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 2**
Date Submitted	2006-JAN-13
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Re:	MBWA Call for Proposal
Abstract	This document presents the **Technology Performance and Evaluation Criteria Report 2** of the Technology Proposal **MBTDD 625k-MC*** (BEST-WINE) for IEEE 802. 20 MBWA
Purpose	To discuss and Adopt **MBTDD 625k-MC** for Draft Specifications of IEEE802.20 MBWA
Notice	
Release	
Patent Policy	

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

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MBTDD 625k-MC[*] (BEST-WINE) Performance Report 2

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

1 Executive Summary

This document **MBTDD 625kHz MC Mode Performance Report 2** 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.

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List of Tables

2 References

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

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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

[8] IEEE_802.20-06/04: MBFDD and MBTDD: Proposed Draft Air Interface Specification

[9] IEEE_802.20-05-77r1.doc: MBTDD 625k-MC Mode Revised Performance Report 1

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),**

This *Evaluation Report 2* report presents both the link level performance and system level Technology Performance results obtained from simulations by following the methodologies specified in the *Evaluation Criteria Document* [5] while using the channel models defined in *Channel Model* document [4].

5.1 Purpose of This Report

This Evaluation Report 2 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.

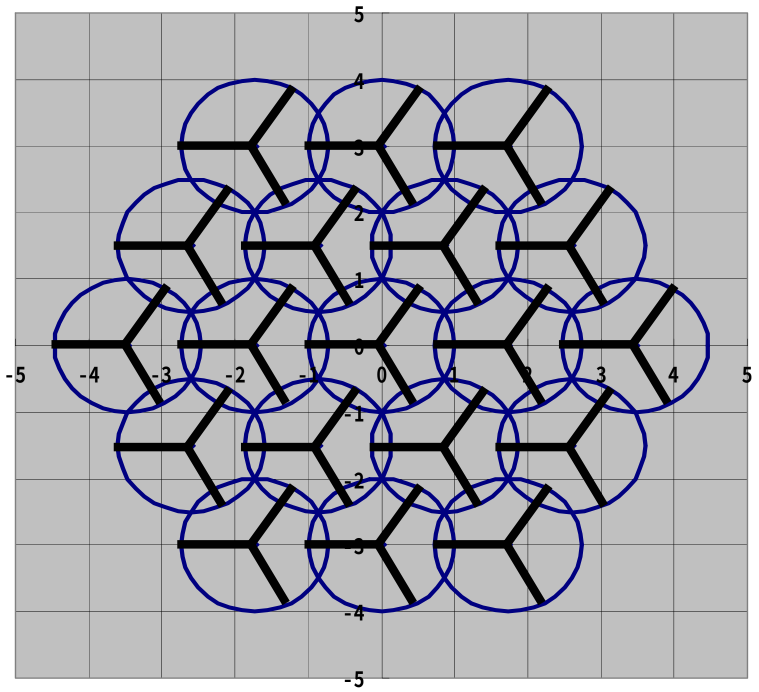

Figure 5-1 Cell definition in the Cartesian coordination system and the numbering of cells

5.3.2 Channel models

The channel models used are as specified in [4]. The channel model and the associated spatial parameters are summarized in Table 5.1. The subpath spatial parameters are shown in Table 5.2.

Table 5-1 Link level simulation channel models and associated spatial parameters

Models		case-i		case-ii		case-iii		case-Iv	
PDP		Pedestrian-A		Vehicular-A		Pedestrian-B (Phase I)		Vehicular-B (Phase I)	
Number of Paths		4		6		6		6	
Relative Path power (dB)	Delay (ns)	0	0	0	0	0	0	-2.5	0
		-9.7	110	-1.0	310	-0.9	200	0	300
		-19.2	190	-9.0	710	-4.9	800	-12.8	8900
		-22.8	410	-10.0	1090	-8.0	1200	-10.0	12900
				-15.0	1730	-7.8	2300	-25.2	17100
				-20.0	2510	-23.9	3700	-16.0	20000
Speed (km/h)		3, 30, 120		30, 120, 250		3,		30, 120, 250	
M o	Topology	0.5λ		0.5λ		0.5λ		0.5λ	

	PAS	1) LOS on: Fixed AoA for LOS component, remaining power has 360 degree uniform PAS. 2) LOS off: PAS with a Laplacian distribution, RMS angle spread of 35 degrees per path	RMS angle spread of 35 degrees per path with a Laplacian distribution Or 360 degree uniform 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 Or 360 degree uniform PAS
	DoT (degrees)	0	22.5	-22.5	22.5
	AoA (degrees)	22.5 (LOS component) 67.5 (all other paths)	67.5 (all paths)	67.5 (all paths)	67.5 (all paths)
Base Station	Topology	Reference: ULA with 0.5λ-spacing or 4λ-spacing or 10λ-spacing			
	PAS	Laplacian distribution with RMS angle spread of 2 degrees or 5 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 5-2 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 Link Level Simulations

The link level simulation results for the Pedestrian A, Pedestrian B, Vehicular A and Vehicular B channels are presented for both uplink and downlink. The FER and throughput results for ModClasses 0-10 [8] and [9] are plotted in Fig. 6-1 to 6-40.

6.1 3 km/hr Pedestrian A

6.1.1 Uplink

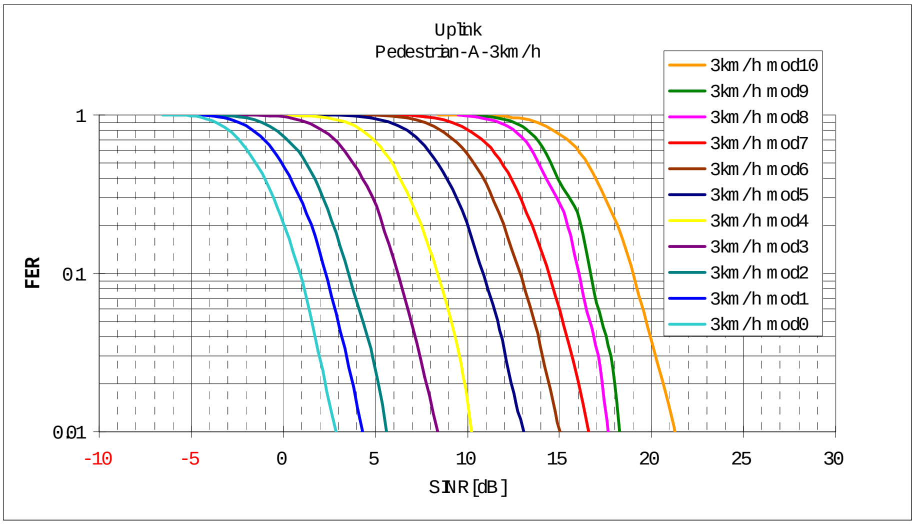

Figure 6-1 FER for 3km/hr Pedestrian A (Uplink)

