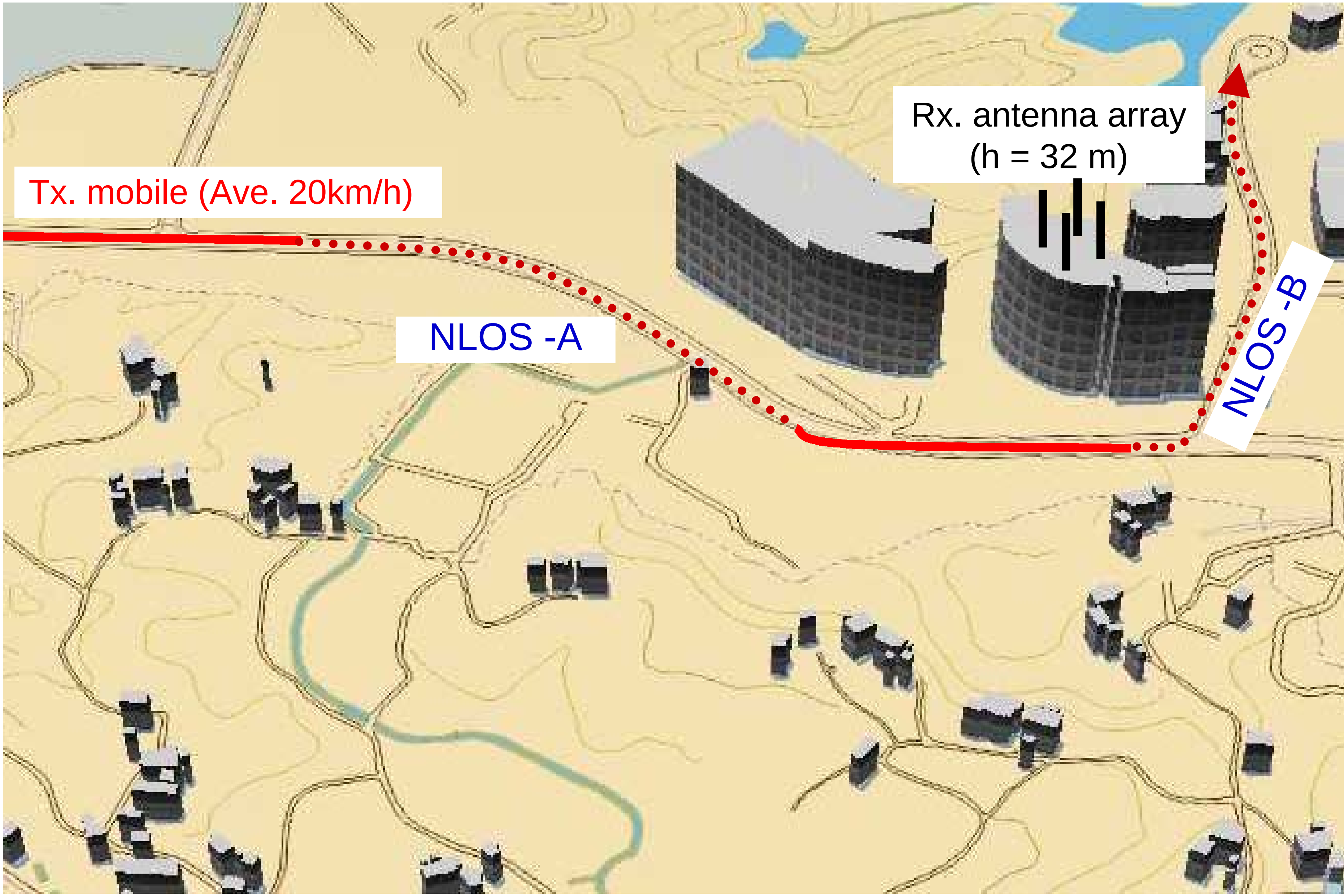


Mobile Station (Transmitter)

