

Project	<b>IEEE 802.20 Working Group on Mobile Broadband Wireless Access</b> < <a href="http://grouper.ieee.org/groups/802/mbwa">http://grouper.ieee.org/groups/802/mbwa</a> >	
Title	<b>MIMO Channel Model for MBWA</b>	
Date Submitted	<b>2003-03-06</b>	
Source(s)	Insoo Sohn, Heesoo Lee, KyungHi Chang 161 Gajeong-Dong, Yuseong-Gu Daejeon, KOREA 305-350	Voice: +82-42-860-1027 Fax: +82-42-860-6732 Email: isohn@etri.re.kr
Re:		
Abstract	This contribution presents the METRA MIMO channel model as the MIMO channel model for MBWA system. MIMO channel parameters are also given as an example.	
Purpose	For informative use only.	
Notice	This document has been prepared to assist the IEEE 802.20 Working Group. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.20.	
Patent Policy	The contributor is familiar with IEEE patent policy, as outlined in Section 6.3 of the IEEE-SA Standards Board Operations Manual < <a href="http://standards.ieee.org/guides/opman/sect6.html#6.3">http://standards.ieee.org/guides/opman/sect6.html#6.3</a> > and in <i>Understanding Patent Issues During IEEE Standards Development</i> < <a href="http://standards.ieee.org/board/pat/guide.html">http://standards.ieee.org/board/pat/guide.html</a> >.	

# MIMO Channel Model for MBWA



Insoo Sohn, Heesoo Lee, KyungHi Chang  
March 2003

# Contents

---

- **Introduction**
- **MIMO Channel**
- **METRA Channel Model**
- **Conclusions**
- **References**
- **Appendix**

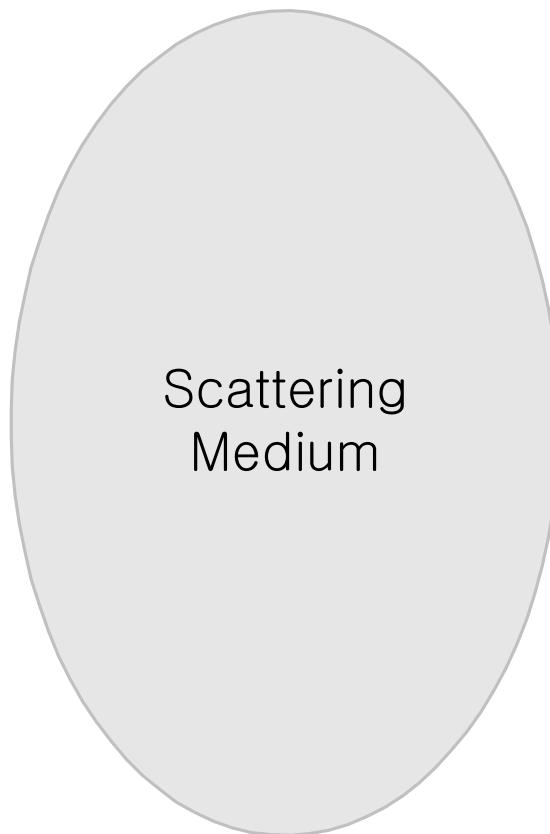
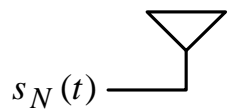
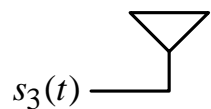
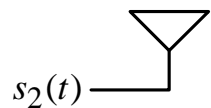
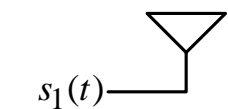
# Introduction

---

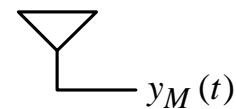
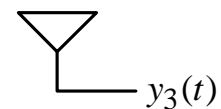
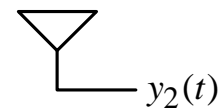
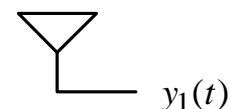
- Use of multiple transmit and multiple receive antenna, known as MIMO (Multiple Input Multiple Output) system, is gaining interest for next generation mobile wireless communication systems.
- It has been shown by Foschini [1], MIMO system can achieve enormous capacity gain from multiple parallel sub-channels created in rich scattering environment.
- Recently, spectral efficiencies ranging 20-40bit/s/Hz with 30kHz bandwidth were demonstrated at Lucent using V-BLAST (Vertical – Bell Laboratories Layered Space Time) system in MIMO environment.