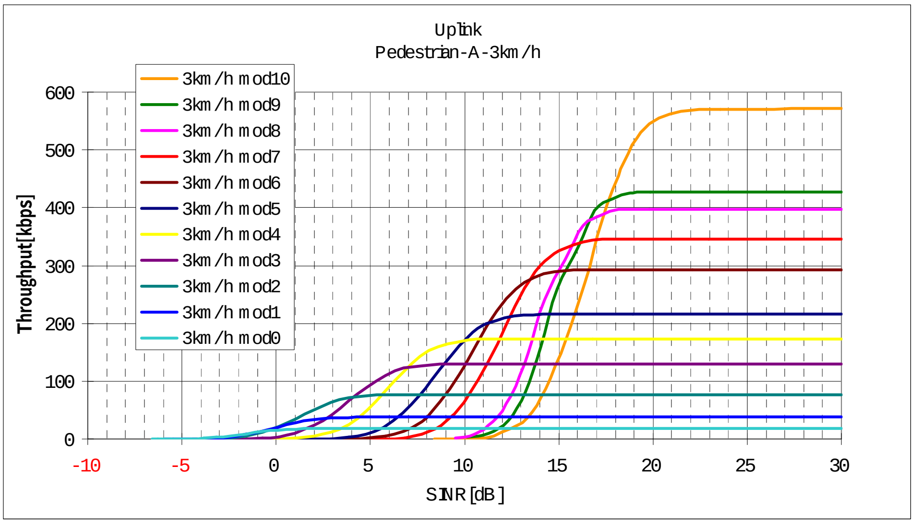

Figure 6-2 Throughput for 3km/hr Pedestrian A (Uplink)

6.1.2 Downlink

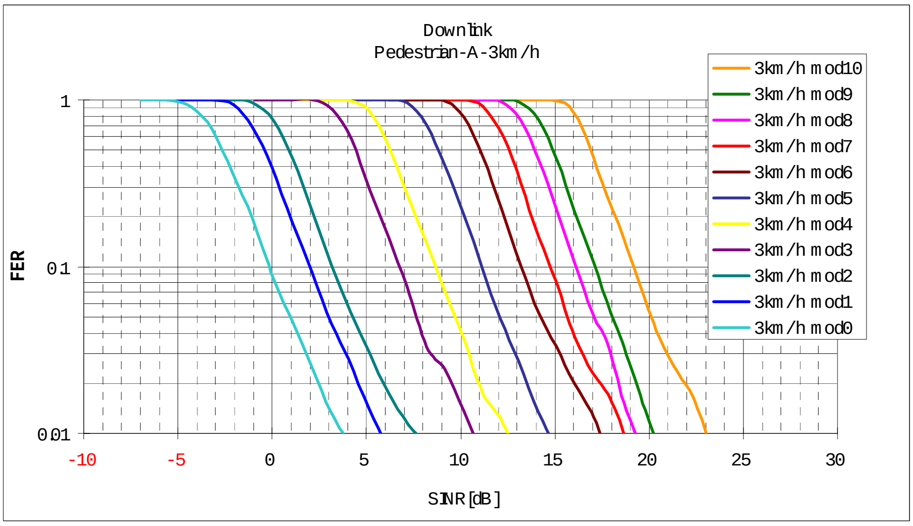

Figure 6-3 FER for 3km/hr Pedestrian A (Downlink)

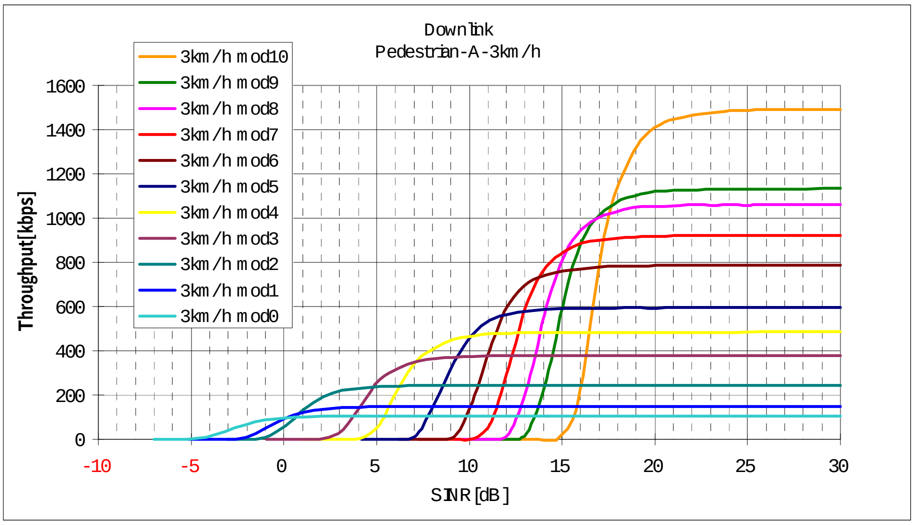

Figure 6-4 Throughput for 3km/hr Pedestrian A (Downlink)

6.2 30km/hr Pedestrian A

6.2.1 Uplink

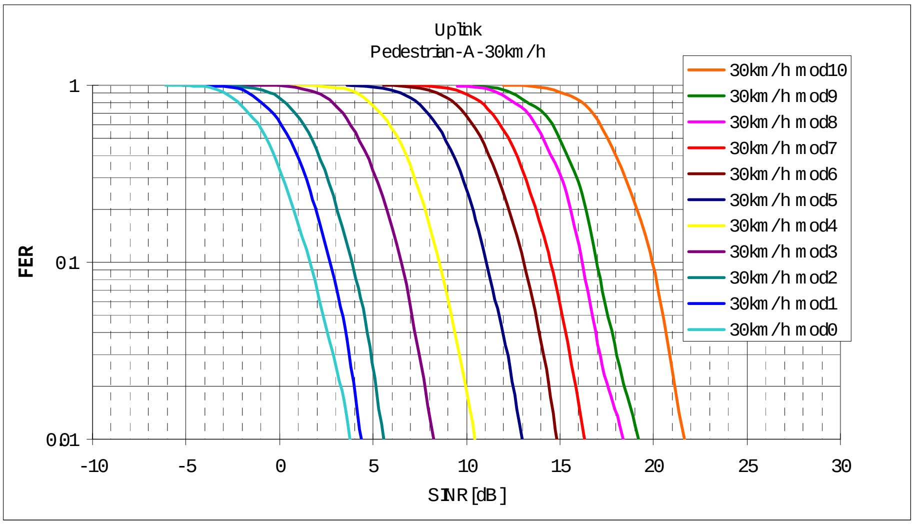

Figure 6-5 FER for 30km/hr Pedestrian A (Uplink)

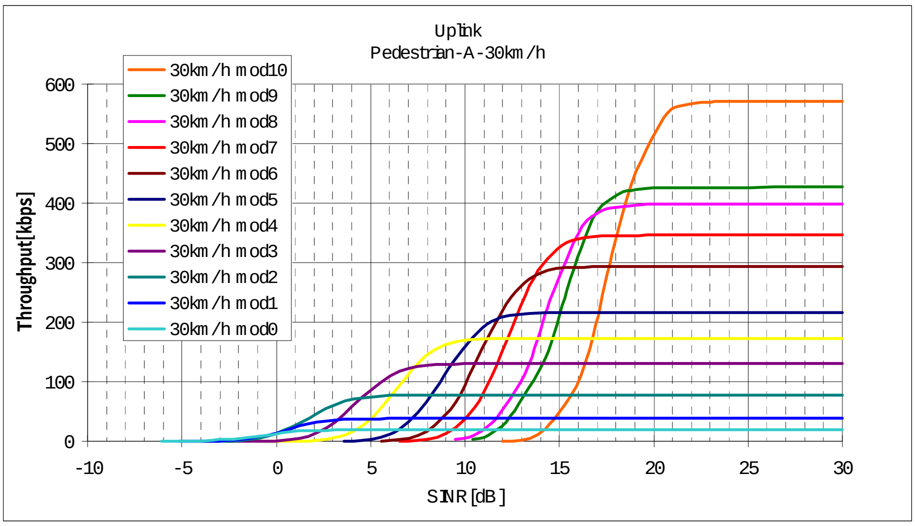

Figure 6-6 Throughput for 30km/hr Pedestrian A (Uplink)