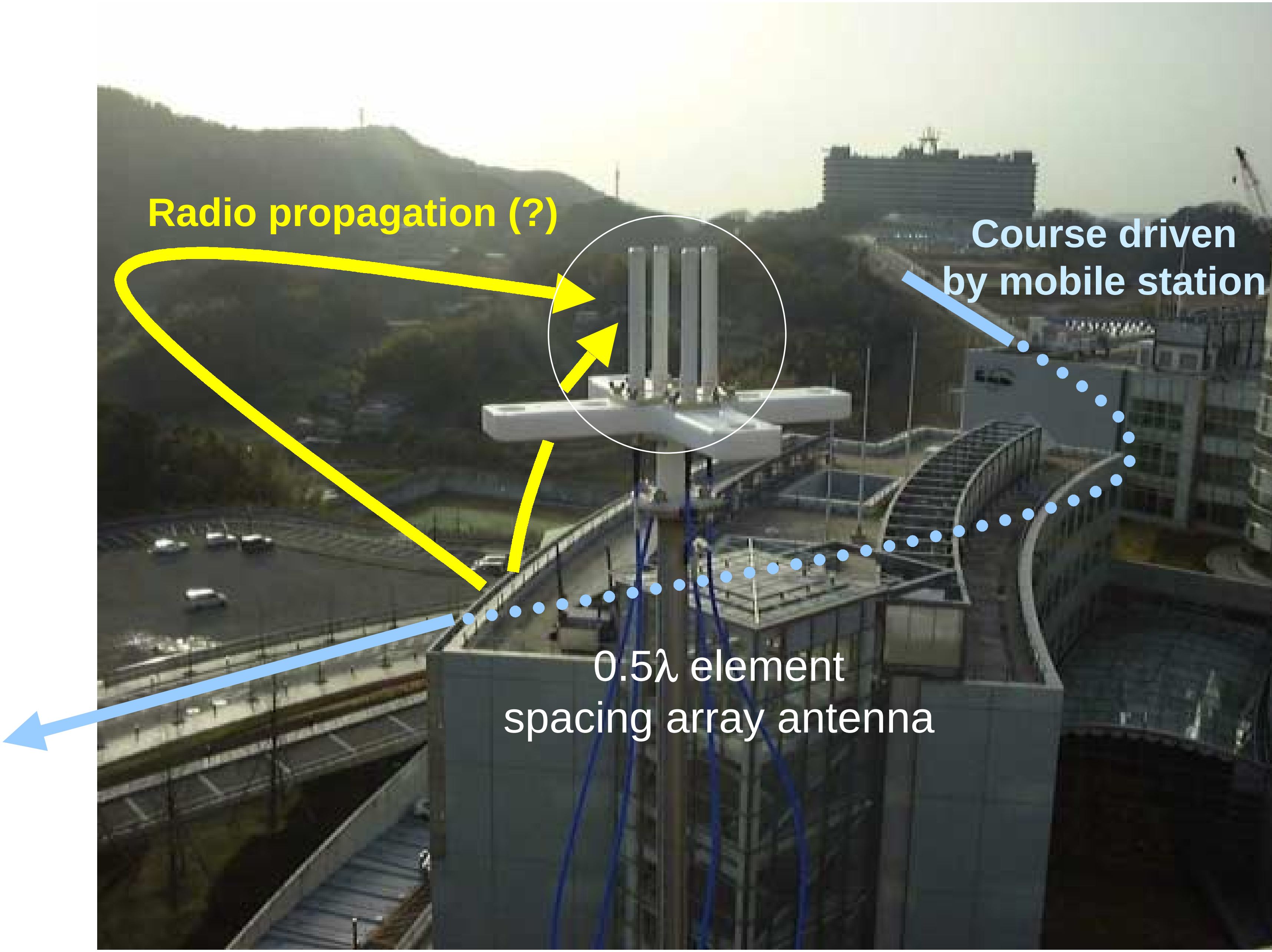
Antenna for Mobile Station

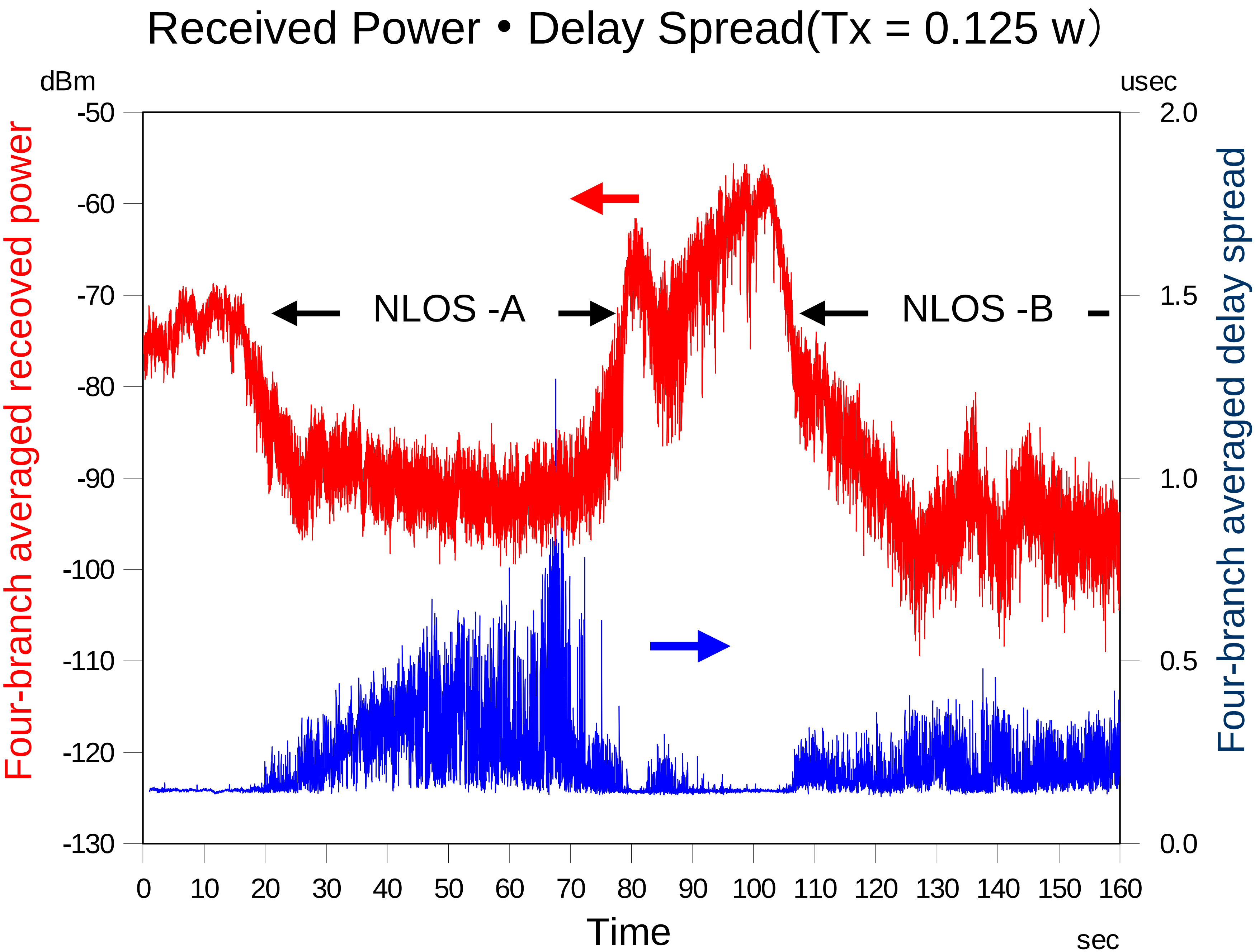


Field Test Environment



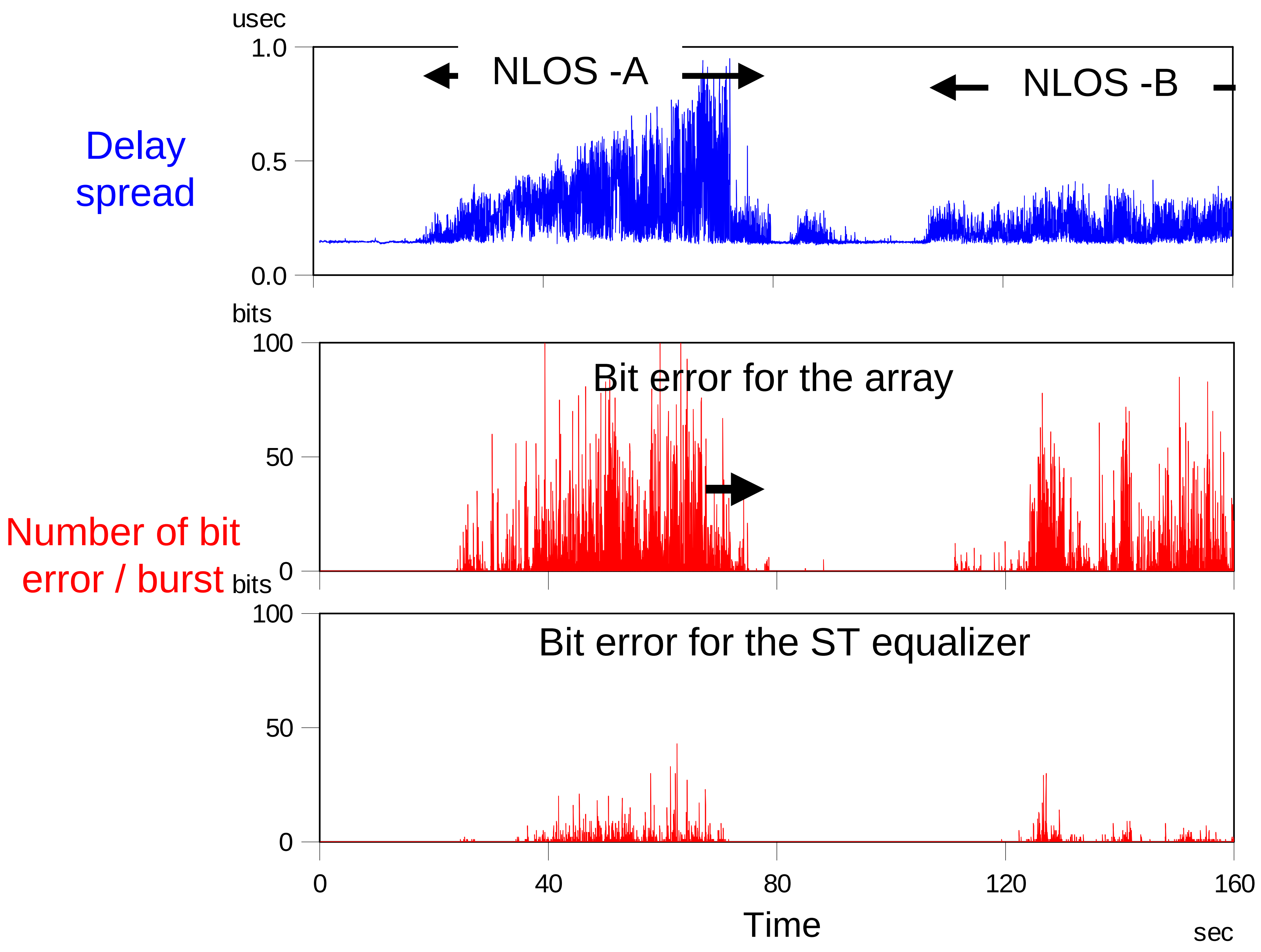
Array Antenna on Top of Bulding



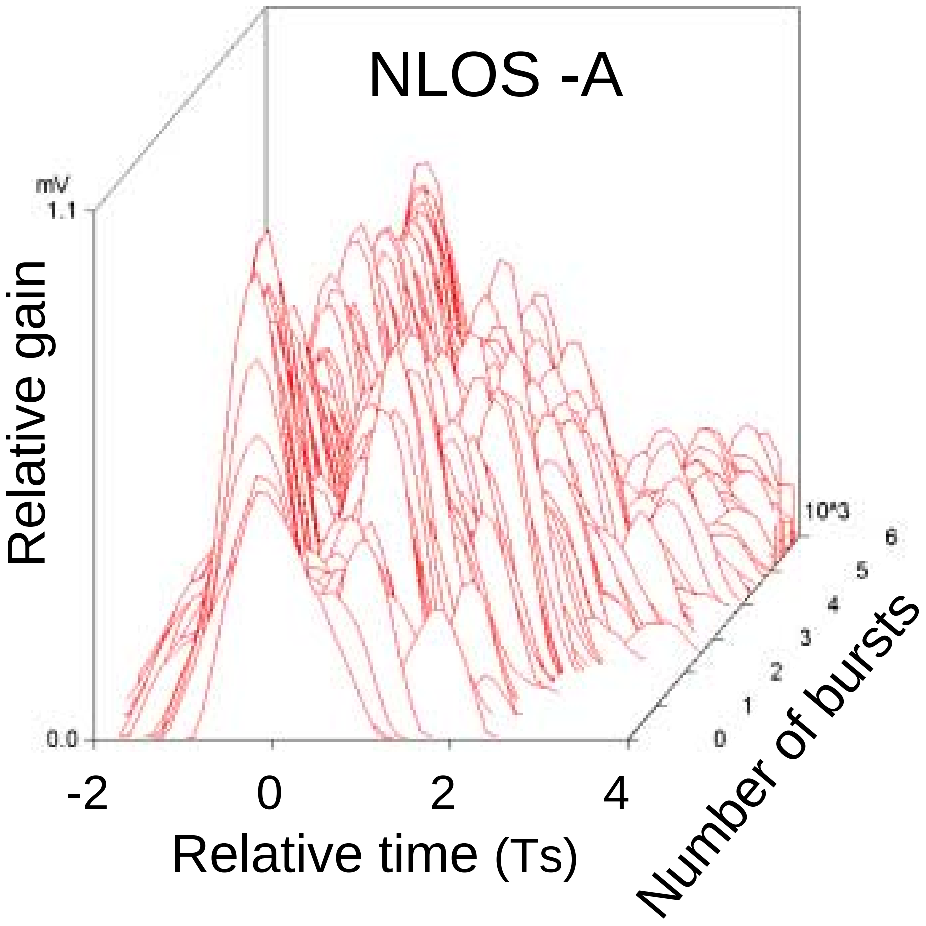