# MIMO Channel

Mobile Station (MS)



Base Station (BS)



# MIMO Channel

## ■ METRA Model

- ◆ Combines independent complex Gaussian correlation matrices at the transmitter and receiver for MIMO correlation matrix.
- ◆ ITU model is used for modeling power delay profile.
- ◆ Realistic and easy-to-use with backward compatibility to ITU model.
- ◆ AWGN, shadowing, and path loss models are not included.

## ■ Ray-Tracing Model

- ◆ Models location of scatterers by following the propagation path through the channel.
- ◆ Provides fairly accurate channel prediction.
- ◆ Too complex for major outdoor environment.

## ■ Scattering Model

- ◆ Assumes particular distribution of scatterers.
- ◆ Generates channel modeling through interaction of scatterers and planar wavefronts.
- ◆ Requires large number of parameters.

# METRA Channel Model

---

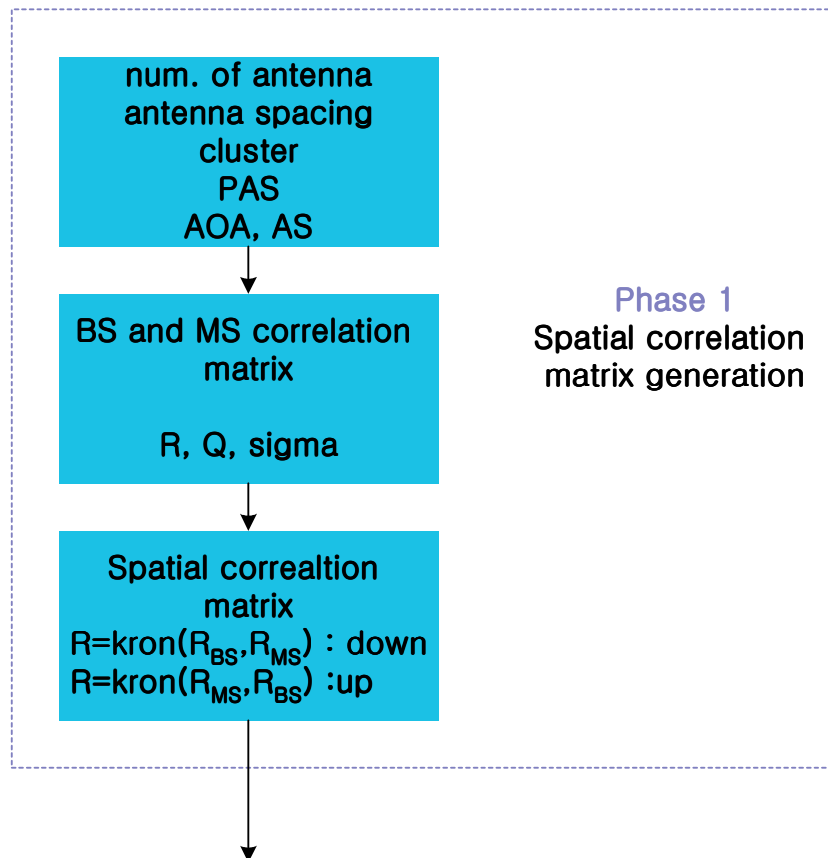
- The METRA Project is one of the various projects under the IST (Information Society Technologies) Program.
- The METRA Consortium
  - ◆ Universitat Politecnica de Catalunya
  - ◆ Aalborg University
  - ◆ Nokia Networks
  - ◆ Nokia Mobile Phones
  - ◆ Vodafone Ltd
- The METRA Project builds on the previous EC funded projects on smart antennas for mobile communications
  - ◆ TSUNAMI (Technology in Smart Antennas for Universal Advanced Mobile Infrastructure Project)
  - ◆ SUNBEAM (Smart Universal Beamforming)