6.2.2 Downlink

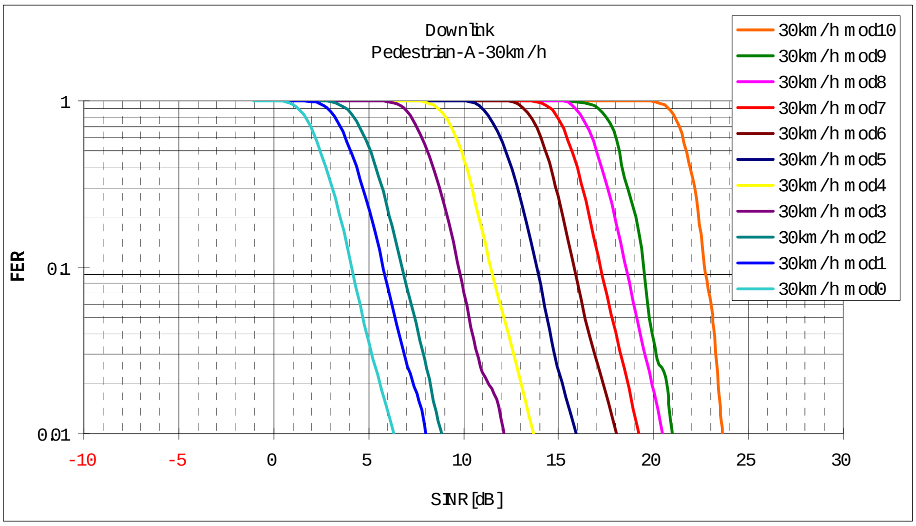

Figure 6-7 FER for 30km/hr Pedestrian A (Downlink)

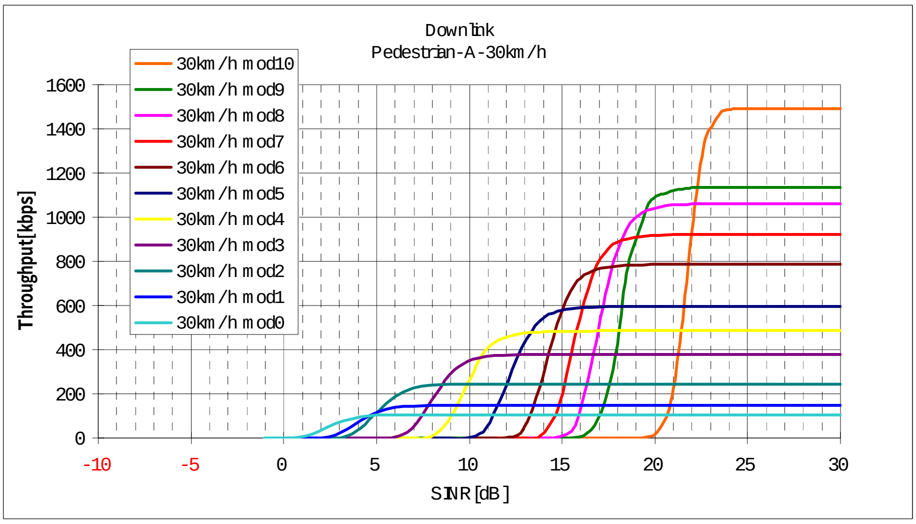

Figure 6-8 Throughput for 30km/hr Pedestrian A (Downlink)

6.3 120 km/hr Pedestrian A

6.3.1 Uplink

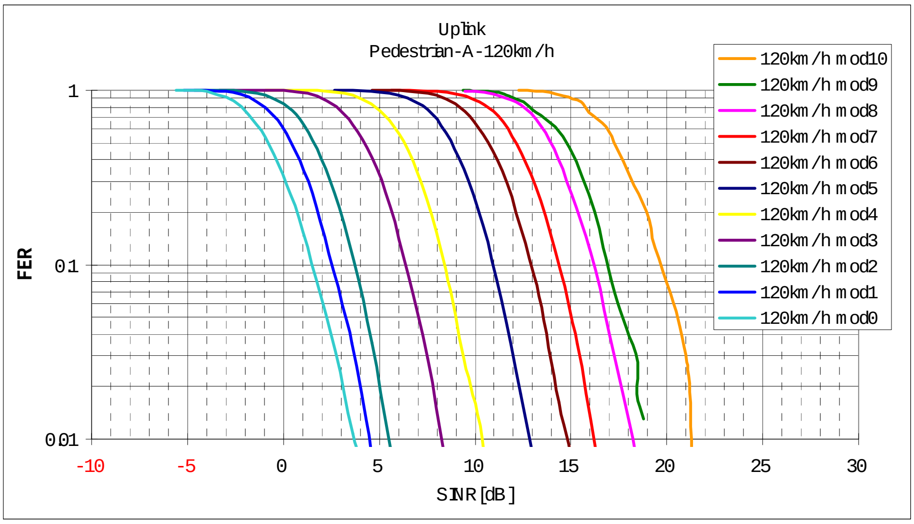

Figure 6-9 FER for 120km/hr pedestrian A (Uplink)

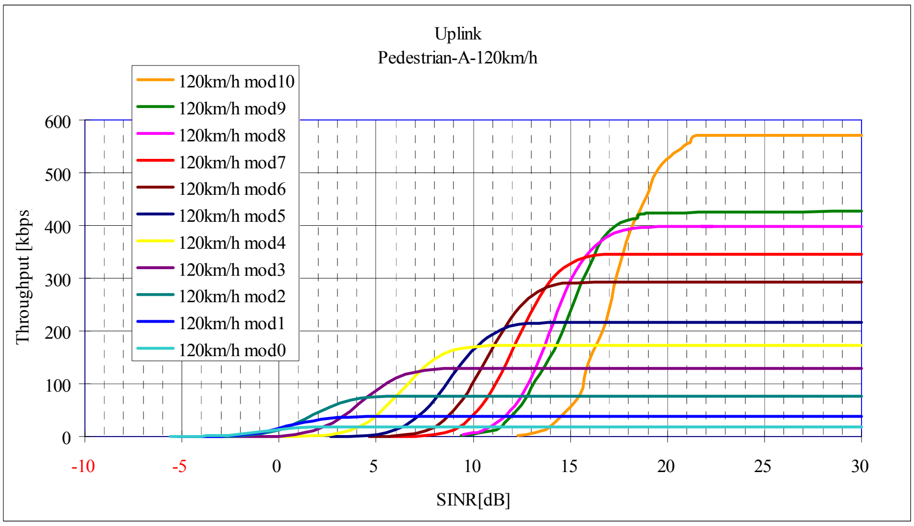

Figure 6-10 Throughput for 120km/hr pedestrian A (Uplink)

