Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** <**http://grouper.ieee.org/groups/802/20/**>
Title	**MBTDD 625k-MC* MODE Performance Report 1**
Date Submitted	2006-JAN-06
Authors(s)	Radhakrishna Canchi KYOCERA Telecom.Research.Corp. 2480 N. First Street, Suite#280 San Jose, CA 95131 Voice: +1-408-952-4701 Fax: +1-408-954-8709 Email: cradhak@ktrc-na.com Kazuhiro Murakami KYOCERA 2-1-1 Kagahara, Tsuzuki-ku, Yokohama, KANAGAWA 224-8502, JAPAN Voice: +81-45-943-6130 Fax: +81-45-943-6175 Email: kazuhiro.murakami.xm@kyocera.jp Minako Kithara KYOCERA 2-1-1 Kagahara, Tsuzuki-ku, Yokohama, KANAGAWA 224-8502, JAPAN Voice: +81-45-943-6102 Fax: +81-45-943-6175 Email: minako.kitahara.nf@kyocera.jp
Re:	MBWA Call for Proposal
Abstract	This document presents the **Technology Performance and Evaluation Criteria Report 1** of the Technology Proposal **MBTDD 625k-MC*** (BEST-WINE) for IEEE 802. 20 MBWA
Purpose	To discuss and Adopt **MBTDD 625k-MC*** (BEST-WINE) for Draft Specifications of IEEE802.20 MBWA
Notice	
Release	
Patent Policy	

* 625k-MC(625kHz625kiloHertz-spaced MultiCarrier) is Previously known as BEST-WINE: BEST-WINE: Broadband MobilE SpaTial Wireless InterNet AccEss

THE NEW VALUE FRONTIER
KYOCERA

MBTDD 625k-MC*
(BEST-WINE)
Performance Report 1

* 625k-MC(625kHz625kiloHertz-spaced MultiCarrier) is Previously known as BEST-WINE: BEST-WINE: Broadband MobilE SpaTial Wireless InterNet AccEss

1 Executive Summary

This document **MBTDD 625kHz MC Mode Performance Report 1** reports the performance of the 625k-MC(BEST-WINE) based on the evaluation methodology defined in *IEEE802.20 Evaluation Criteria* document [5]. The channel models of *IEEE802.20 Channel Model* document [4] were used.

Table of Contents

List of Figures

List of Tables

2 References

[1] ATIS-PP-0700004*-2005, High Capacity-Spatial Division Multiple Access (HC-SDMA), September 2005

a. ***The copyright of this document is owned by the Alliance for Telecommunications Industry Solutions. Any request to reproduce this document, or portion thereof, shall be directed to ATIS, 1200 G Street, NW, Suite 500, Washington, DC 20005.***

b. ***For Electronic Downloads, Paper Copy or CD-ROM please follow the link https://www.atis.org/atis/docstore/doc_display.asp?ID=3617***

[2] IEEE 802.20 PD-2.doc: Mobile Broadband Wireless Access Systems: Approved PAR (02/12/11):

[3] IEEE 802.20 PD-06r1.doc: IEEE 802.20 System Requirement Document (V 1.0)

[4] IEEE_802.20-PD-08.doc: IEEE 802.20 Channel Models (V 1.0)

[5] IEEE_802.20-PD-09.doc: IEEE 802.20 Evaluation Criteria (V 1.0)

[6] IEEE_802.20-PD-10.doc: IEEE 802.20 Technology Selection Process (V 1.0)

[7] X.P0011-001-D on 3gpp2 TSG-X specification

3 Definitions

As defined in the References [1],[2],[3]

4 Abbreviations and acronyms

AA	Access Assignment
AAA	Adaptive Antenna Array
ACLPR	Adjacent Channel Leakage Power Ratio
ACS	Adjacent Channel Selectivity
AM	Acknowledged Mode
API	Application Programming Interface
ARQ	Automatic Repeat Request
BCH	Broadcast Channel
BS	Base Station
BSCC	Base Station Color Code
CA	Certificate Authority
CCH	Configuration Channel
CM	Configuration Message
CoS	Class of Service
CR	Configuration Request
CRC	Cyclic Redundancy Check
EUD	End User Device
FACCH	Fast Associated Control Channel
FEC	Forward Error Control
FER	Frame Error Rate
GPS	Global Positioning System
HC-SDMA	High Capacity Spatial Division Multiple Access
i-HAP	Handshake and Authentication Protocol
IMSI	International Mobile Station Identifier
IPPR	Intermodulation Product Power Ratio
i-SEC	Secure Communications Protocol
i-TAP	Terminal Authentication Protocol
IWAN	Interconnection Wide Area Network
L2	Layer 2
L2TP	Layer 2 Tunneling Protocol
L3	Layer 3
L3 CM	L3 Connection Management
L3 MMC	L3 Mobility Management and Control
L3 RM	L3 Registration Management
LLC	Logical Link Control
LDAP	Lightweight Directory Access Protocol
LFSR	Linear Feedback Shift Register
LNA	Low Noise Amplifier
LNS	L2TP Network Server
LSB	Least Significant Bit
MAC	Medium Access Control
MBWA	Mobile Broadband Wireless Access
MSB	Most Significant Bit
PA	Power Amplifier
PAR	Project Authorization Requirements
PCH	Paging Channel
PDCL	Packet Data Conversion Layer
PHY	Physical Layer
PID	Paging Identity
PPM	Parts Per Million
PPP	Point to Point Protocol
PPPoE	PPP over Ethernet
PSS	Packet Services Switch

QoS	Quality of Service
RA	Request Access
RACH	Random Access Channel
RSA	Rivest, Shamir, Adleman
RF	Radio Frequency
RLC	Radio Link Control
RM	Registration Management
RMU	RLC Message Unit
RRC	Radio Resource Control or Root Raised Cosine
RSSI	Received Signal Strength Indicator
SDMA	Space Division Multiple Access
SDU	Service Data Unit
SINR	Signal-to-Interference plus Noise Ratio
SN	Slot Number
SNR	Signal to Noise Ratio
TCH	Traffic Channel
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TWAN	Transport Wide Area Network
UM	Unacknowledged Mode
UT	User Terminal

5 Introduction

By this document, Kyocera team respectfully submits Technology Performance and Evaluation Report 1 for the proposed TDD technology tilted MBTDD 625k-MC (BEST-WINE) (**Broadband MobilE SpaTial Wireless InterNet AccEss**), which is an enhanced air interface based on "**ATIS-PP-0700004-2005, High Capacity-Spatial Division Multiple Access (HC-SDMA), (Pre Published American National Standard)**"[1].

This *Evaluation Report 1* report presents both the link and system level Technology Performance results obtained from simulations by following the methodologies specified in the *Evaluation Criteria Document* [5] while using Suburban Macro Channel model and related spatial parameters as defined in *Channel Model* document [4]. Both the link level and system level performances are obtained at the User Terminal (UT) mobility speeds of 3kmph and 120kmph. Also this report provides link budget calculation for each of the channel models.

5.1 Purpose of This Report

This Evaluation Report 1 serves as the basis for comparing with other technology proposals.

5.2 Key Technologies

Key technologies of the MBTDD 625k-MC (BEST-WINE) system are

- Adaptive Antenna Array Processing
- Spatial Division Multiple Access
- Link Adaptation with Modulation and Coding

5.3 System Model

5.3.1 Cell layout: 19BS / 3sector

The system layout consists of 19 cells with each cell split into 3 sectors as shown in Figure 5-1. Inter BS separation is 1.73 km and the cell radius is 1km.

Each cell is divided into 3 sectors, characterized by the antenna direction of each sector. The sectors are numbered counter-clock wise as 0, 1 and 2, respectively, where the respective antenna direction is 0: $\theta=0°$, 1: $\theta=120°$, 3: $\theta=240°$; θ is the local polar angle of the cell. Following this convention, the first sector of the center cell is indexed (0, 0), while the last sector is indexed (18,2). Mobiles are uniformly dropped in each sector excluding an area of radius 35 meters around the cell center. The unit of distance is meter. Each sector in each base station employs antennas that has radiation pattern as shown in Figure 5-2 .

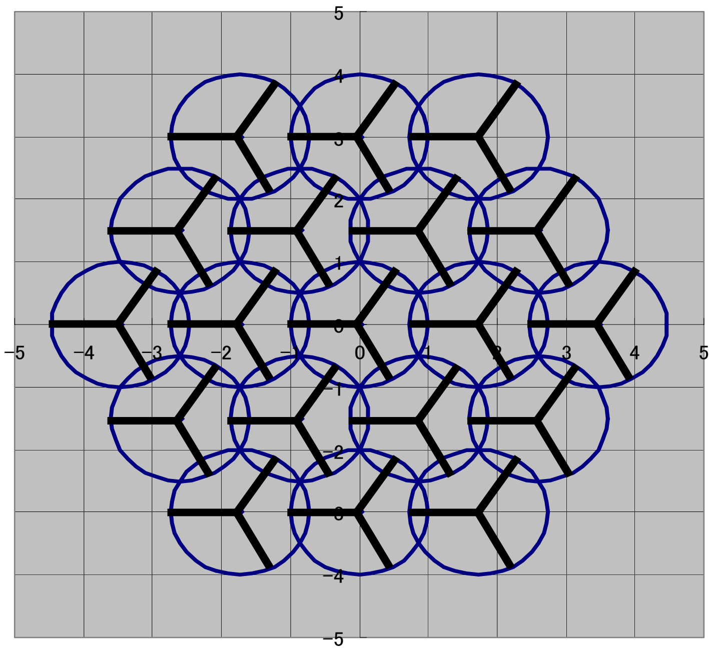

Figure 5-1 Cell definition in the Cartesian coordination system and the numbering of cells

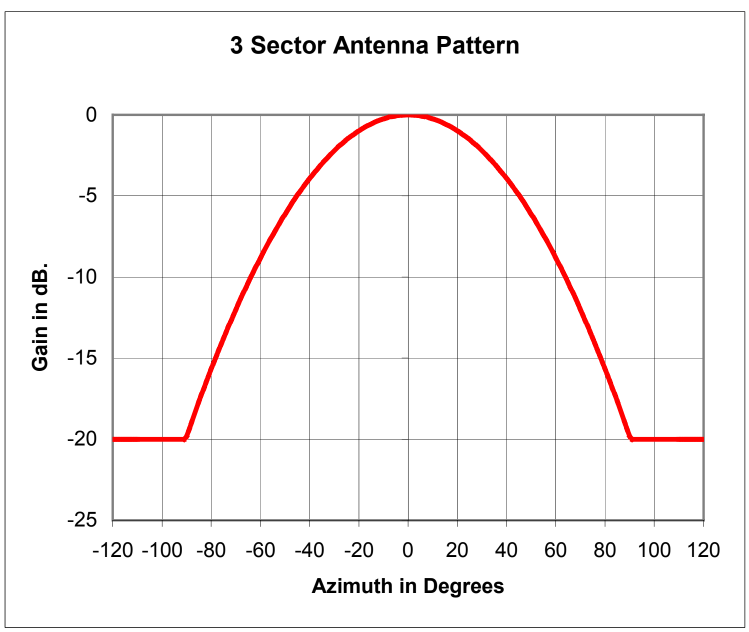

Figure 5-2 Base station antenna pattern

5.3.2 Base Station & Mobile Station (User Terminals)

The BS and UT parameters are shown in Table 5-1.