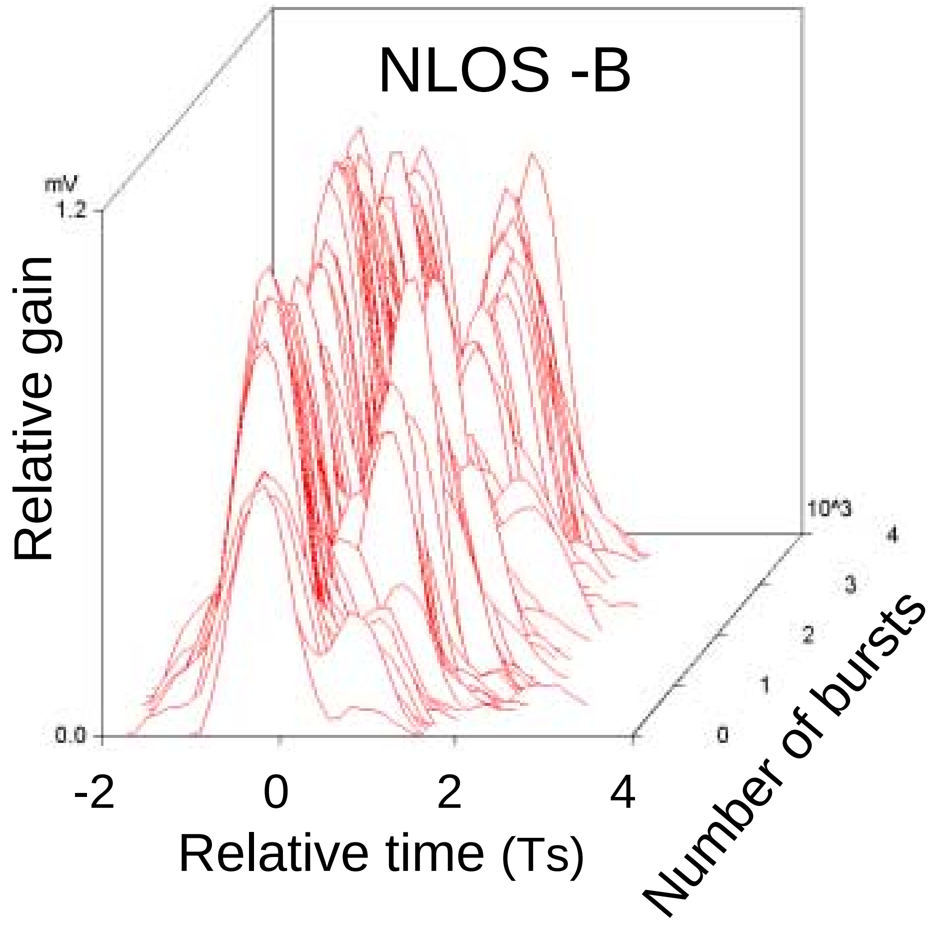
Received Power • Delay Spread(Tx = 0.125 w)
dBm
usec
Four-branch averaged receoved power
Four-branch averaged delay spread
-50
-60
-70
-80
-90
-100
-110
-120
-130
2.0
1.5
1.0
0.5