6.3.2 Downlink

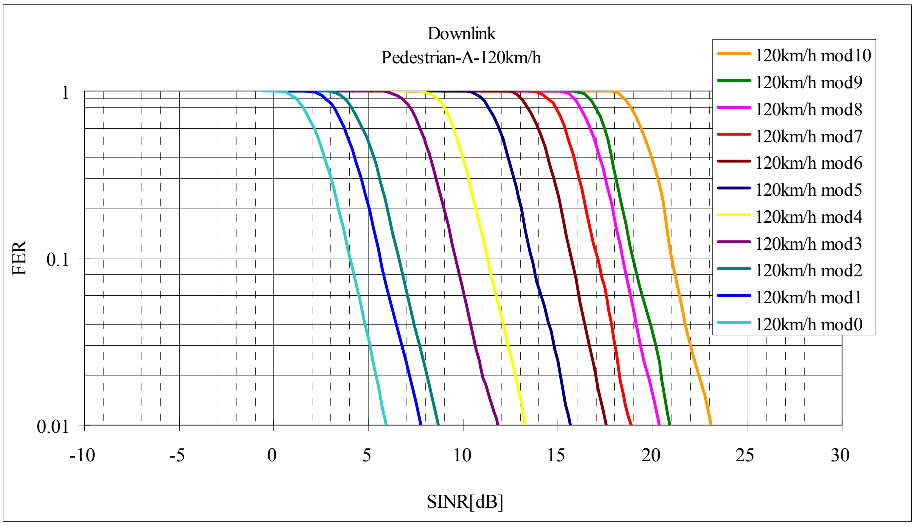

Figure 6-11 FER for 120km/hr Pedestrian A (Downlink)

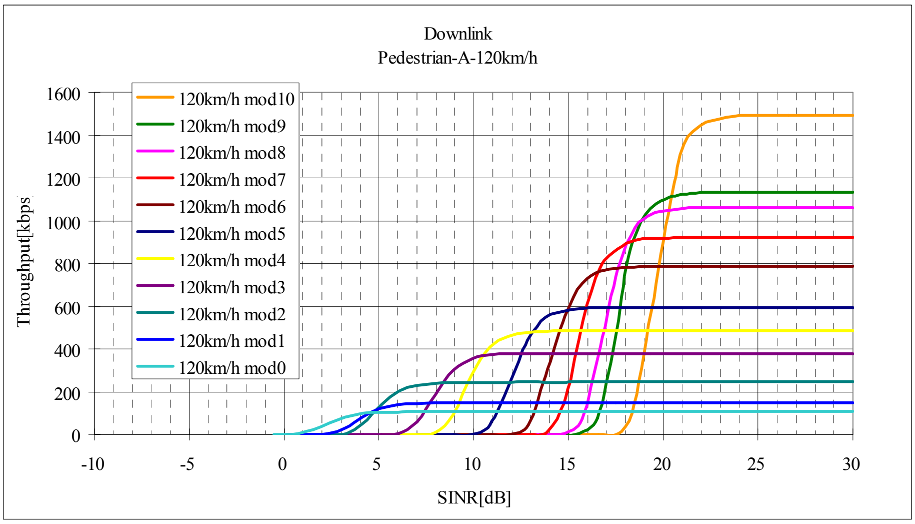

Figure 6-12 Throughput for 120km/hr Pedestrian A (Downlink)

6.4 30 km/hr Vehicular A

6.4.1 Uplink

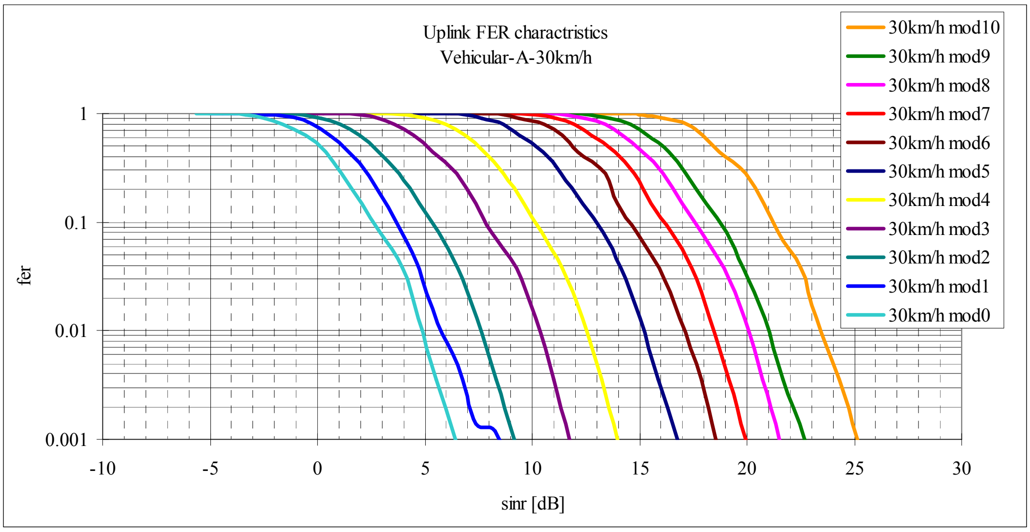

Figure 6-13 FER for 30km/hr Vehicular A (Uplink)

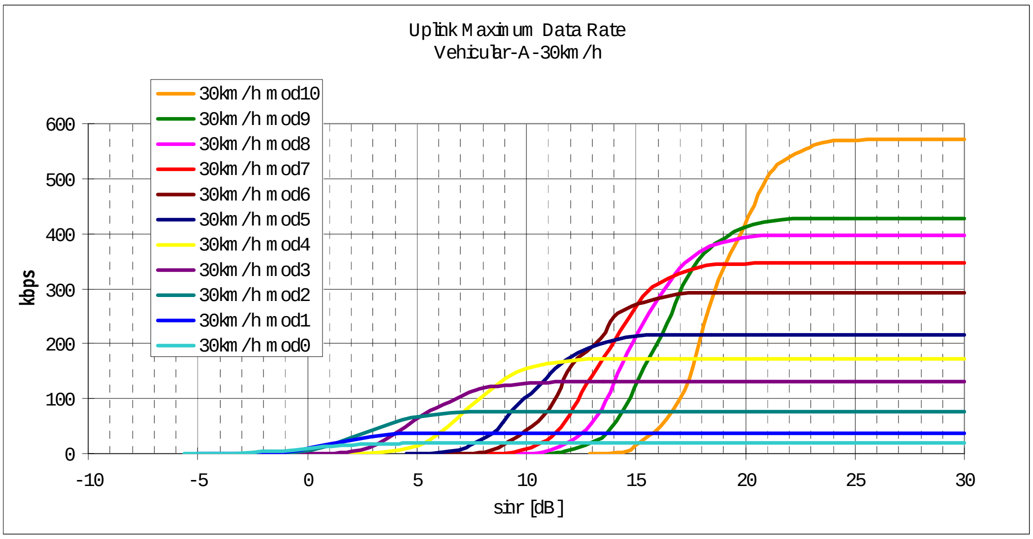

Figure 6-14 Throughput for 30km/hr Vehicular A (Uplink)