Table 5-1 BS and UT parameters

BS	Cell radius	1Km
	BS separation	1.73Km
	Tx/rx antenna elements	12
	Antenna separation	0.5λ
UT	Load users	86
	Distribution	Uniform in the 19BS area
	Rx. antenna	4
	Tx. antenna	1
	Antenna separation	0.5λ
	Sates	Connected state Not connected state

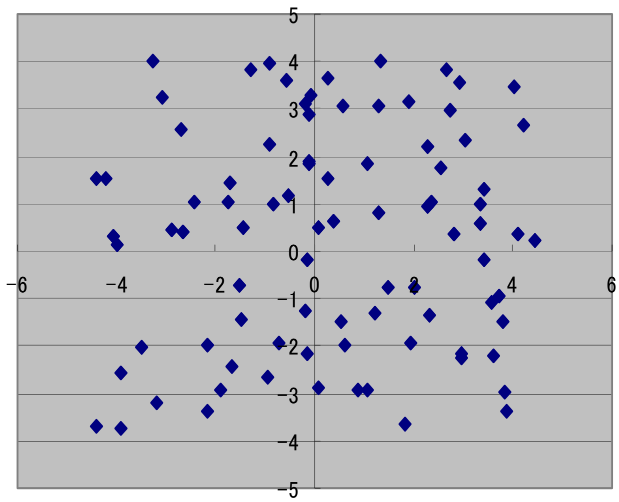

Figure 5-3 UT positions

5.4 RF parameters

5.4.1 RF Parameters

The RF parameters are shown in Table 5-2.

Table 5-2 RF parameter table

#	RF Parameter (TDD System)	Base Value 1 MHz Channel	2.5 MHz (TDD System)
1	Transmitter Power -- BS	43 dBm/MHz	+44 dBm
2	Transmitter Power -- MS	27 dBm	+27 dBm
3	Out of Band emission limits – BS and MS (emission measured in 1 MHz resolution bandwidth)	Attenuation of the transmit power P by: 43 +10 log(P) dB	-13 dBm

#	RF Parameter (TDD System)	Base Value 1 MHz Channel	2.5 MHz (TDD System)
4	ACLR - Attenuation of emissions into an adjacent channel (same Ch BW) – BS	43 dB	50.2 dB
5	ACLR - Attenuation of emissions into an adjacent channel (same Ch BW) – MS	36.8 dB	35.4 dB
6	Receiver noise figure -- BS	5 dB	5 dB
7	Receiver noise figure -- MS	10 dB	10 dB
8	Receiver reference sensitivity (to be proposed by each technology)	Specify at BER of 0.1%	See link budget
9	Receiver Selectivity -- BS	Mod 0 to 10 : 30 dB	30 dB
10	Receiver Selectivity -- MS	Mod 0 to 6 : 30 dB Mod 7 to 8 : 27 dB Mod 9 to 10 : 25 dB	30 dB 27 dB 25 dB
11	Receiver Blocking – BS (level of same technology blocking signal at frequency offset of 2 times Channel BW)	Mod 0 : -50.8 dBm Mod 7 : -36.8 dBm Mod 10 : -31.4 dBm	-50.8 dBm -36.8 dBm -31.4 dBm
12	Receiver Blocking – MS (level of same technology blocking signal at frequency offset of 2 times Channel BW)	Mod 0 : -58.5 dBm Mod 8 : - 42.6 dBm Mod 10 : - 39.1 dBm	-58.5dBm -42.6dBm -39.1dBm

5.4.2 Out-of-band emission

The spectral shape of the transmitted modulated carrier are shown in Figure 5-4 and Figure 5-5 for single carrier and multiple carriers, respectively. It can be observed that the out-of-band emission limit specified by the FCC is satisfied.

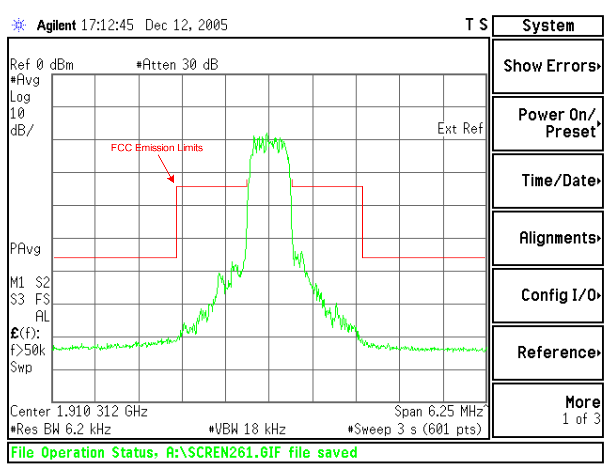

Figure 5-4a User Terminal mod 0

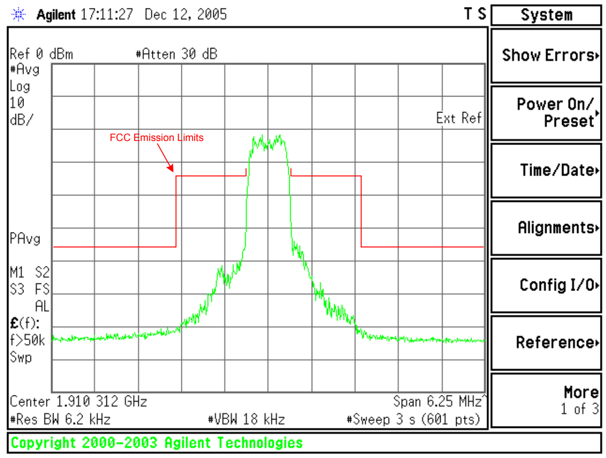

Figure 5-4b User Terminal mod 7

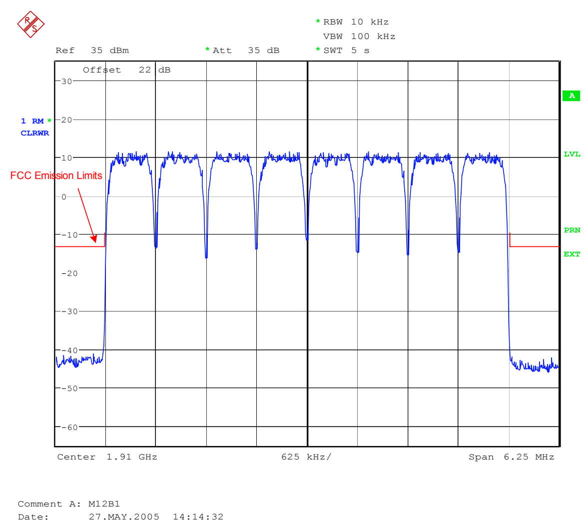

Figure 5-5 Base Station 8 carriers

5.5 MBTDD 625k-MC (BEST-WINE) System's PHY and MAC Layer information

5.5.1 MBTDD 625k-MC (BEST-WINE) System Basic PHY/MAC layer parameters Channel structure

The basic PHY/MAC layer parameters are shown in Table 5-3.

Table 5-3 MBTDD 625k-MC (BEST-WINE) PHY/MAC Basic Parameters

Items		Specification
Duplexing		TDD
Mutiple Access		TDMA・SDMA
Single Carrier Bandwidth		625 kHz
Frame Length		5 ms
Symbol Duration		2usec
Uplink Time Slot	Slots	3
	Length	545 us

	Payload	182 symbols
Downlink Time Slot	Slots	3
	Length	1090 us
	Payload	494 symbols
Symbol rate		500 ksps

For MBTDD 625k-MC (BEST-WINE) TDD system, block assignment size of 2.5MHz has been assumed. So, this block assignment accommodates 4 carriers of 625kHz bandwidth as shown in Figure 5-6.

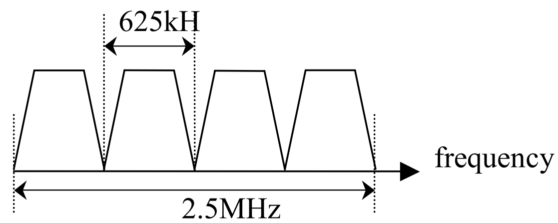

Figure 5-6 Channel configuration in a block assignment of 2.5 MHz

MBTDD 625k-MC (BEST-WINE) System employs Adaptive Antenna Array processing using MMSE algorithm. Antenna array weights are calculated for the uplink transmissions and the same weights are used for Downlink transmissions that follow.

5.5.2 MBTDD 625k-MC (BEST-WINE) Modulation classes

MBTDD 625k-MC (BEST-WINE) system supports 10 modulation classes, referred as ModClass, which defines the modulation and coding scheme combination. There are 10 ModClasses as mentioned in the Table 5-4. The tiered multilevel modulation schemes facilitate link adaptation. 8 different modulation schemes are incorporated, namely: BPSK, QPSK, 8-PSK, 12QAM, 16QAM, 24QAM, 32QAM and 64QAM. The data rates per carrier associated with these ModClasses are shown in the Table 5-4.

Table 5-4 Modulation Classes and Data Rates

ModClass	Modulation Method	Down Link(Kbps)		Up Link(Kbps)	
		Data Rate /Slot	Data Rate /Carrier	Data Rate /Slot	Data Rate /Carrier
0	BPSK	35	106	6	19
1	BPSK	50	149	13	38
2	QPSK	82	245	26	77
3	QPSK	126	379	43	130
4	8PSK	162	485	58	173
5	8PSK	198	595	72	216
6	12QAM	262	787	98	293
7	16QAM	307	922	115	346
8	24QAM	354	1061	133	398
9	32QAM	378	1133	142	427
10	64QAM	498	1493	190	571

The data rate with 4 carrier aggregation is as follows:

Down Link : 1493kbps x 4 Carrier aggregation = 5.97 Mbps

Up Link : 571kbps x 4 Carrier aggregation = 2.28 Mbps

5.6 Link Budget

Suburban macro-cell environment with Pedestrian B (3Kmph) and Vehicular B (120Kmph) channel models are considered as mandated by [5]. The test environment parameters for the two channel models are shown in Table 5-5 and Table 5-6 respectively.