0.0
NLOS -A
NLOS -B
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
Time
sec

Delay Spread • Bit Error /Burst (Tx = 0.125 w)

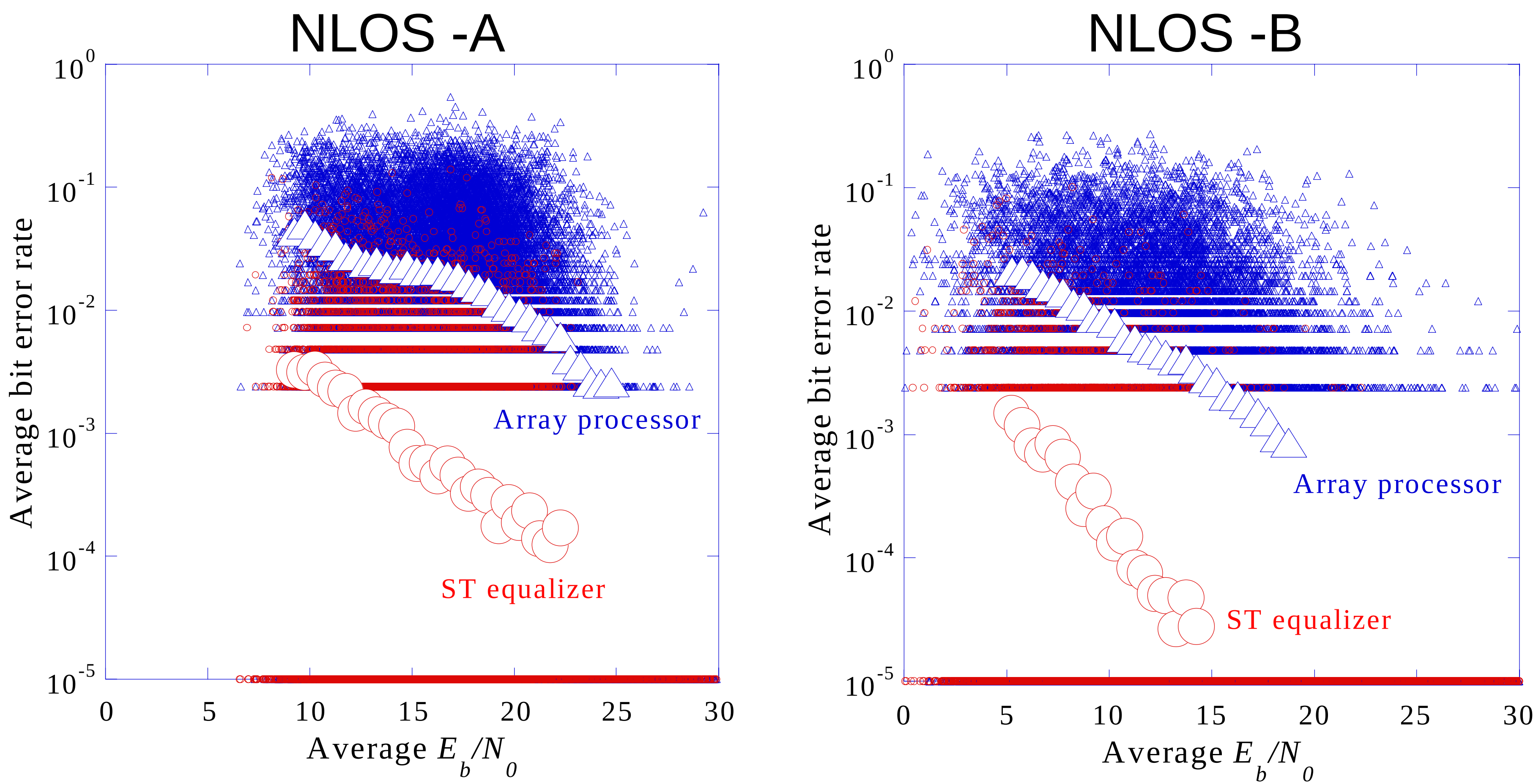


Delay Profile





BER Performances (Array v.s. ST equalizer)