6.4.2 Downlink

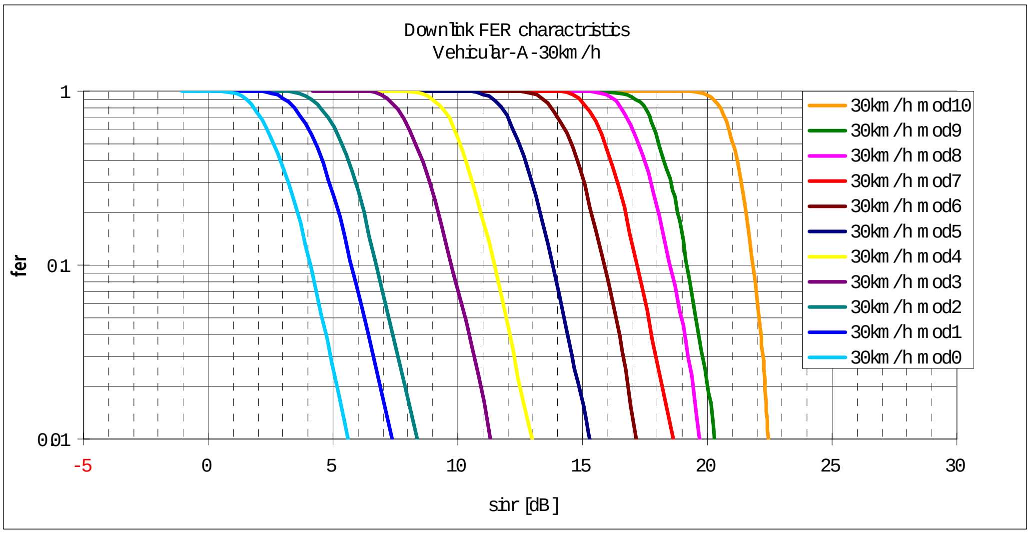

Figure 6-15 FER for 30km/hr Vehicular A (Downlink)

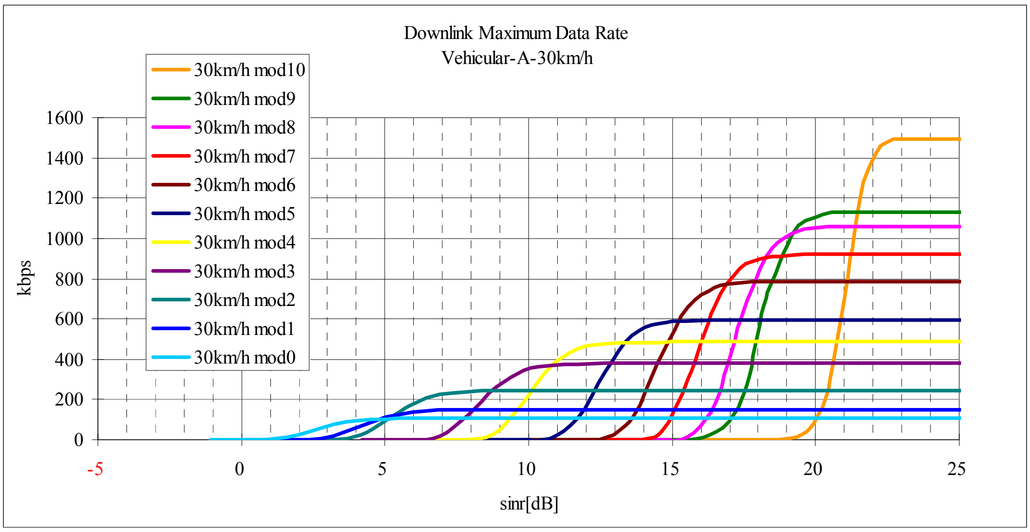

Figure 6-16 Throughput for 30km/hr Vehicular A (Downlink)

6.5 120 km/hr Vehicular A

6.5.1 Uplink

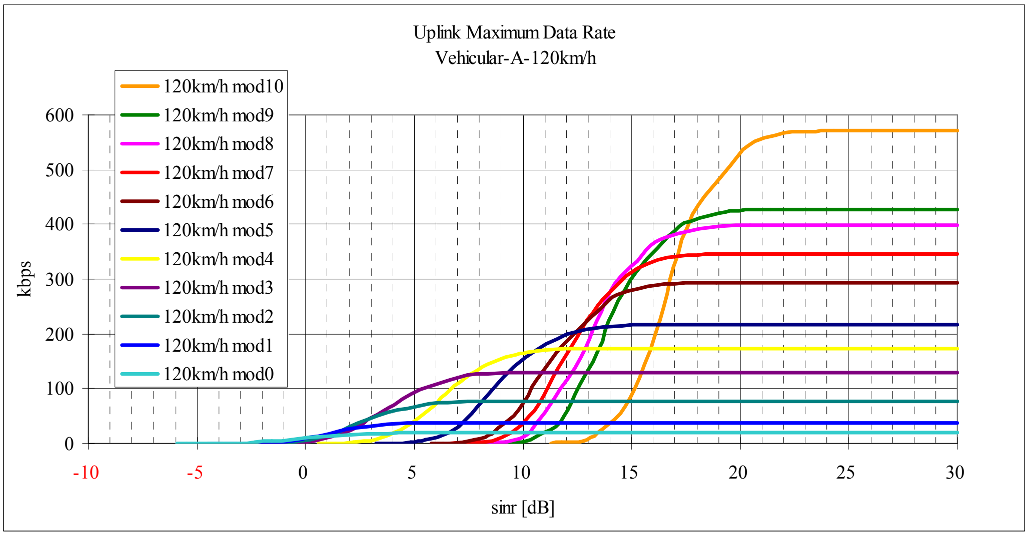

Figure 6-17 FER for 120km/hr Vehicular A (Uplink)

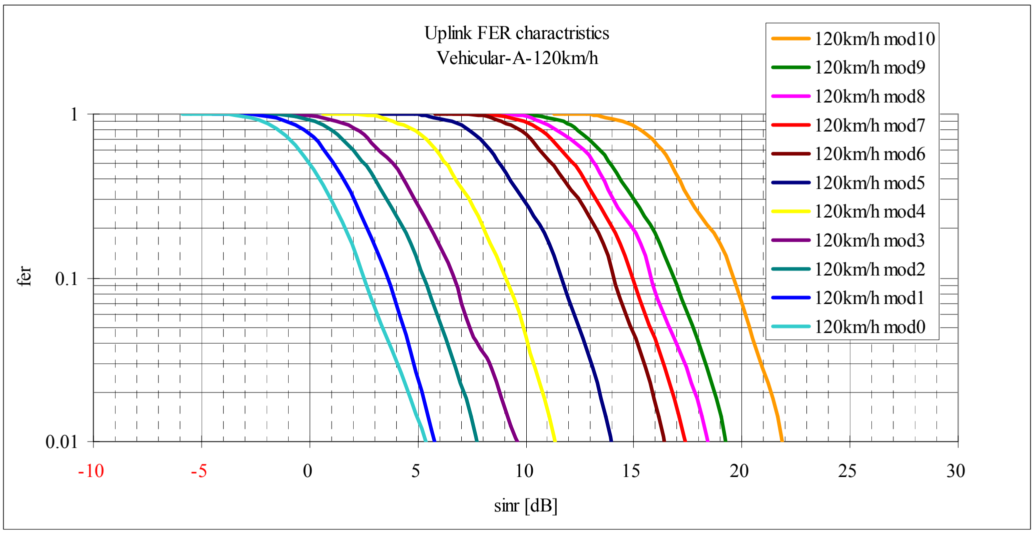

Figure 6-18 Throughput for 120km/hr Vehicular A (Uplink)