5.6.1 Suburban Macro Test Environment – Pedestrian B (3KMPH)

Table 5-5 Link Budget (3km/h)

id/ii	Item	Downlink	Uplink
	Test environment	Suburban macro-cell	Suburban macro-cell
	Operating frequency	1.9GHz	1.9GHz
	Test service	full buffer	full buffer
	Multipath channel class	CaseIII Pedestrian B)	CaseIII Pedestrian B)
ii/id	(a0) Average transmitter power per traffic channel	1slot :32.3 dBm 2slot: 35.3 dBm 3slot: 37.0 dBm	1slot: 17.1 dBm 2slot: 20.1 dBm 3slot: 21.9 dBm
id	(a1) Maximum transmitter power per traffic channel dBm	39	27
id	(a2) Maximum total transmitter power dBm/MHz	43	27
ii	(b) Cable, connector, and combiner losses (enumerate sources) [dB]	3	0
	Body Losses [dB]	0	3
ii	(c) Transmitter antenna gain [dBi]	17	0
id	(d1) Transmitter e.i.r.p. per traffic channel [dBm] =a1-b+c	53	27
id	(d2) Total transmitter e.i.r.p. =a2-b+c	57	27
	Penetration Loss (Ref: 3GPP2) 10 dB (Vehicular)	0	0
ii	(e) Receiver antenna gain [dBi]	0	17
ii	(f) Cable and connector losses [dB]	0	3
	Body Losses [dB]	3	0
ii	(g) Receiver noise figure [dB]	10	5
ii	(h) Thermal noise density dBm/Hz (H) (linear units) mW/Hz	-174 3.98×10^{-18}	-174 3.98×10^{-18}
id	(i) Receiver interference density (NOTE 1) [dBm/Hz] (I) (linear units) [mW/Hz]	-140.83 8.25×10^{-15}	-159.06 $1.24\times{}^{-16}$
id	(j) Total effective noise plus interference density [dBm/Hz] = 10 log (10((g + h)/10) + I)	-140.81	-158.64
I	(k) Information rate (10 log (Rb)) [dB(Hz)] @mod0	53.98	53.98
Id	(l) Required Eb/(N0 + I0) @mod0	1.81	4.01
Id	CNR@BER0.1%point @mod0	-1.2	1.0
Id	(m) Receiver sensitivity = (j + k + l) @mod0	-85.03	-100.06
id	(n) Hand-off gain[dB]	2	2
Id	(o) Explicit diversity gain [dB]	6	0
Id	(o') Other gain [dB]	21.6	10.8
Id	(p) Log-normal fade margin [dB]	10.4	10.4
Id	(q) Maximum path loss = {d1–m+(e–f)+o+n+o'–p} [dB] @mod0	154.23	144.06
id	(r) Maximum range @mod0	3209.51	1643.95

5.6.2 Suburban Macro Test Environment Vehicular B (120 KMPH)

Table 5-6 Link Budget (120km/h)

id/ii	Item	Downlink	Uplink
	Test environment	Suburban macro-cell	Suburban macro-cell
	Operating frequency	1.9GHz	1.9GHz
	Test service	full buffer	full buffer
	Multipath channel class	CaseIV Vehicular B	Case IV Vehicular B
ii/id	(a0) Average transmitter power per traffic channel	1slot: 32.3dBm 2slot: 35.3 dBm 3slot: 37.0dBm	1slot: 17.1 dBm 2slot: 20.1 dBm 3slot: 21.9dBm
id	(a1) Maximum transmitter power per traffic channel dBm	39.0	27
id	(a2) Maximum total transmitter power dBm/MHz	43	27
ii	(b) Cable, connector, and combiner losses (enumerate sources) [dB]	3	0
	Body Losses [dB]	0	3
ii	(c) Transmitter antenna gain [dBi]	17	0
id	(d1)Transmitter e.i.r.p. per traffic channel [dBm]=a1-b+c	53	27
id	(d2) Total transmitter e.i.r.p =a2-b+c	57	27
	Penetration Loss (Ref: 3GPP2) 10 dB (Vehicular)	10	10
ii	(e) Receiver antenna gain [dBi]	0	17
ii	(f) Cable and connector losses [dB]	0	3
	Body Losses [dB]	3	0
ii	(g) Receiver noise figure [dB]	10	5
ii	(h) Thermal noise density dBm/Hz (H) (linear units) mW/Hz	-174 3.98×10^{-18}	-174 3.98×10^{-18}
id	(i) Receiver interference density (NOTE 1) [dBm/Hz] (I) (linear units) [mW/Hz]	-141.97 6.35×10^{-15}	-165.31 2.94×10^{-17}
id	(j) Total effective noise plus interference density [dBm/Hz] = 10 log (10((g + h)/10) + I)	-141.94	-163.76
ii	(k) Information rate (10 log (Rb)) [dB(Hz)] @mod0	53.98	53.98
id	(l) Required Eb/(N0 + I0) @mod0	6.21	5.01
Id	CNR@BER0.1%point @mod0	3.2	2.0
Id	(m) Receiver sensitivity = (j + k + l) @mod0	-81.75	-104.78
id	(n) Hand-off gain[dB]	2	2
Id	(o) Explicit diversity gain [dB]	3.7	0
Id	(o') Other gain [dB]	18.7	10.8
Id	(p) Log-normal fade margin [dB]	10.4	10.4
Id	q)Maximumpathloss {d1–m+(e–f)+o+n+o'–p}dB@mod0	135.75	138.18
id	(r) Maximum range @mod0	952.07	1116.78

6 Simulation environment

6.1 Link – System Interface

The simulations were divided into two steps, link level simulation and system level simulation. The SINR versus FER characteristic were obtained by the link level simulation for all the modulation classes. Based on this link level simulation results, system (network) level simulations were carried out to obtain the performance of MBTDD 625k-MC (BEST-WINE) air interface in the defined suburban macro radio test environment.

6.2 Link level simulation

6.2.1 Link Level simulation Parameters

- TDD /TDMA system
- 3 timeslot structure
- Number of BS antenna: 12
- Number of UT antenna: 4
  - Antennas used for transmission: 1
  - Antennas used for receiving: 4 or 1
- Adaptive Array Antenna Algorithm: MMSE
- Equalizer: Receiver equalization is used.

6.2.2 Channel models used in Link Level Simulations

The channel models used are as specified in [4]. The channel model and the associated spatial parameters are summarized in Table 6-1. The subpath spatial parameters are shown in Table 6-2.

Table 6-1 Link level simulation channel models and associated spatial parameters

Models		case-iii		case-iv	
PDP		Pedestrian-B (Phase I)		Vehicular-B (Phase I)	
Number of Paths		6		6	
Relative Path power (dB)	Delay (ns)	0	0	-2.5	0
		-0.9	200	0	300
		-4.9	800	-12.8	8900
		-8.0	1200	-10.0	12900
		-7.8	2300	-25.2	17100
		-23.9	3700	-16.0	20000
Speed (km/h)		3		120	
Mobile Station	Topology	0.5λ		0.5λ	
	PAS	RMS angle spread of 35 degrees per path with a Laplacian distribution		RMS angle spread of 35 degrees per path with a Laplacian distribution	
	DoT (degrees)	-22.5		22.5	
	AoA (degrees)	67.5 (all paths)		67.5 (all paths)	
Base Station	Topology	0.5λ-spacing			
	PAS	Laplacian distribution with RMS angle spread of 2 degrees per path depending on AoA/AoD			
	AoD/AoA (degrees)	50° for 2° RMS angle spread per path 20° for 5° RMS angle spread per path			

Table 6-2 Sub-path spatial parameters AoD and AoA offset

Sub-path # (*m*)	Offset for a 2 deg AS at BS (Macrocell) $\Delta_{n,m,AoD}$ (degrees)	Offset for a 35 deg AS at MS $\Delta_{n,m,AoA}$ (degrees)
1, 2	± 0.0894	± 1.5649
3, 4	± 0.2826	± 4.9447
5, 6	± 0.4984	± 8.7224
7, 8	± 0.7431	± 13.0045
9, 10	± 1.0257	± 17.9492
11, 12	± 1.3594	± 23.7899
13, 14	± 1.7688	± 30.9538
15, 16	± 2.2961	± 40.1824
17, 18	± 3.0389	± 53.1816
19, 20	± 4.3101	± 75.4274

6.3 System level simulation environment

6.3.1 System level simulation features

- TDD system
- 3 timeslot structure
- Spatial Division multiple Access Channels (Max. 4)
- Power control
- Link adaptation

6.3.2 System level simulation parameters

Table 6-3 System level simulation parameters

BS antenna	Number of antennas	12
	Antenna separation	0.5 λ
UT antenna	Number of antennas	4
	Antenna separation	0.5 λ
Layout		19BS with 3sector each
max Tx power at BS		39dBm/12ant
max Tx power at UT		27dBm
BS antenna gain		17dBi
UT antenna gain		0dBi
BS NF		5dB
UT NF		10dB
Temperature		15°C
BS cable loss		3dB
UT body loss		3dB
Simulation bandwidth		2.5MHz (4 carriers) (1 carrier= 625kHz)

6.3.3 System level simulation channel mode

Table 6-4 Suburban Macro Environment Parameters

Channel Scenario	Suburban Macro
Number of paths (N)	6
Number of sub-paths (M) per-path	20
Mean AS at BS	E[σ_{AS}] =5^0
AS at BS as a lognormal RV $\sigma_{AS} = 10\,\hat{}\,(\varepsilon_{AS} x + \mu_{AS}),\ x \sim \eta(0,1)$	μ_{AS} = 0.69 ε_{AS} = 0.13
$r_{AS} = \sigma_{AoD} / \sigma_{AS}$	1.2
Per-path AS at BS (Fixed)	2^0
BS per-path AoD Distribution standard distribution	$\eta(0, \sigma^2_{AoD})$ where $\sigma_{AoD} = r_{AS}\sigma_{AS}$
Mean AS at MS	E[$\sigma_{AS,\ MS}$] = 68^0
Per-path AS at MS (fixed)	35^0
MS Per-path AoA Distribution	$\eta(0, \sigma^2_{AoA}(\Pr))$
Delay spread as a lognormal RV $\sigma_{DS} = 10\,\hat{}\,(\varepsilon_{DS} x + \mu_{DS}),\ x \sim \eta(0,1)$	μ_{DS}= - 6.80 ε_{DS}= 0.288
Mean total RMS Delay Spread	E[σ_{DS}] = 0.17 μs
$r_{DS} = \sigma_{delays} / \sigma_{DS}$	1.4
Distribution for path delays	
Lognormal shadowing standard deviation	10dB
Pathloss model (dB), d is in meters	$31.5 + 35\log_{10}(d)$

6.3.4 Traffic Model System Level Simulation

The simulation was carried out by full-duplex mode (UL-DL) in the same run and by assuming full buffers (infinite backlog) model. No ARQ is employed.

7 Simulation Results

7.1 Link level simulation

The following sections report the FER versus SINR performance and link level throughput curves for the 7 ModClasses in uplink and 8 ModClasses in downlink.

7.1.1 FER vs. SINR Performance

The FER vs. received SINR curves are plotted for the Pedestrian B and Vehicular B channels for both uplink and downlink. It can be observed that, as expected, the FER worsens for higher ModClass.