# METRA Channel Model

- According to [2-3], the METRA MIMO channel model uses generalized tap delay line model with time variation specified by Doppler spectrum.
- The correlation matrices to characterize the MIMO channel are defined by
  - ◆ Power azimuth spectrum (PAS)
  - ◆ Azimuth spread (AS)
  - ◆ Mean angle of arrival (AoA)
  - ◆ Antenna spacing.
- The METRA MIMO model's power delay profile is based on the ITU channel profile, therefore backward compatible with widely used ITU SISO model.

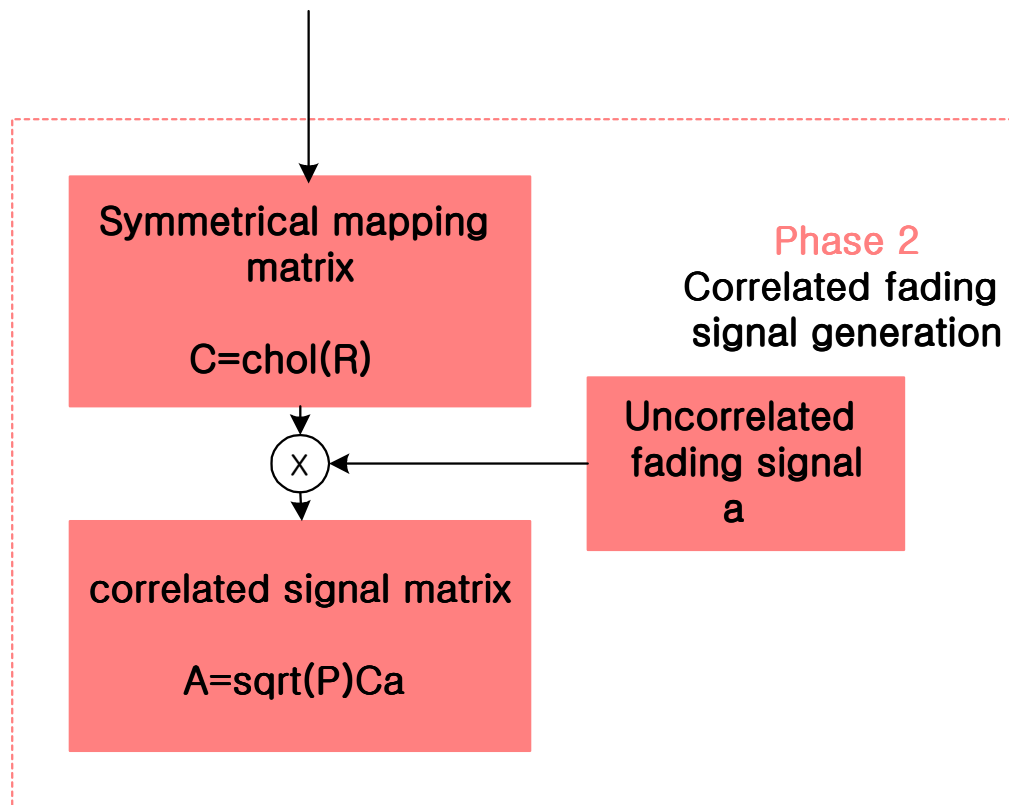
# METRA Channel Model

## Channel Modeling Procedures



# METRA Channel Model

## Channel Modeling Procedures (Cont.)



# METRA Channel Model

## ■ MIMO Channel Parameters (source: 3GPP TR 25.876 V1.0.1)

		Case A Rayleigh Uncorrelated	Case B Macrocell Ped A	Case C Macrocell Veh A	Case D Microcell/Bad-urban PedB
Number of paths		1	4	6	6
PDP		N/A	ITU Pedestrian A	ITU Vehicular A	ITU Pedestrian B
Doppler spectrum		Classical	Classical	Laplacian	Laplacian
Speed(km/h)		3/40/120	3/40/120	3/40/120	3/40/120
UE	Topology	N/A	0.5λ spacing	0.5λ spacing	0.5λ spacing
	PAS	N/A	Path #1, Rician, K=6dB Uniform over 360	Laplacian, AS=35 (Uniform over 360)	Laplacian, AS=35 (Uniform over 360)
	DoM(deg)	N/A	0	22.5	-22.5
	AoA(deg)	N/A	22.5	67.5 (all path)	22.5 (odd paths) -67.5 (even paths)