6.5.2 Downlink

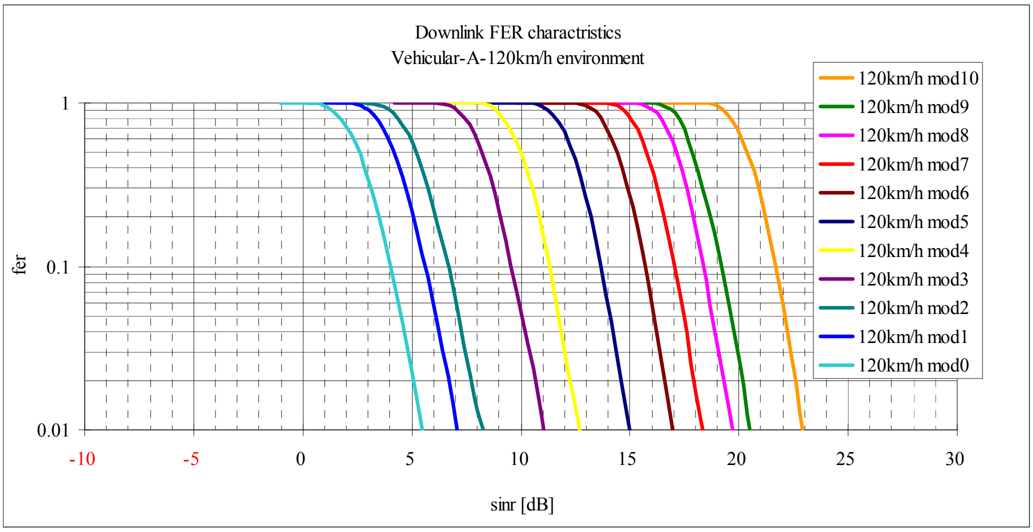

Figure 6-19 FER for 120km/hr Vehicular A (Downlink)

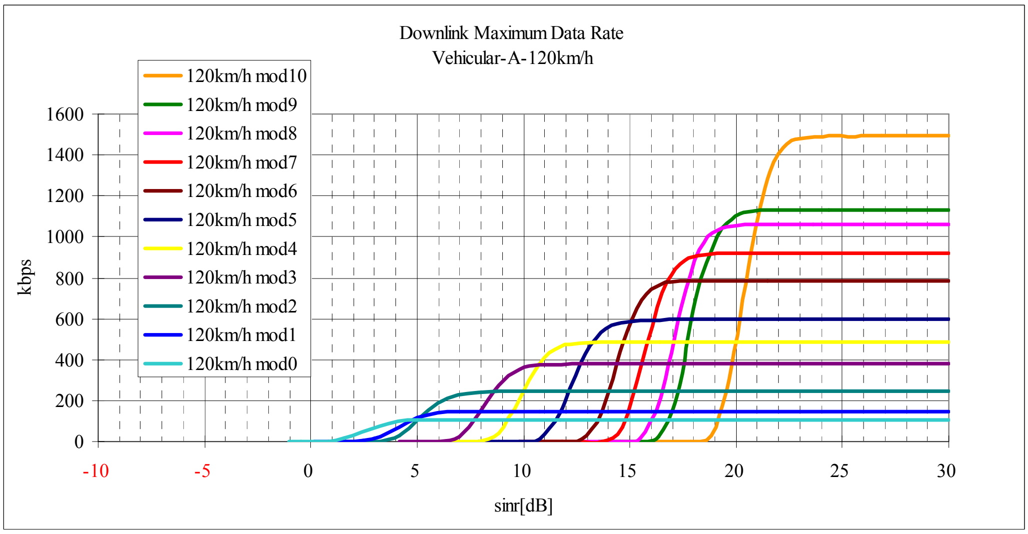

Figure 6-20 Throughput for 120km/hr Vehicular A (Downlink)

6.6 250 km/hr Vehicular A

6.6.1 Uplink

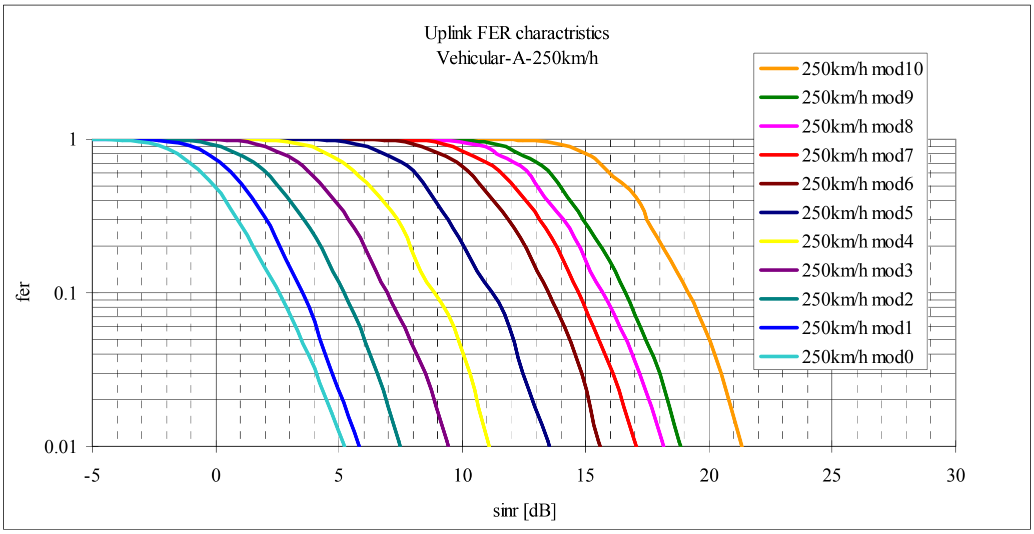

Figure 6-21 FER for 250km/hr Vehicular A (Uplink)

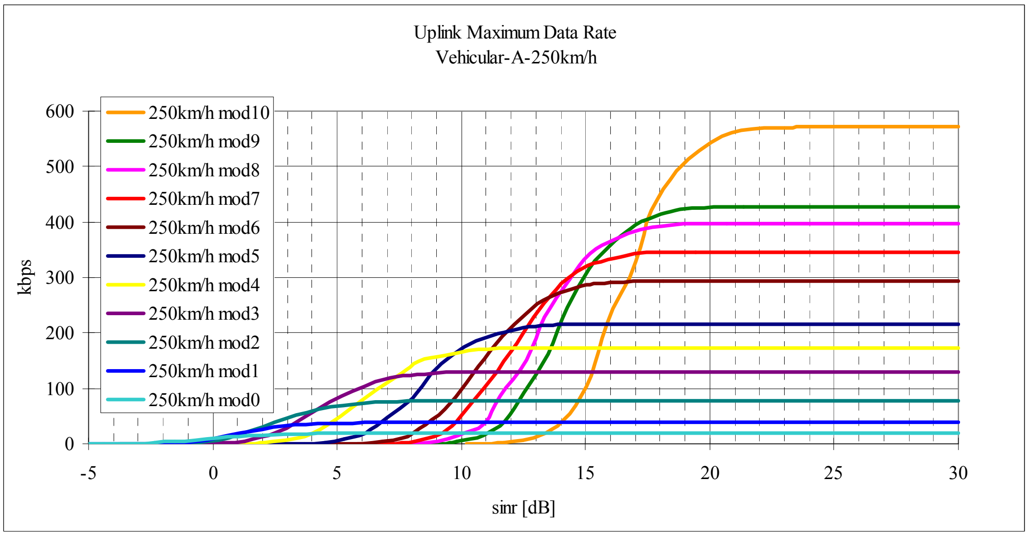

Figure 6-22 Throughput for 250km/hr Vehicular A (Uplink)