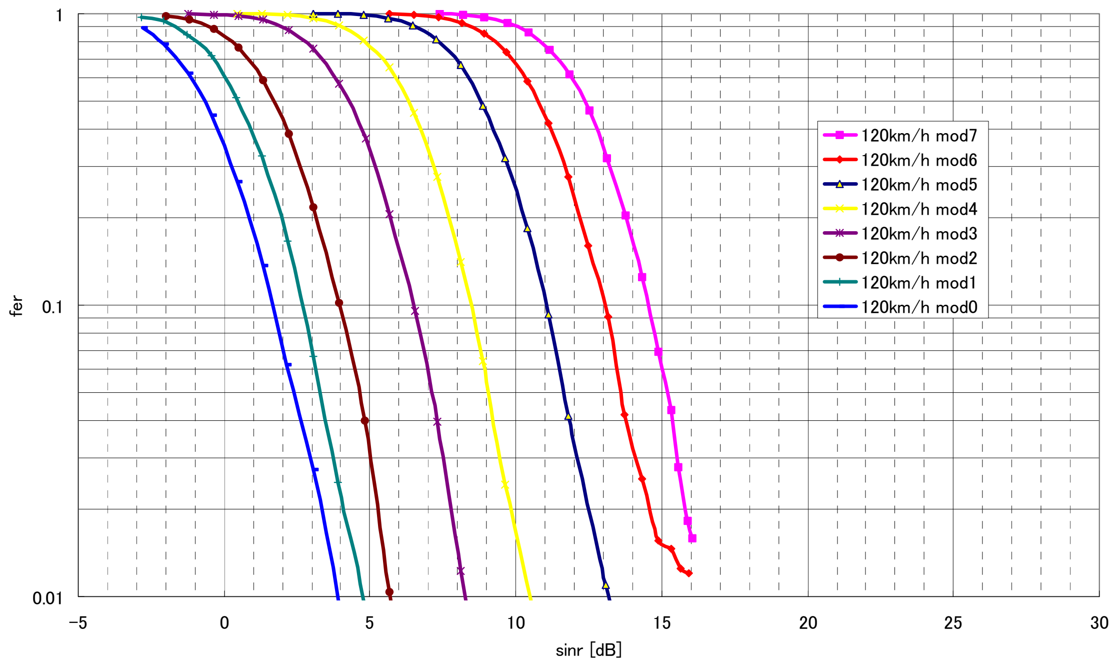

Figure 7-1 Uplink (Vehicular B model) 120kmph

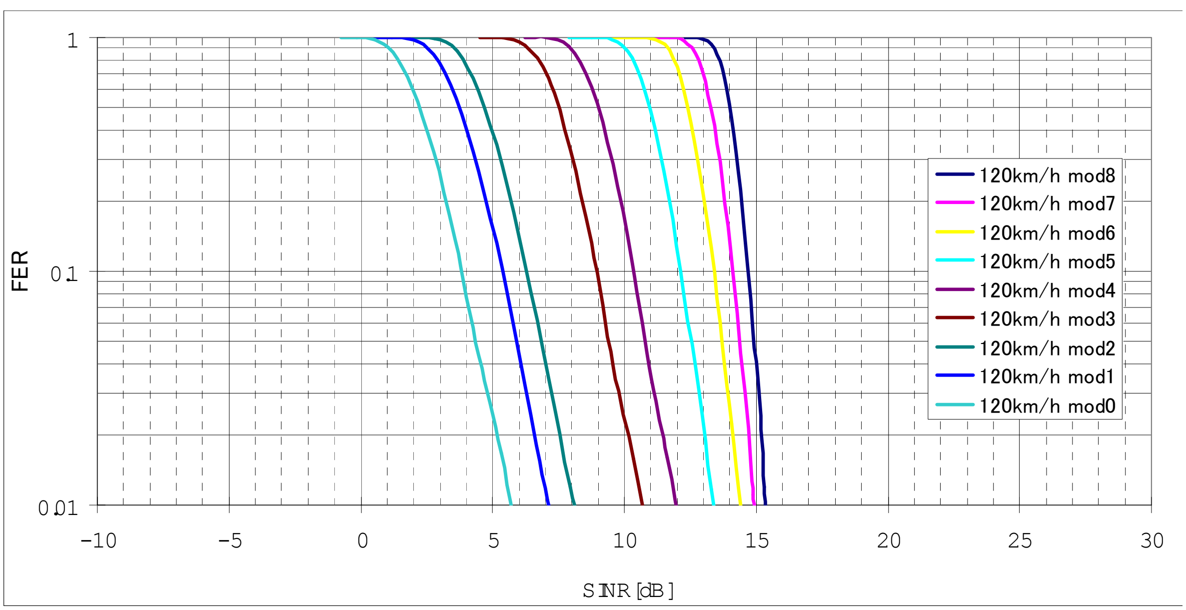

Figure 7-2 Downlink (Vehicular B model) 120kmph

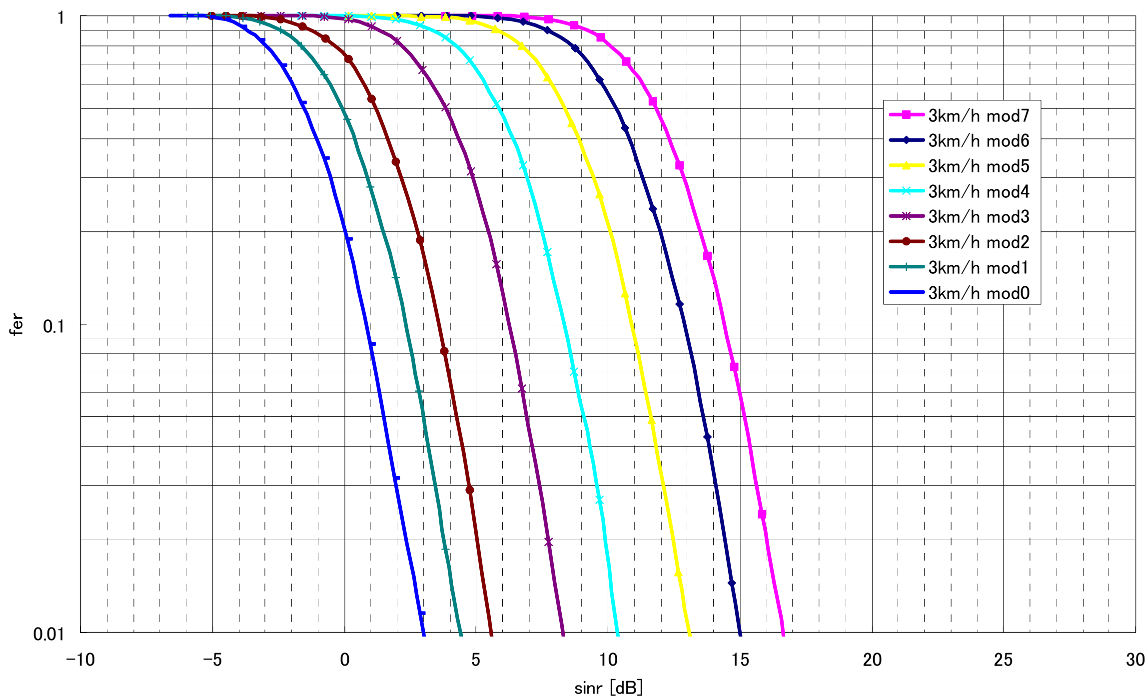

Figure 7-3 Uplink (Pedestrian B model) 3kmph

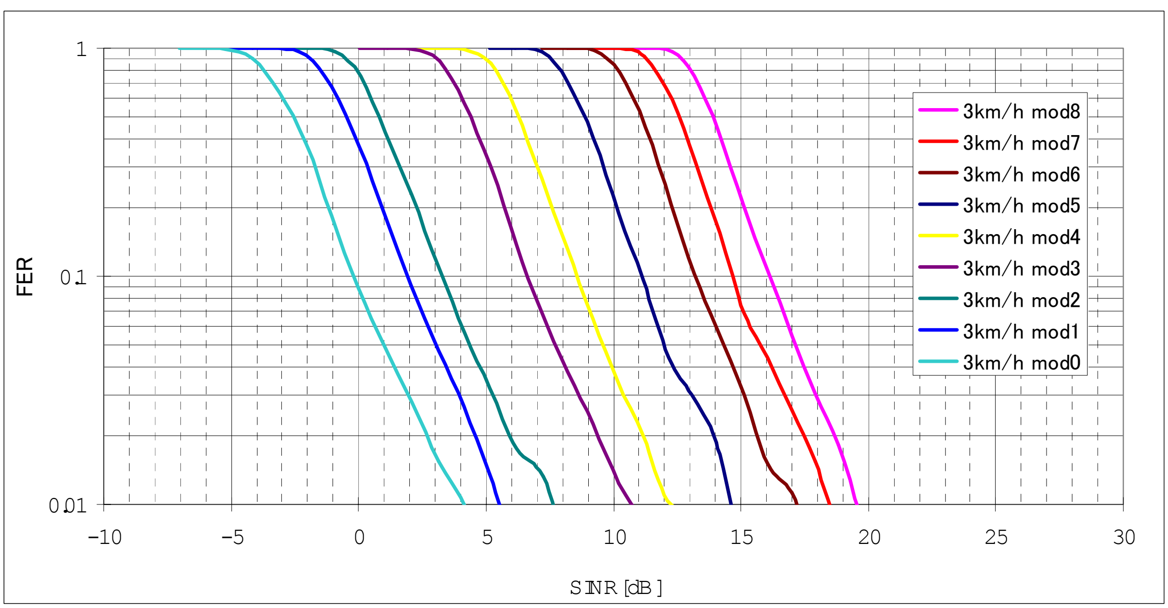

Figure 7-4 Downlink (Pedestrian B model) 3kmph

7.1.2 Throughput vs SINR Performance

The throughput vs. received SINR are plotted in Figure 7-5 to Figure 7-8.