Node B	Topology	N/A	Uniform linear array: 1) 0.5λ spacing 2) 4.0λ spacing		
	PAS	N/A	Laplacian, <u>AS=5</u>	Laplacian, <u>AS=10</u>	Laplacian, <u>AS=15</u>
	AoA	N/A	<u>20,50<sup>1)</sup></u>	<u>20,50<sup>1)</sup></u>	<u>2,-20,10,-8,-33,31<sup>2)</sup></u>

# METRA Channel Model

## Correlation Matrix for 4TX-4RX:

### Case B

$$\begin{bmatrix} 1 & 0.4640+0.8499i & -0.4802+0.7421i & -0.7688-0.0625i \\ 0.4640-0.8499i & 1 & 0.4640+0.8499i & -0.4802+0.7421i \\ -0.4802-0.7521i & 0.4640-0.8499i & 1 & 0.4640+0.8499i \\ -0.7688+0.0625i & -0.4802-0.7421i & 0.4640-0.8499i & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & -0.3043 & 0.2203 & -0.1812 \\ -0.3043 & 1 & -0.3043 & 0.2203 \\ 0.2203 & -0.3043 & 1 & -0.3043 \\ -0.1812 & 0.2203 & -0.3042 & 1 \end{bmatrix}$$

### Case C

$$\begin{bmatrix} 1 & 0.4290+0.7766i & -0.3642+0.5475i & -0.4527-0.0502i \\ 0.4290-0.7766i & 1 & 0.4290+0.7766i & -0.3642+0.5475i \\ -0.3642-0.5475i & 0.4290-0.7766i & 1 & 0.4290+0.7766i \\ -0.4527+0.0521i & -0.3642-0.5475i & 0.4290-0.7766i & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & -0.6906+0.3419i & 0.4903-0.3626i & -0.3733+0.3450i \\ -0.6906-0.3419i & 1 & -0.6906+0.3419i & 0.4903-0.3626i \\ 0.4903+0.3626i & -0.6906-0.3419i & 1 & -0.6906+0.3419i \\ -0.3733-0.3450i & 0.4903+0.3626i & -0.6906-0.3419i & 1 \end{bmatrix}$$