△, ○ : BER/burst

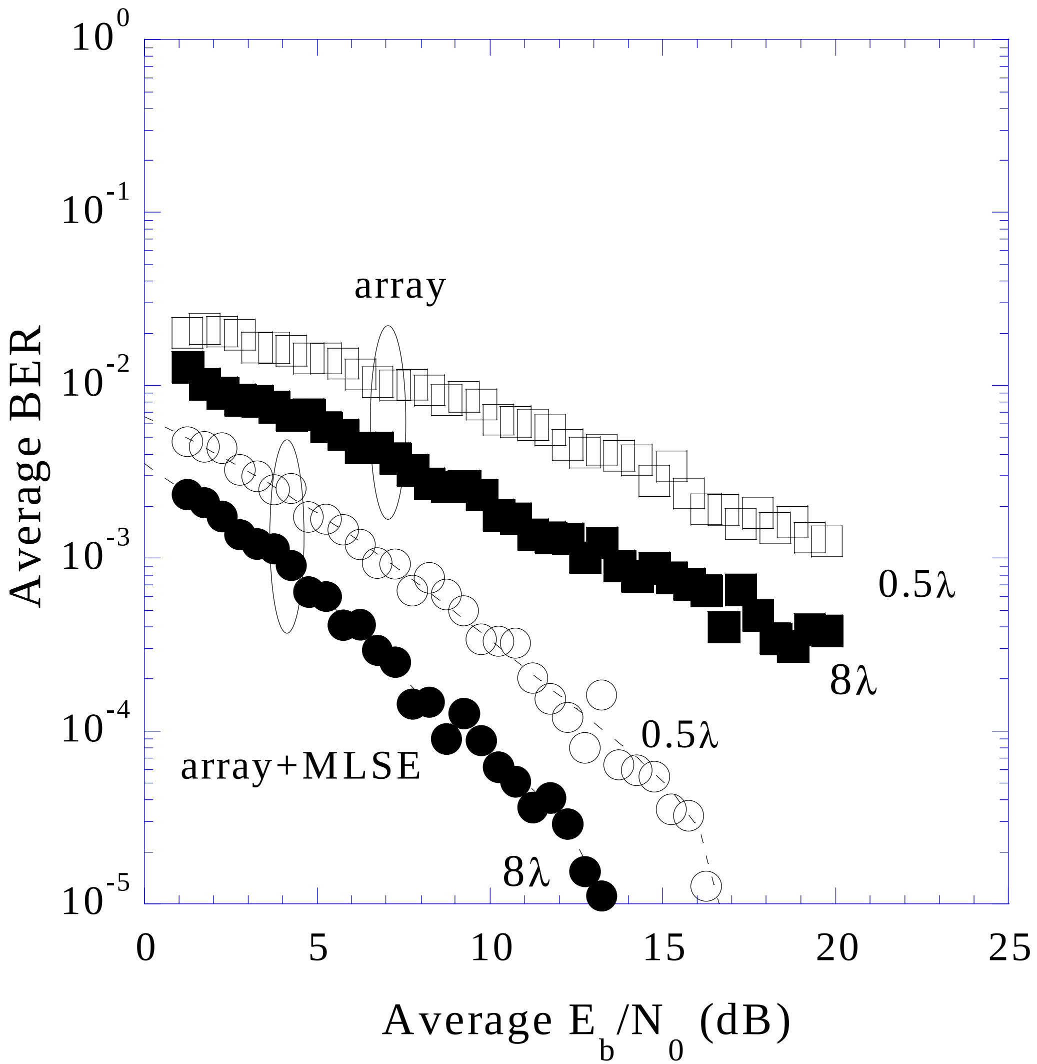
△, ○: BER averaged by 0.5 dB step

Widely spaced Antenna Array for Receiver

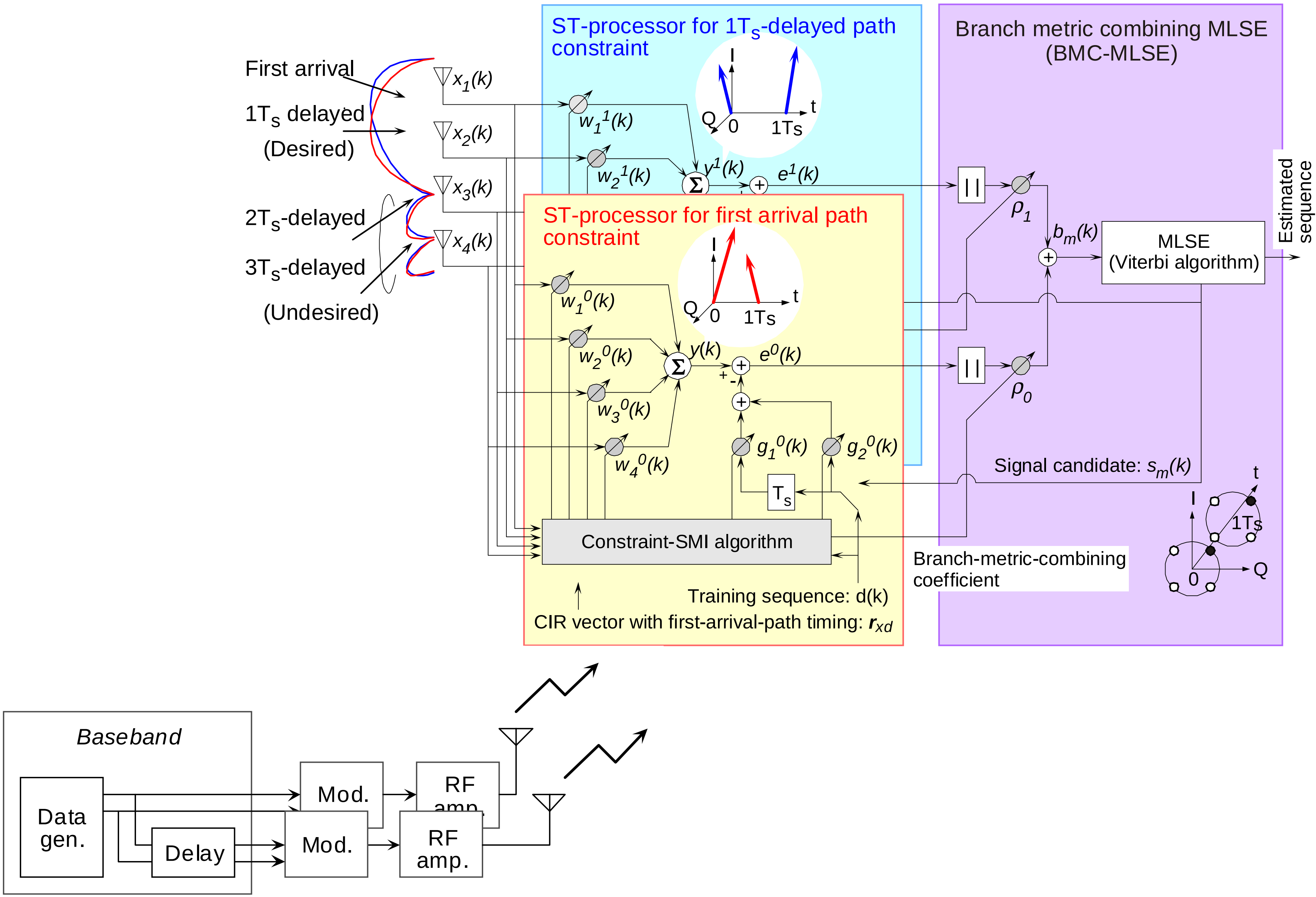
0.5λ element spacing

8λ element spacing