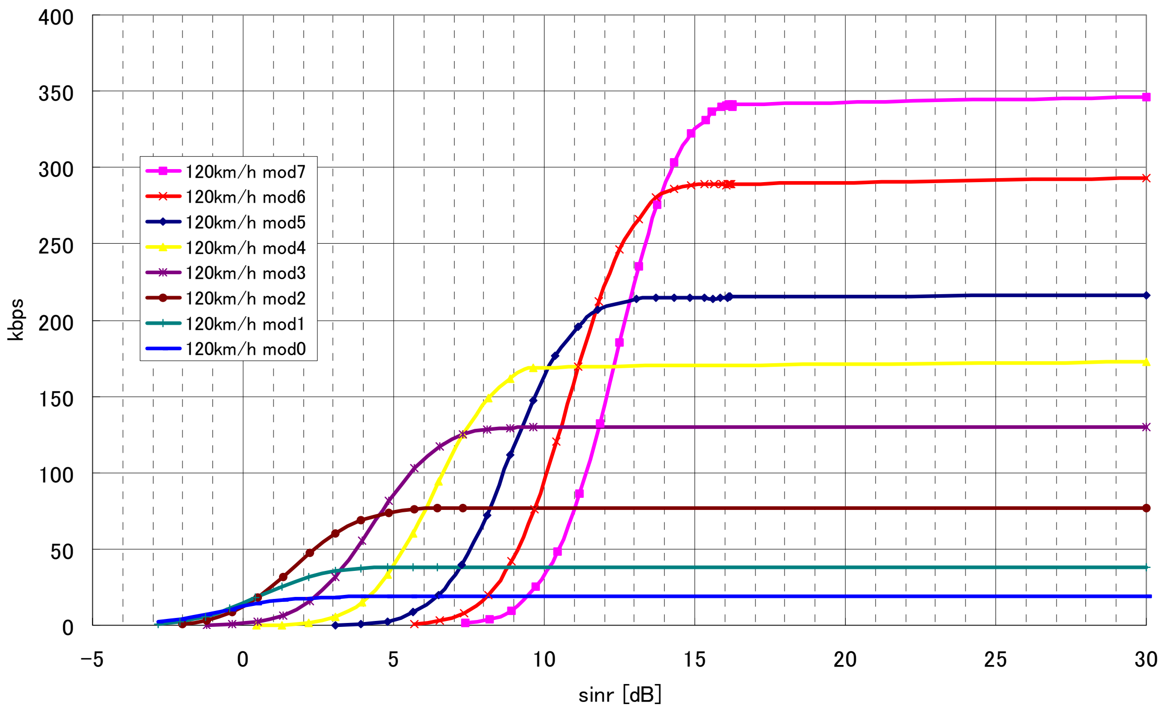

Figure 7-5 Uplink (Vehicular B model)120kmph

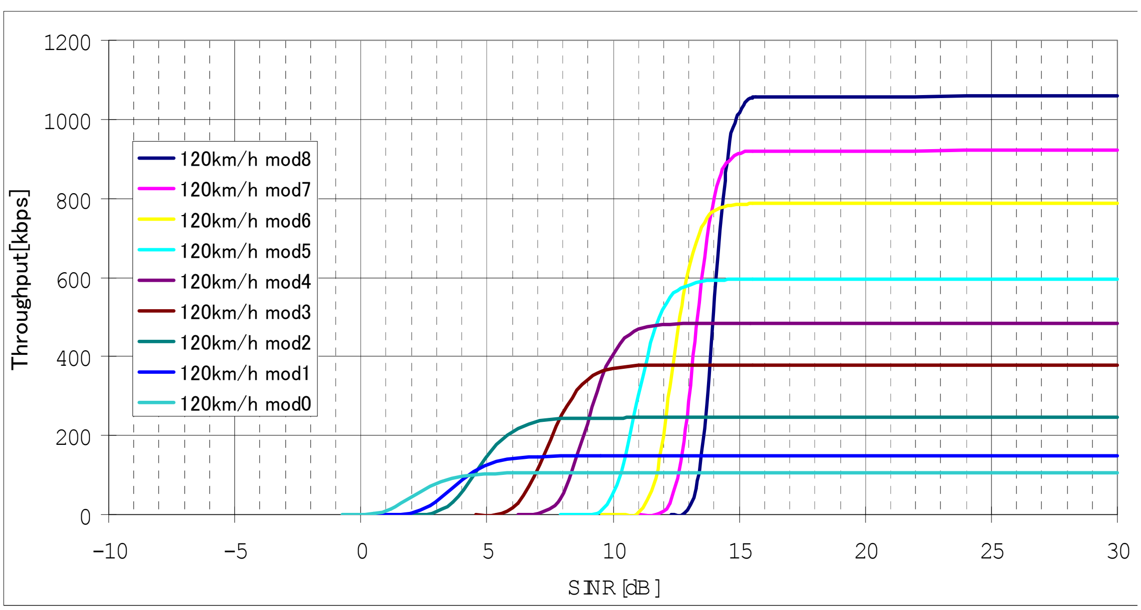

Figure 7-6 Downlink (Vehicular B model) 120kmph

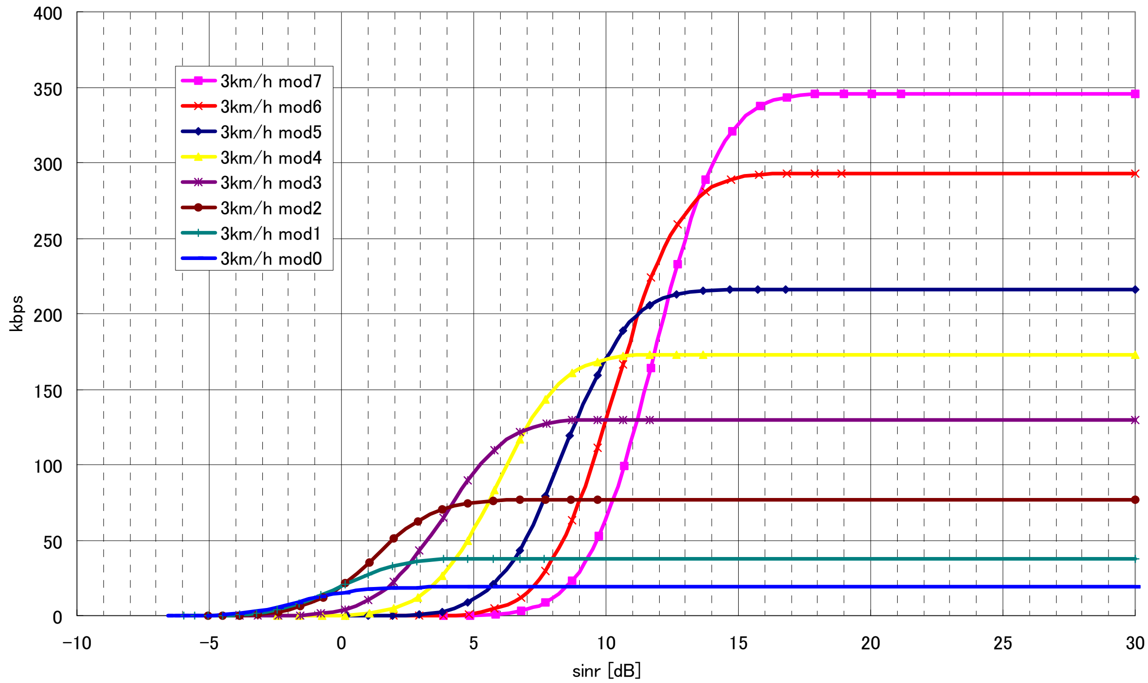

Figure 7-7 Uplink (Pedestrian B model) 3kmph

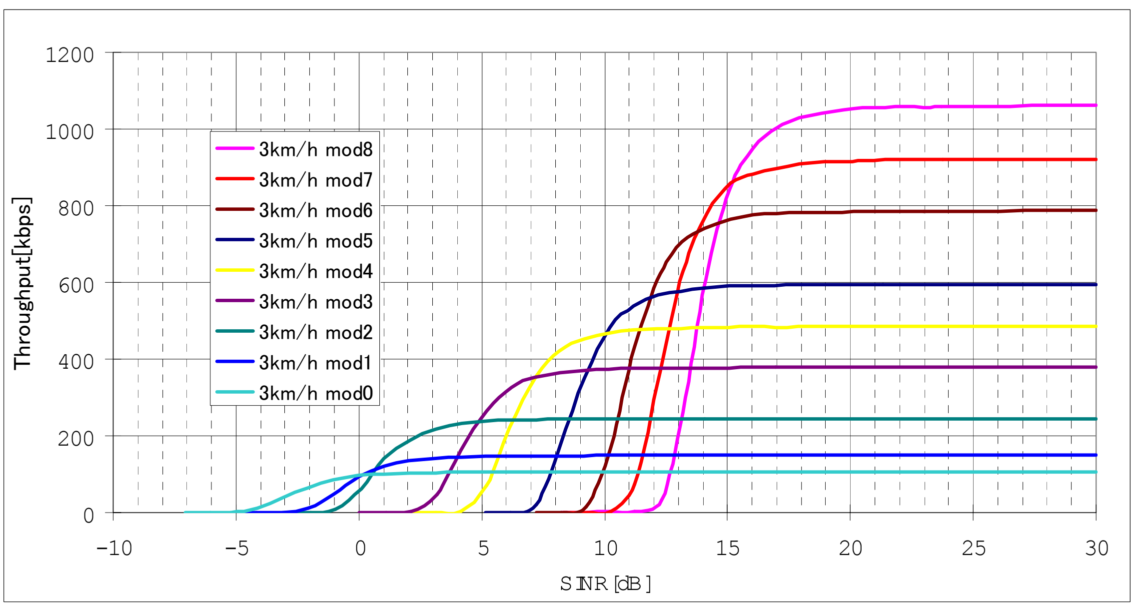

Figure 7-8 Downlink (Pedestrian B model) 3kmph

7.2 System level simulation calibration result

7.2.1 System level simulation calibration condition and parameters

- Number of paths: 1
- Environment: Suburban macro
- Number of BS & MS antenna: 1

- Inter BS separation 2.5km
- 1 user/timeslot @sector
  - user1 @ (-60, R/2) intimeslot1
  - user2 @ (0,R/2) in timeslot2
  - user3 @ (60, R) in timeslot3

System level simulation calibration results are presented below. The cdf of the C/I, when the users are located at fixed positions as shown in Figure 7-9

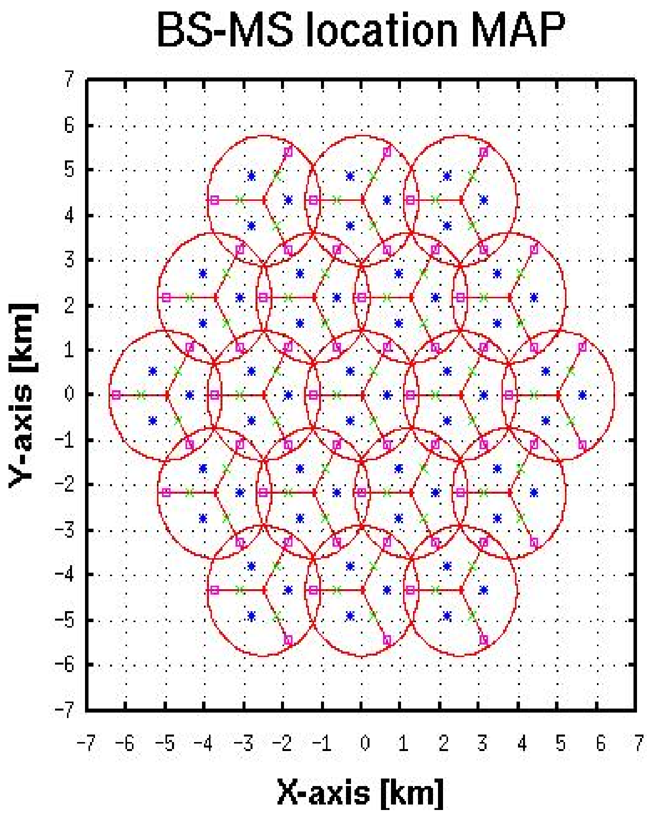

Figure 7-9 User Terminal Location Map for Deterministic calibration

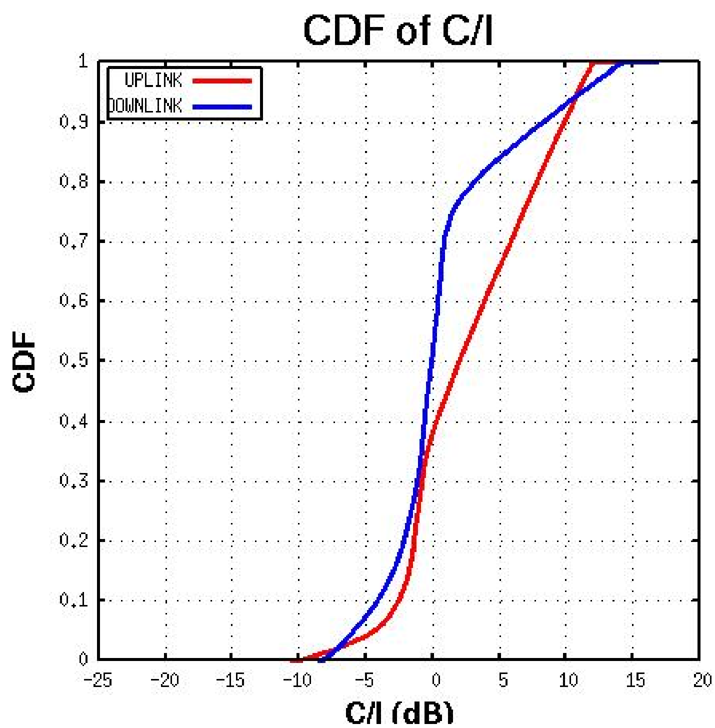

Figure 7-10 CDF for C/I with users at fixed locations

7.3 System Level Simulation Results

7.3.1 User Date Rate CDF

In this section we present system level simulation results as per the output metrics suggested by the *Evaluation Criteria* document [5]. In the following User Data rate CDFs are plotted.