6.6.2 Downlink

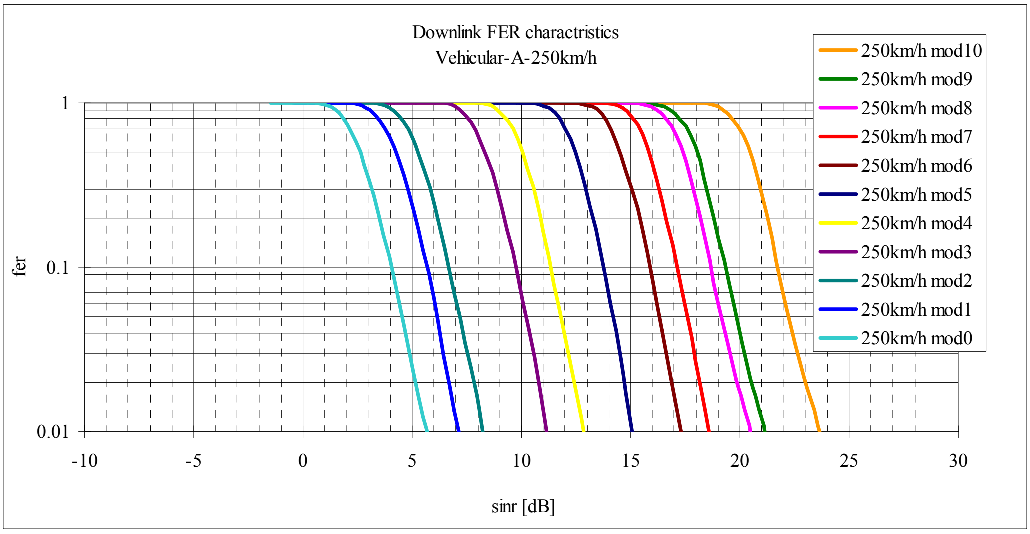

Figure 6-23 FER for 250km/hr Vehicular A (Downlink)

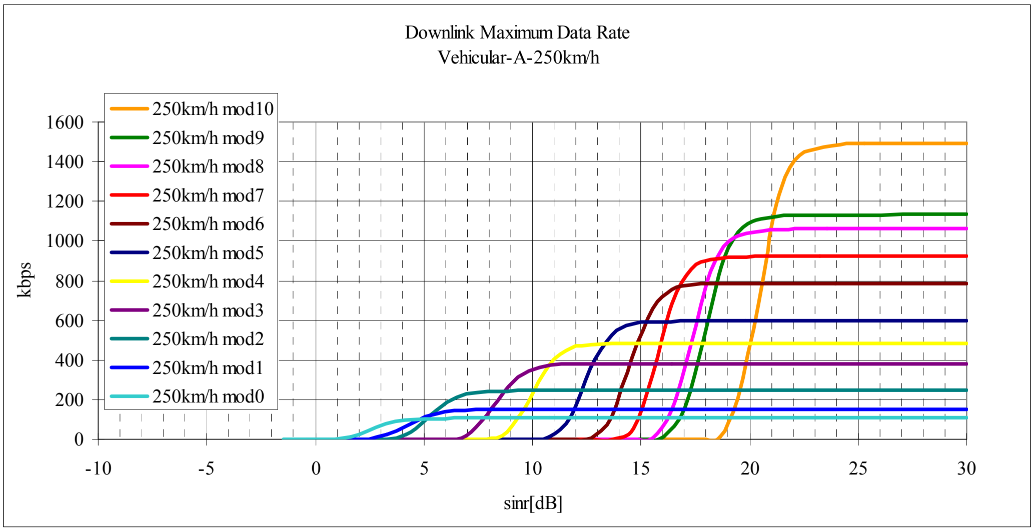

Figure 6-24 Throughput for 250km/hr Vehicular A (Downlink)

6.7 3 km/hr Pedestrian B

6.7.1 Uplink

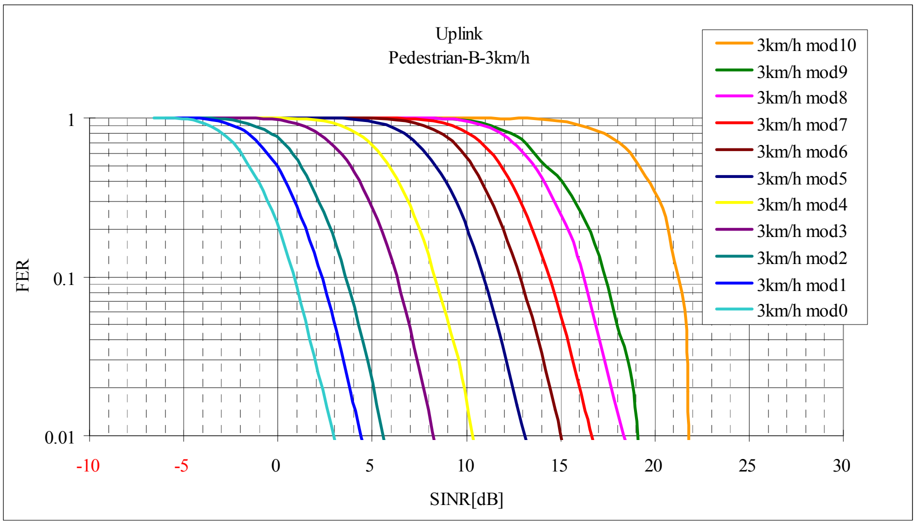

Figure 6-25 FER for 3km/hr Pedestrian B (Uplink)

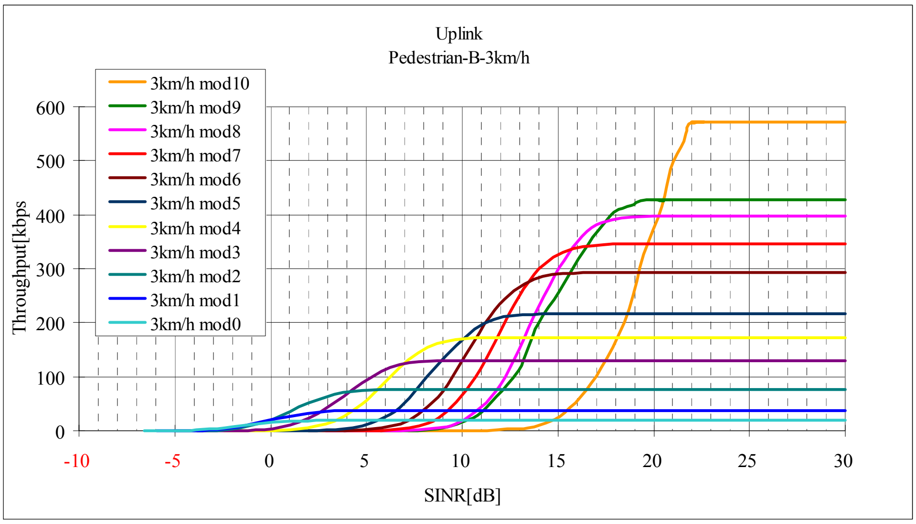

Figure 6-26 Throughput for 3km/hr Pedestrian B (Uplink)