BER Performances for Element Spaceing (0.5λ v.s. 8λ)



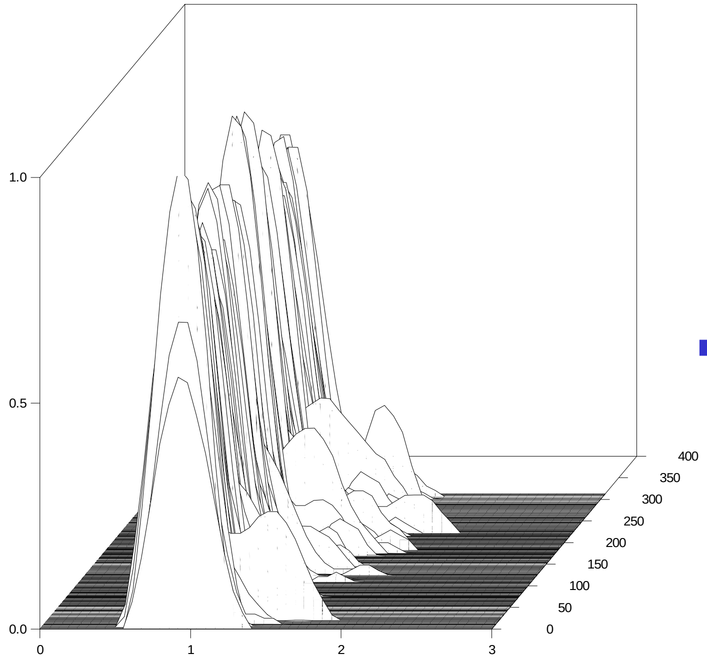
Delayed Diversity Transmission (DDT)



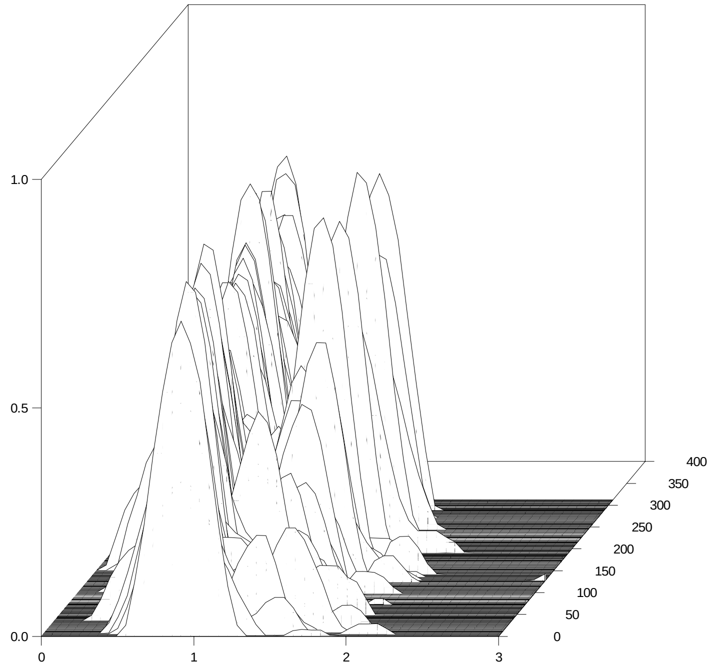
Mobile Station with tow antennas for DDT