7.3.2 120km/h User Date Rate CDF

The CDF of user data rate for uplink and downlink at 120 kmph is shown in Figure 7-11. The blue line plots downlink throughput CDF and red line plots uplink throughput CDF.

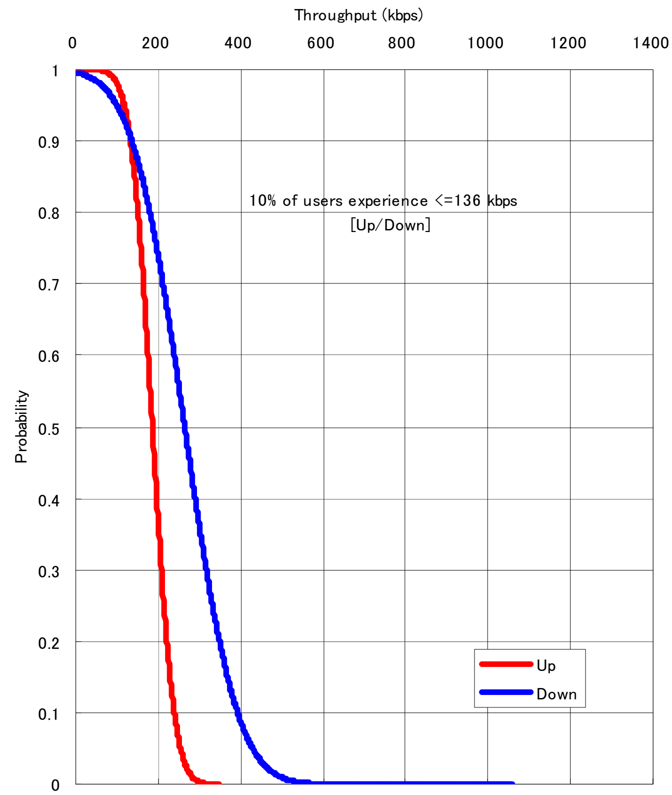

Figure 7-11 120kmph User Date Rate CDF

7.3.2.1 3km/h Uplink and Downlink

The CDF of user data rate for uplink and downlink at 3 kmph is shown in Figure 7-12. The blue line plots downlink throughput CDF and red line plots uplink throughput CDF.

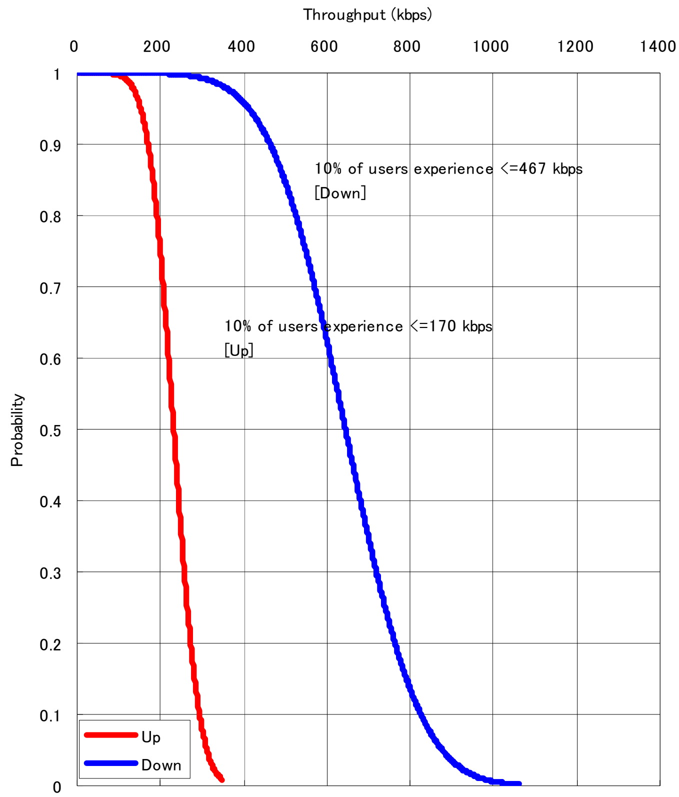

Figure 7-12 3km/h CDF of throughput vs SINR

7.3.3 Number of users vs Base station Separation

The minimum service level is computed from simulation, by changing inter BS separation and the number of load users.

In the measurement of minimum service level, the degradation due to the increase in the number of load users is larger compared with the degradation due to the increase in base station separation.

In the 120 km/h simulation [vehicular B], aggravation of frequency efficiency was seen compared with 3 km/h [Pedestrian B].

7.3.3.1 Downlink

Figure 7-13 and Figure 7-14 plot the contour of constant downlink minimum service levels for full buffer users per sector versus base station separation. 3 timeslot aggregations is assumed for each carrier in each cell.

7.3.3.1.1 3 Kmph

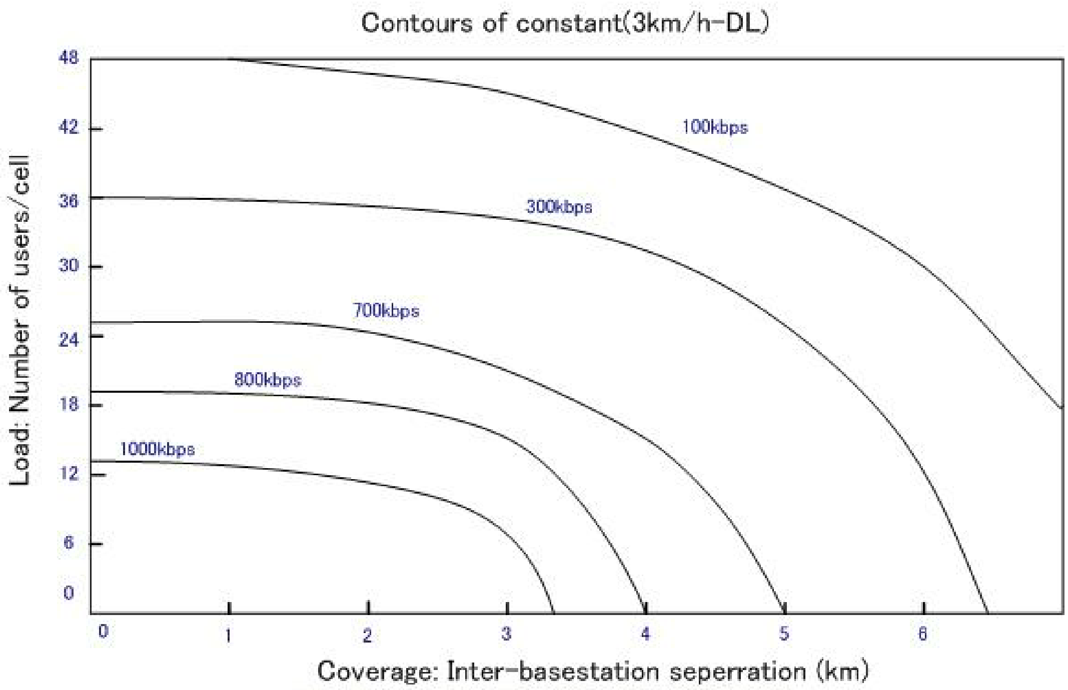

Figure 7-13 Contours of constant Minimum Service Level at 3Kmph -Downlink

7.3.3.1.2 120 Kmph

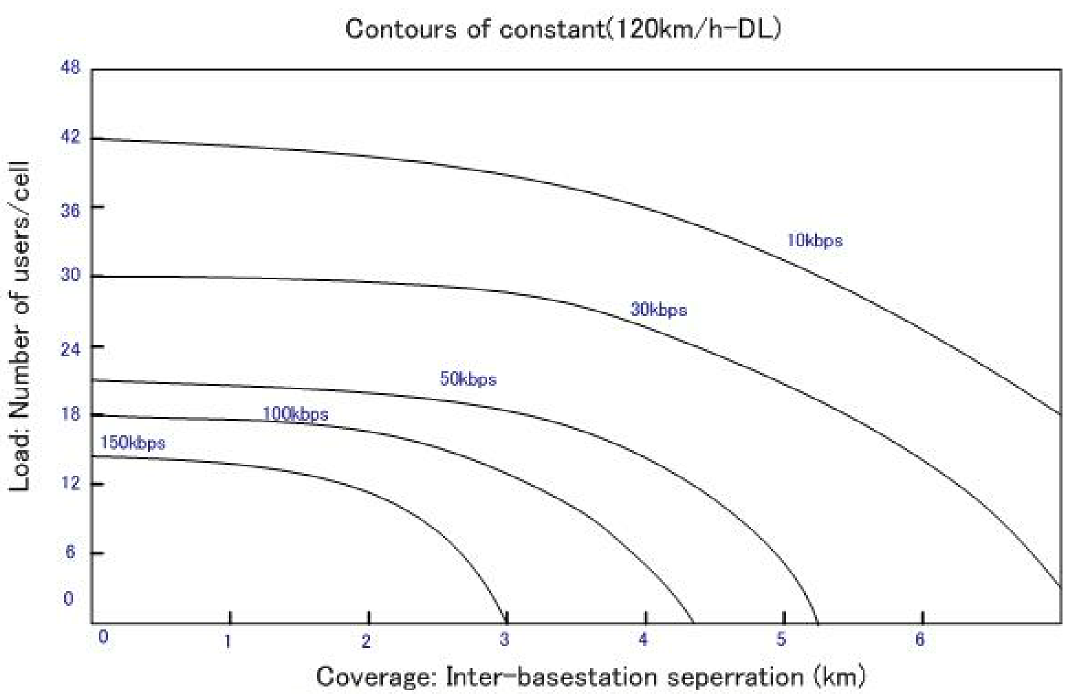

Figure 7-14 Contours of constant Minimum Service Level at 120Kmph - Downlink

7.3.3.2 Uplink

Figure 7-15 and Figure 7-16 plot the contour of constant uplink minimum service levels for full buffer users per sector versus base station separation. 3 timeslot aggregations is assumed for each carrier in each cell.