Node B

Laplacian, AS=5,  
0.5  $\lambda$ , AOA=20°

UE

Uniform, K=6dB  
0.5  $\lambda$ , AOA=22.5°

Node B

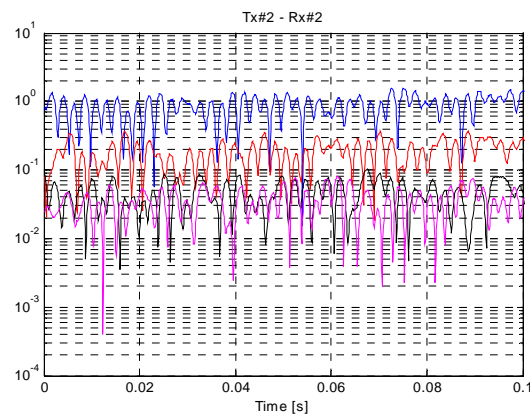
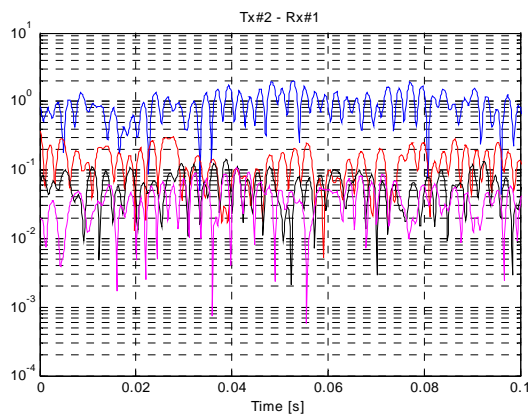
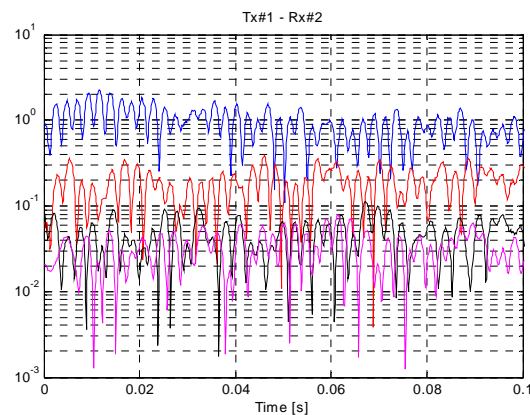
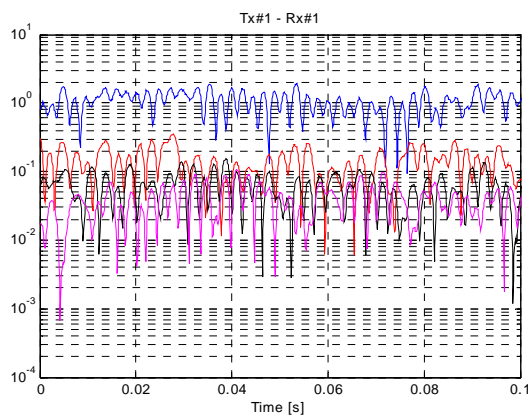
Laplacian, AS=10,  
0.5  $\lambda$ , AOA=20°