Delay Profile with DDT in LOS

Delay = 0.5 Ts



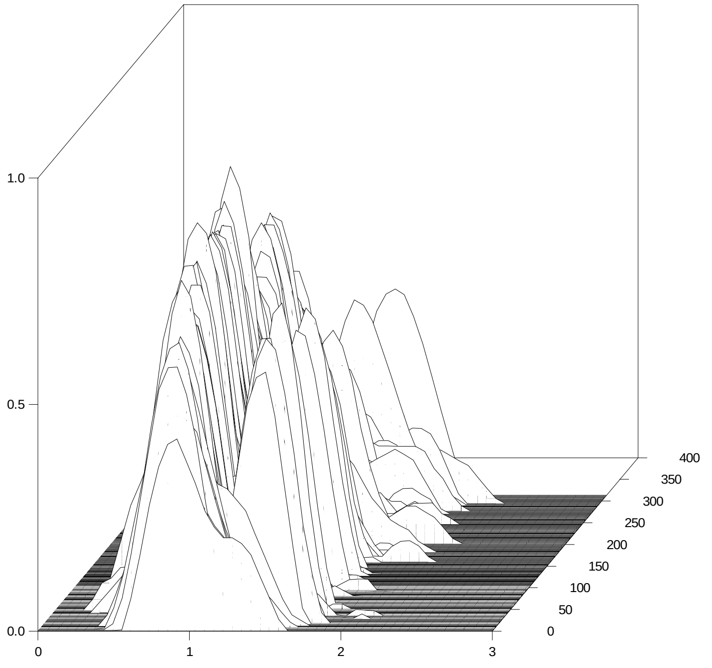
Without DDT



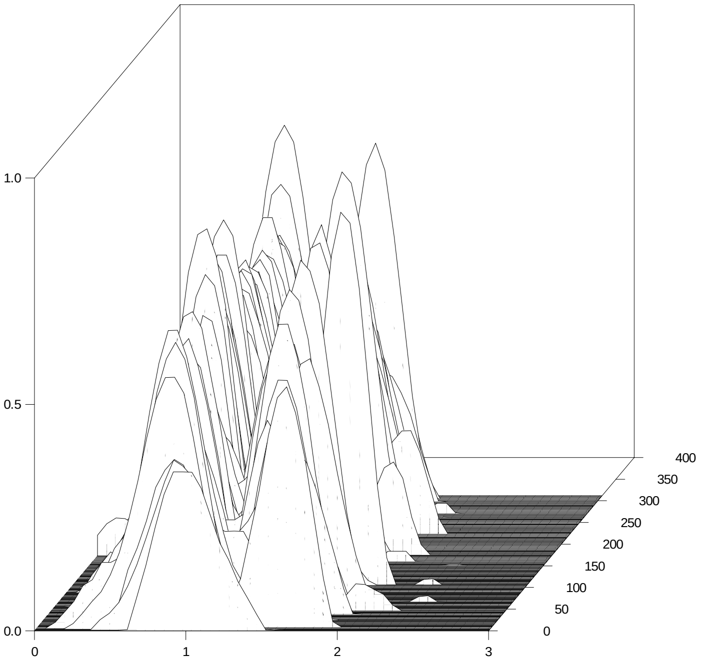
With DDT

Delay Profile with DDT in NLOS

Delay = 0.5 Ts

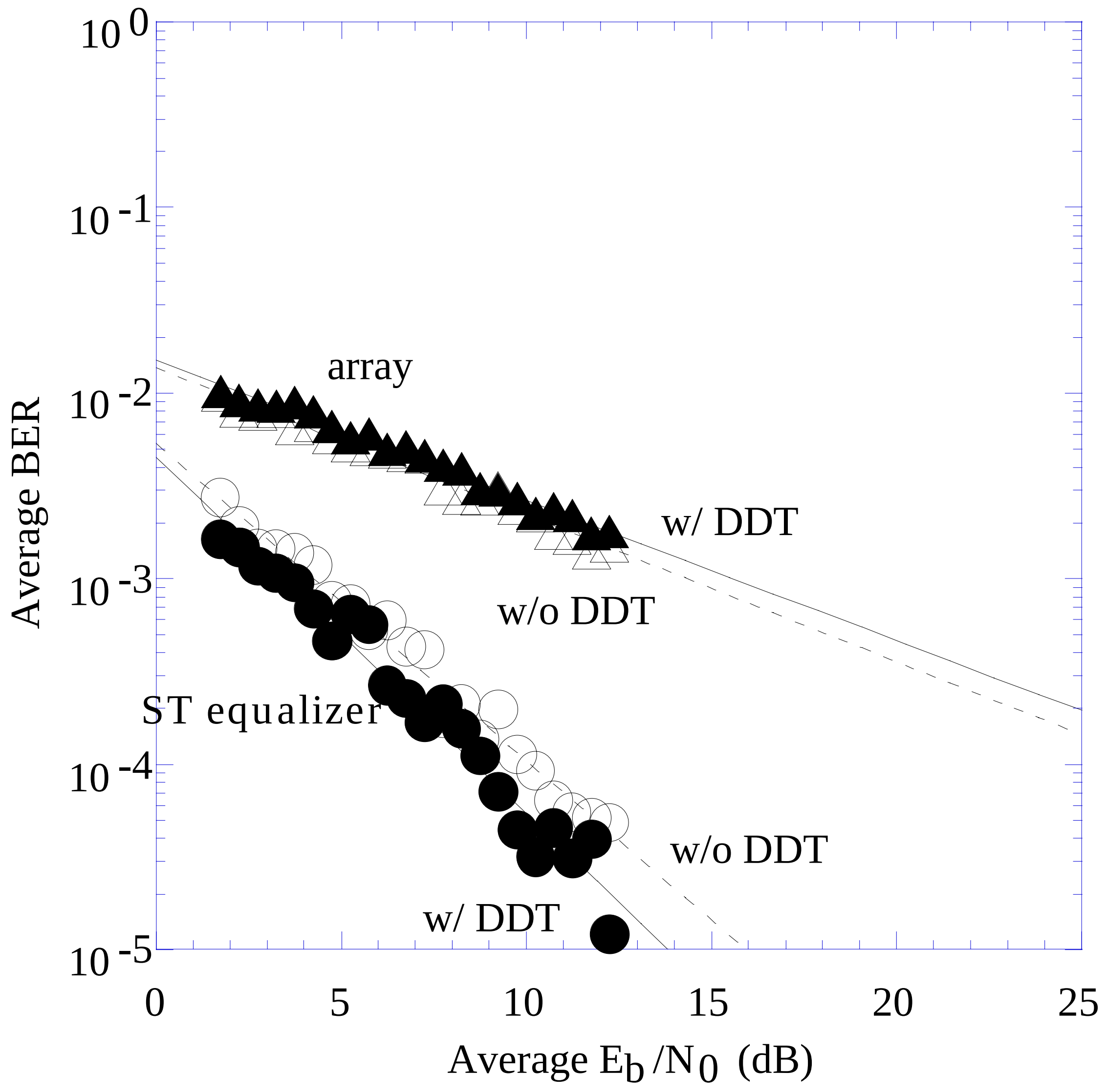


Without DDT



With DDT

BER Performances with DDT



Conclusions

ST equalizer:
better than 10 dB of E_b/N_0 improvement at BER = 10^{-3} as compared with the array, for a channel with an delay spread of less than 1 msec.