7.3.3.2.1 3 kmph

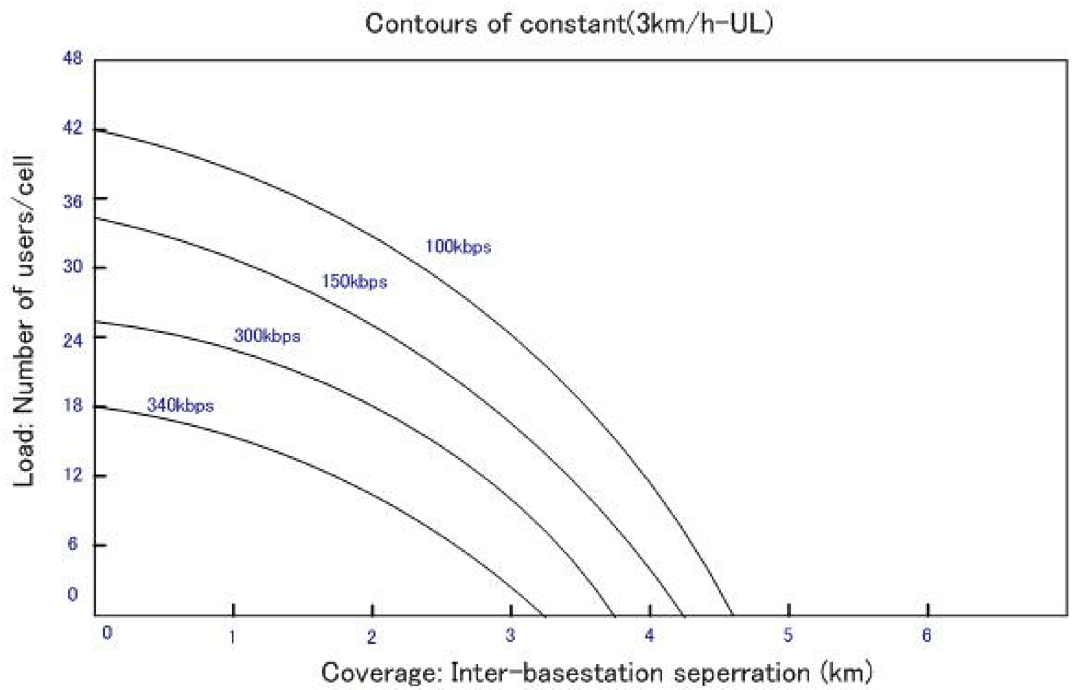

Figure 7-15 Contours of constant minimum service level at 3Kmph - Uplink

7.3.3.2.2 120 kmph

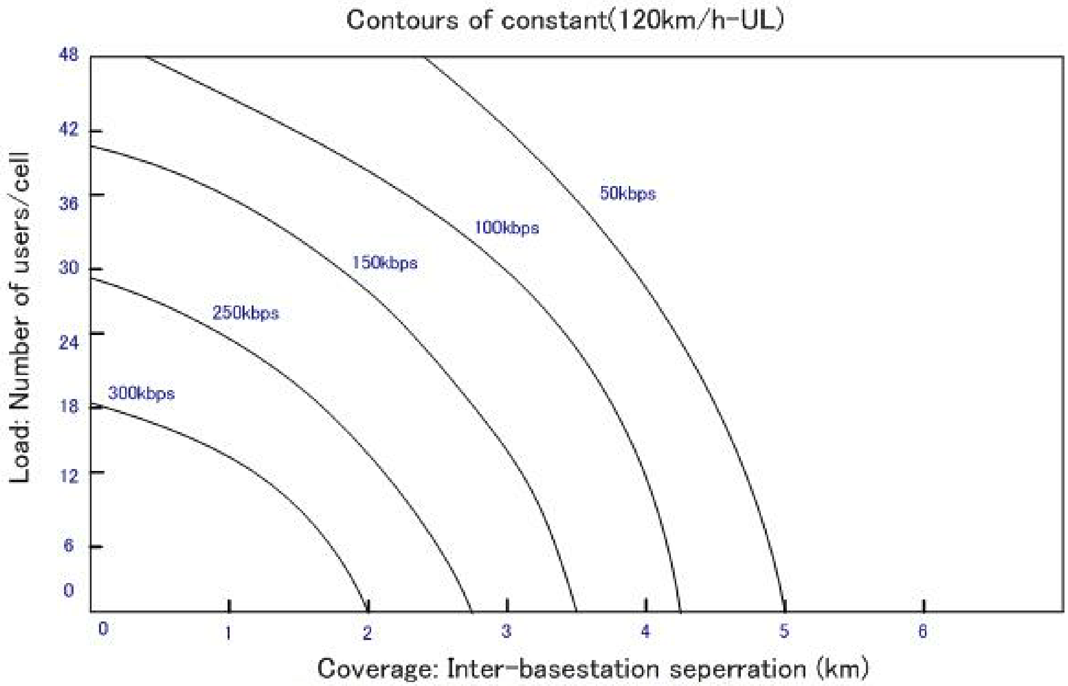

Figure 7-16 Contours of constant minimum service level at 120Kmph – Uplink

7.3.4 Aggregated Throughput vs. Base station Separation

7.3.4.1 DOWNLINK

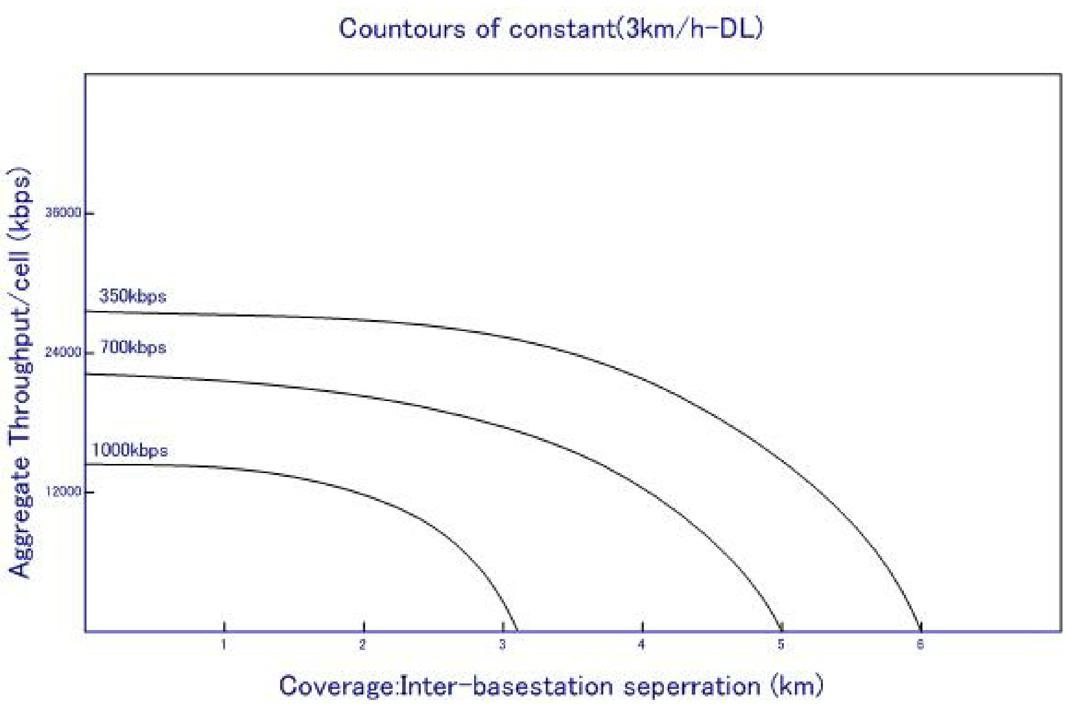

Figure 7-17 Contours of constant minimum service level at 3kmph –Downlink

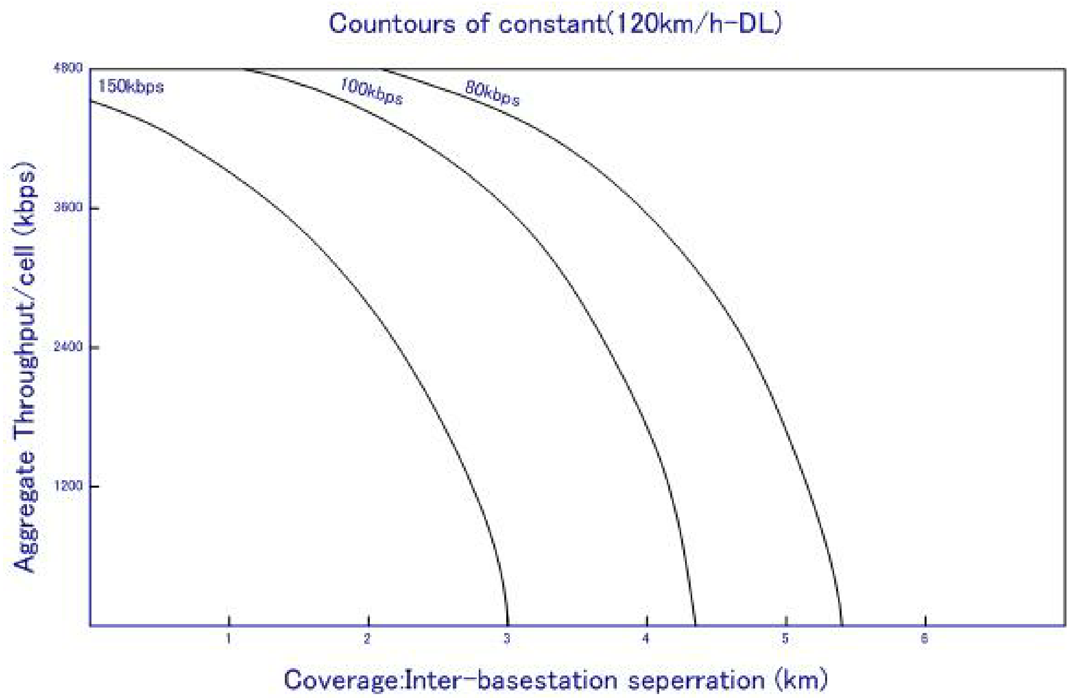

Figure 7-18 Contours of constant minimum service level at 120Kmph – Downlink

7.3.4.2 UPLINK

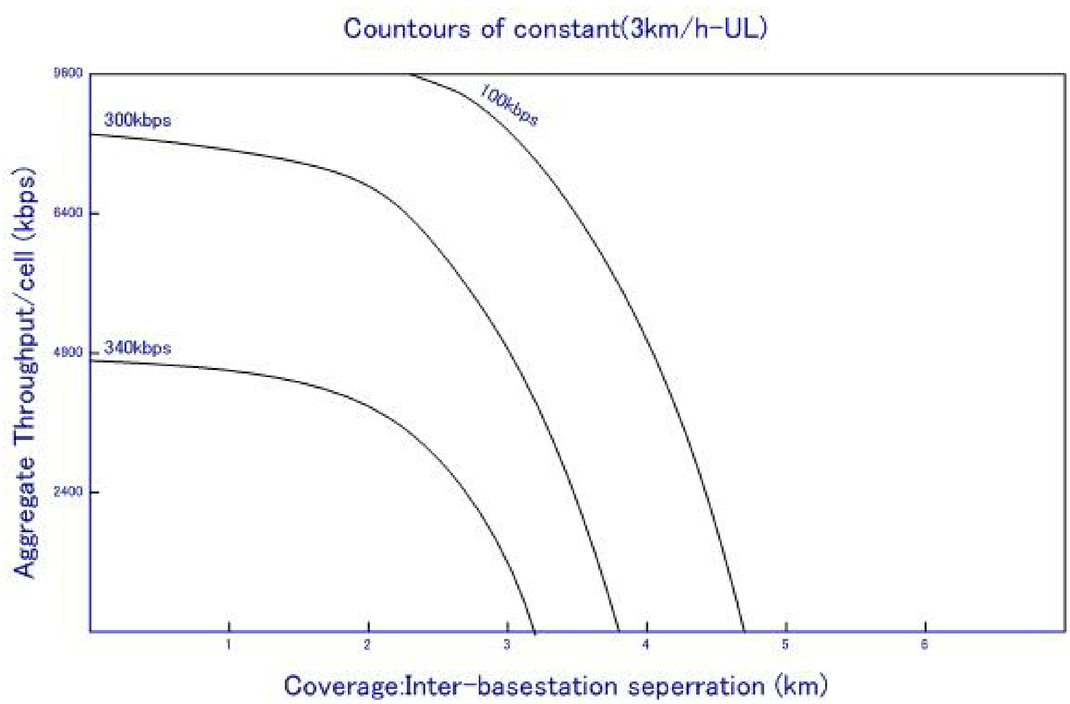

Figure 7-19 Contours of constant minimum service level at 3kmph –Uplink

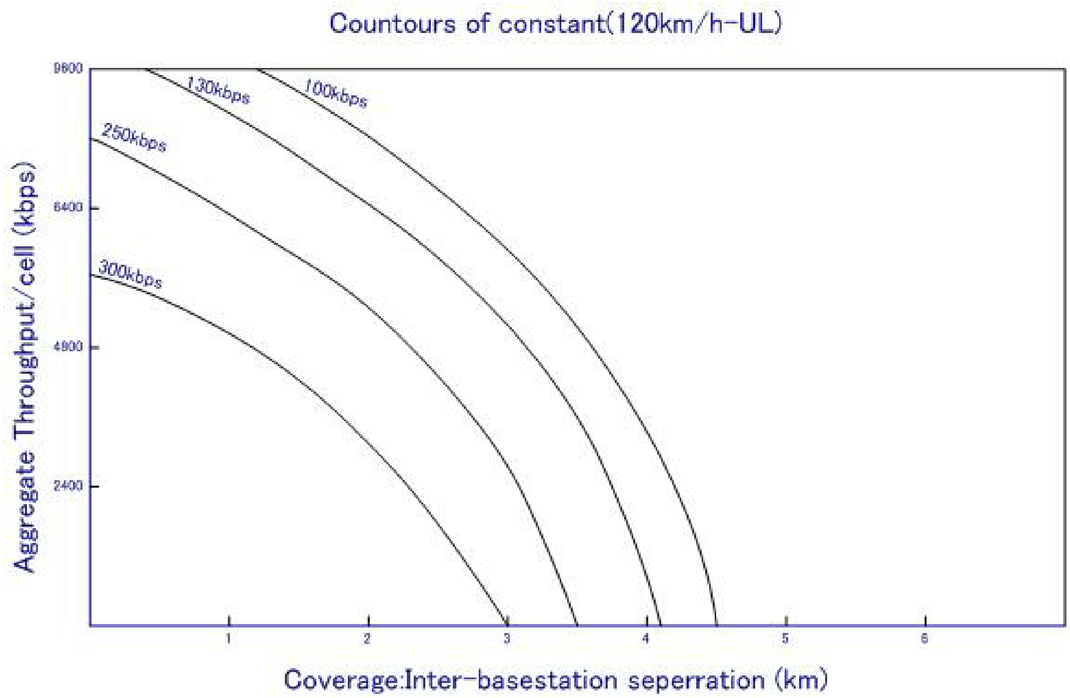

Figure 7-20 Contours of constant minimum service level at 120kmph -Uplink

7.4 Fairness criteria

The CDF of the normalized throughput with respect to average user throughput was determined for a cell radius of 1km.

Table 7-1 Suburban Pedestrian B Case

Normalized throughput with respect to average user throughput	Uplink	Downlink
<0.1	0.001%	0.002%
<0.2	0.006%	0.013%
<0.5	0.823%	1.128%

Table 7-2 Suburban Vehicular B Case

Normalized throughput with respect to average user throughput	Uplink	Downlink
<0.1	0.003%	0.887%
<0.2	0.017%	1.738%
<0.5	1.257%	9.310%

8 Simulations Results Summary

Downlink average spectral efficiency ＝

$$\frac{Downlink\ aggregate\ total\ throughput\ in\ 57\ \sec tors}{57\ \text{sectors} \times (3slot \times 1090\mu\sec / 5m\sec) \times 2.5MHz} \times \frac{11}{12}$$

Uplink average spectral efficiency $=$

$$\frac{Uplink\ aggregate\ total\ throughput\ in\ 57\ \sec tors}{57\ \text{sectors} \times (3slot \times 545\mu\sec / 5m\sec) \times 2.5MHz} \times \frac{11}{12}$$

*Downlink time slot duration: 1090 μ sec, Downlink time slot duration: 545 μ sec
*timeframe duration : 5msec

	Spectral Efficiency @pedestrian B	Spectral Efficiency @Vehicular B
Uplink	3.018	2.479
Downlink	4.063	1.699

9 Practical System Results