UE

Laplacian, AS=35, DOM=22.5°  
0.5  $\lambda$ , AOA=67.5°

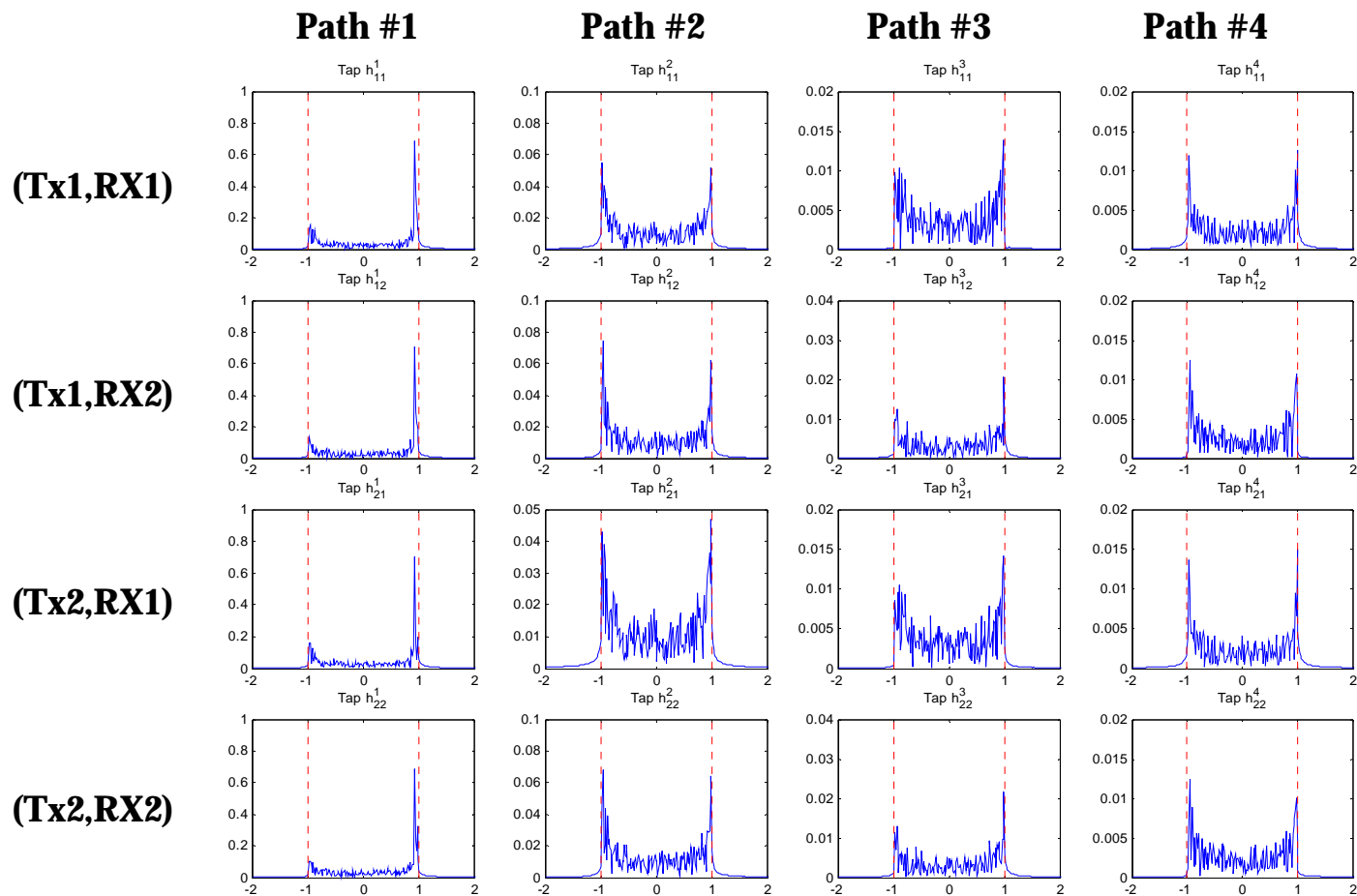
# METRA Channel Model

## ■ METRA Model Case B (2TX-2RX) Channel Gain



# METRA Channel Model

## ■ METRA Model Case B (2TX-2RX) Doppler Spectrum



## Conclusions

---

- MIMO system can achieve enormous capacity gain from multiple parallel sub-channels created in rich scattering environment.
- The METRA MIMO Model, based on the previous EC funded projects, is fairly realistic and easy-to-use with backward compatibility to ITU model.
- This model is currently being considered at 3GPP for MIMO channel model, and has been validated with actual experimental measurements.

## References

---

- [1] G.J. Foschini, M.J. Gans, “On limits of Wireless Communications in a Fading Environment when using Multiple Antennas,” *Wireless Personal Communications*, No. 6, 1998, pp.311-335
- [2] J. P. Kermoal, L. Schumacher, K. I. Pedersen, P. E. Mogensen, and F. Frederiksen, “A Stochastic MIMO Radio Channel Model with Experimental Validation,” *IEEE JSAC*, vol. 20, pp. 1211-1225, Aug. 2002.
- [3] L. Schumacher, J. P. Kermoal, F. Frederiksen, K. I. Pedersen, A. Algans, and P. E. Mogensen, “MIMO Channel Characterisation,” IST Project IST-1999-11729 METRA Deliverable D2, Feb. 2001

# Appendix

## Simulation Results using METRA MIMO Channel

- ◆ METRA Channel Case B (Ped. A) with speed = 60km/h
- ◆ MIMO OFDM System with AMC option of 16 QAM &  $r = 1/2$  LDPC code