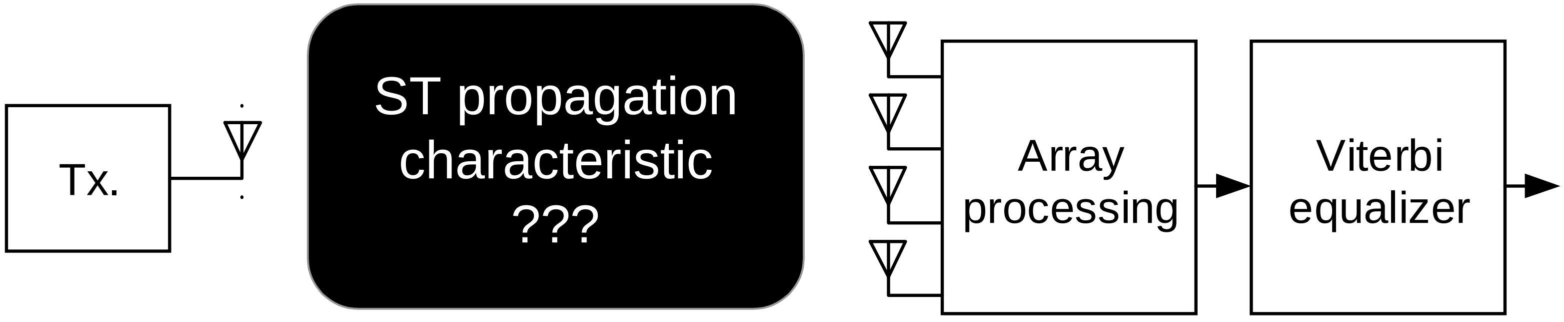
ST equalizer with DDT:
Effective in an environment with a small delay spread.

↓

Future works (joint works with Takada lab. and Araki lab.)

Future Works (1/3)

Measurement of ST propagation characteristic



Behavior of MMSE-array processing **?**
Behavior of Viterbi equalizing **?**

$\rightarrow$ ST diversity mechanism **?**

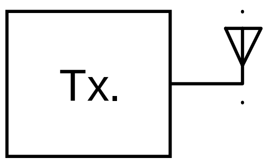
under various ST propagation characteristics

$\rightarrow$ Computer simulation with the measured ST prop. characteristic

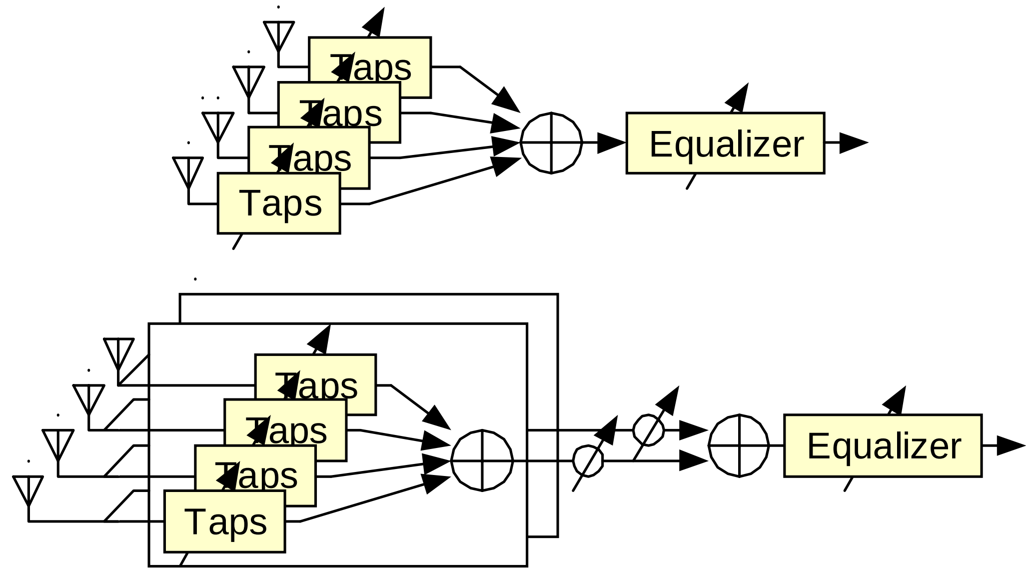
$\rightarrow$ Computer simulation with ray tracing

Future Works (2/3)

Optimization of parameter of ST equalizer according to the measured ST propagation characteristic



The measured ST propagation characteristics



- Number of antenna elements ?
- Element spacing ?
- Number of taps ?
- Array processing algorithms ?
- MLSE, DFE, LE ?

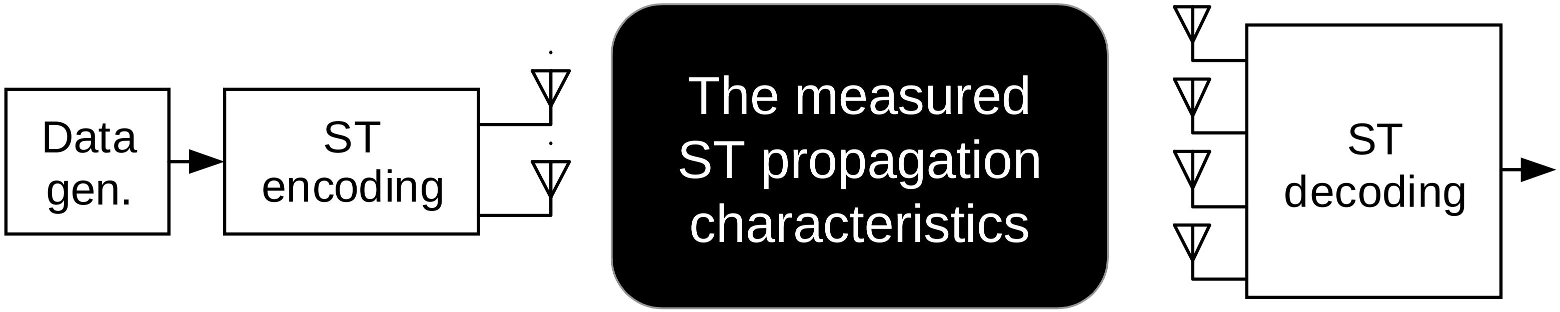
according to the measured ST prop. characteristic

→ Computer simulation

→ Implementation and field test

Future Works (3/3)

MIMO space-time (ST) processing



→ Computer simulation
→ Implementation and field test