The proposed MBTDD 625k-MC (BEST-WINE)'s base system HC-SDMA [1] has been implemented and tested in some countries. The section illustrates the performance results using spatial channels delivering high spectrum efficiency in Australia.

HC-SDMA [1] implemented spatial channel testing on Nov 7th 2003 at North Sydney (North ride). Base station had 12 dipole antennas on a 25m high tower and user terminals were of PCMCIA type as shown in Figure 9-1. Total 5MHz bandwidth (625kHz x 8Carrier) was used for performance testing. The base station performs 8 carrier communications, including BCH, and 3 spatial channels simultaneously. User terminal needs to use 625kHz bandwidths for 1Mbps communication. Therefore, base station delivered the following data rates to a total of 24 (3 × 8) users simultaneously.

User terminal data rate without BCH : Uplink 1,061 kbps
Downlink 346 kbps
User terminal data rate with BCH : Uplink 707 kbps
Downlink 231 kbps

So, Aggregate data rate (1,061 kbps ＋ 346 kbps) × 7 Carrier × 3 Spatial
+ (707 kbps + 231 kbps) × 1 Carrier × 3 Spatial ≅ 32.4 Mbps.

HC-SDMA [1] system could deliver aggregate data rate ≅ 32.4 Mbps. The corresponding maximum spectrum efficiency that is achieved in 5MHz band is 32.4 Mbps / 5 MHz ≅ 6.5 bit/sec/Hz/cell.

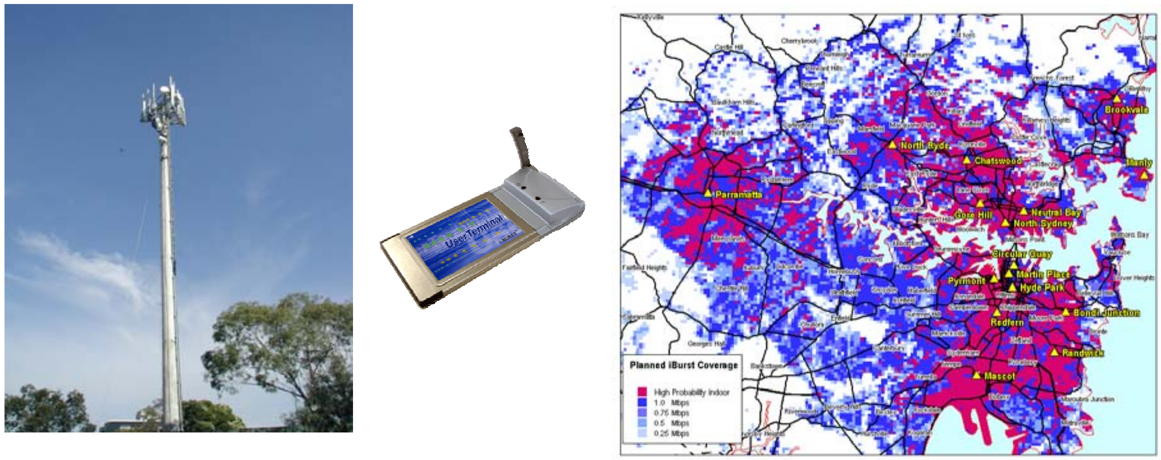

Figure 9-1 25m-high Tower, User terminal and Sydney MAP

The test result for 24 terminals communication achieved a total of 29.6Mbps. Figure 9-2 show throughput result for downlink performance. The logical maximum data rate is 32.4Mbps as already stated. From this result, spatial throughput efficiency is computed as 29.6Mbps / 32.4 Mbps ≅ 0.913 → 91.3%.

Furthermore, the test achieved spectrum efficiency is computed as 29.6 Mbps / 5 MHz ≅ 5.9 bit/sec/Hz/cell.

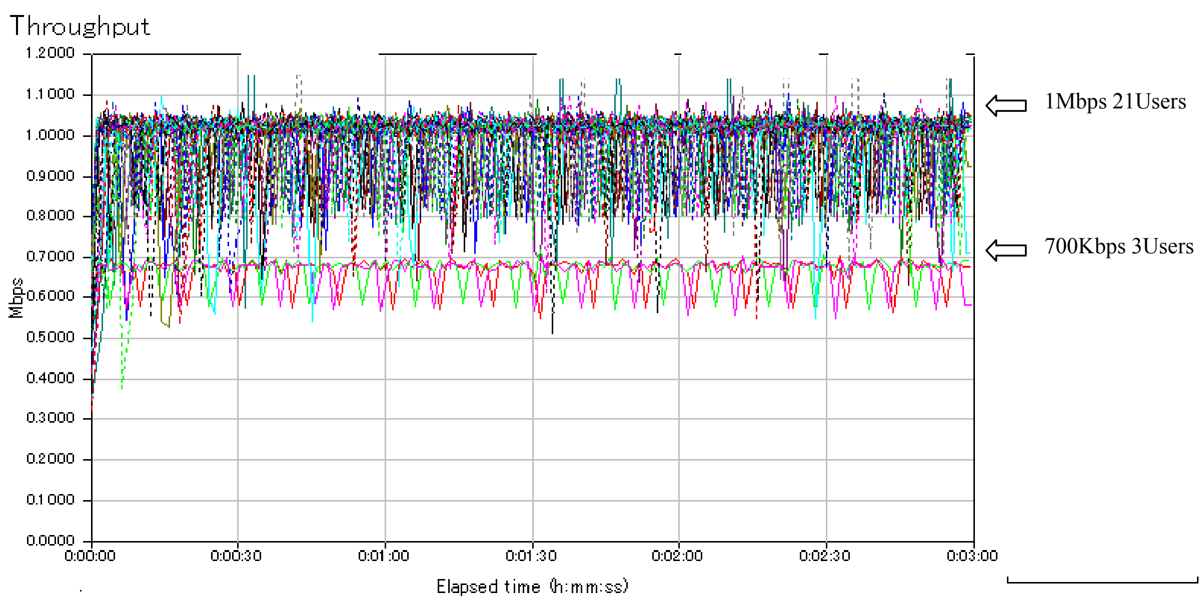

Figure 9-2: Downlink Date Rate Results

Table 9-1 Date rate and spectrum efficiency test results of HC-SDMA in Australia

Data Flow Direction	Typical/Terminal	Total Data Rates/Base station	Spectrum Efficiency (bit/sec/Hz/sector)

Downlink	**942kbps**	**22.6Mbps**	**6.8**
Uplink	**290kbps**	**7.0Mbps**	**4.2**
Total	**1,232kbps**	**29.6Mbps**	**5.9**