6.7.2 Downlink

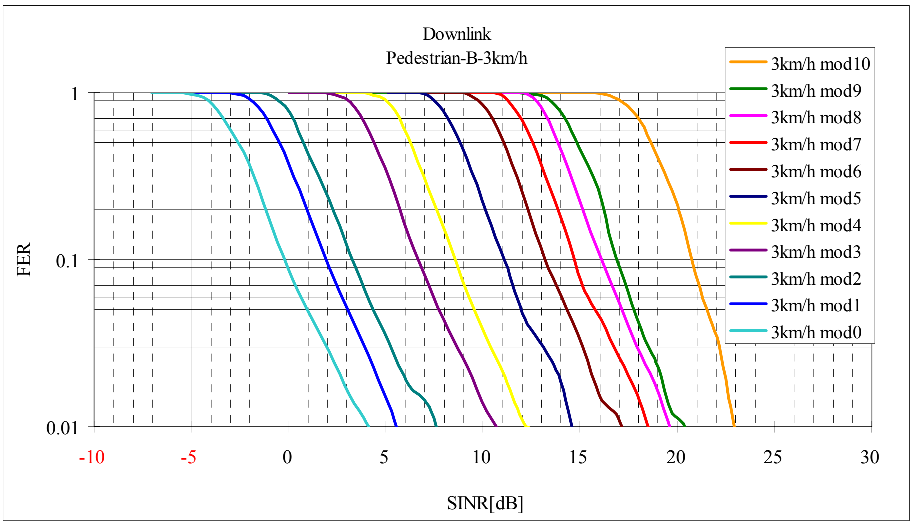

Figure 6-27 FER for 3km/hr Pedestrian B (Downlink)

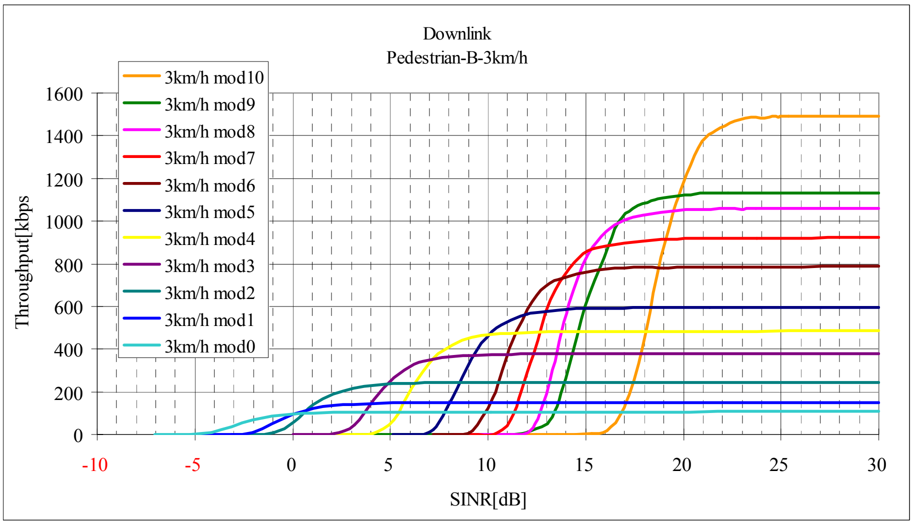

Figure 6-28 Throughput for 3km/hr Pedestrian B (Downlink)

6.8 30 km/hr Vehicular B

6.8.1 Uplink

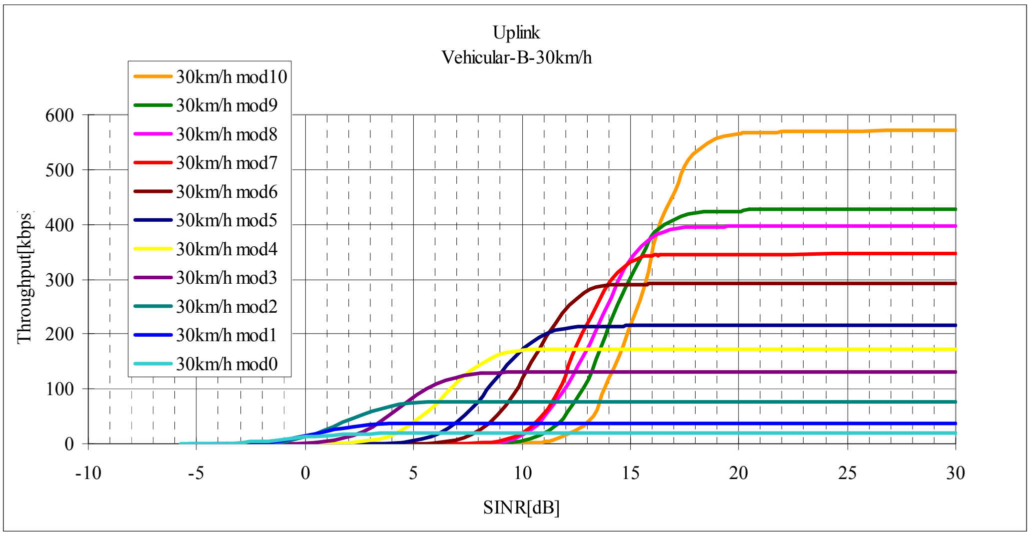

Figure 6-29 FER for 30km/hr Vehicular B (Uplink)

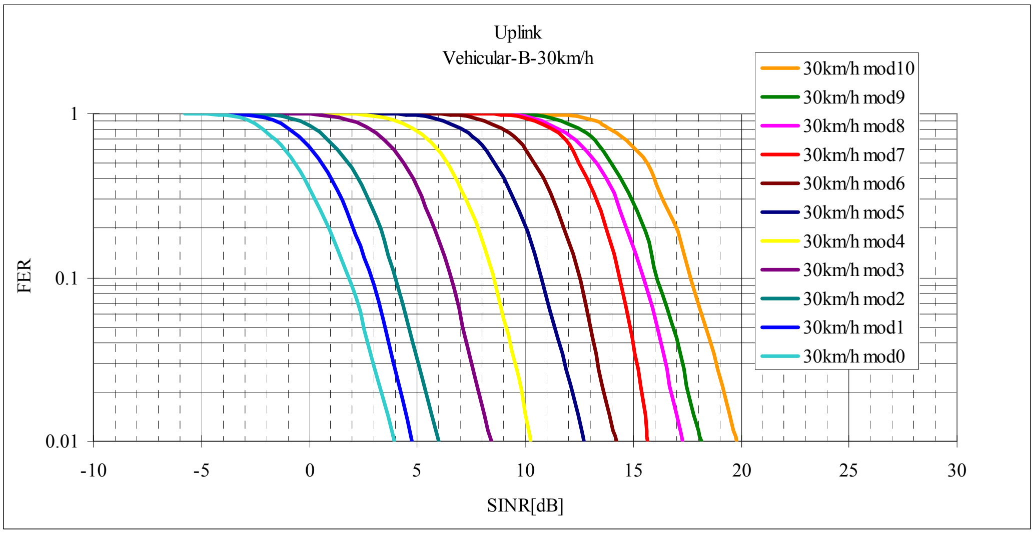

Figure 6-30 Throughput for 30km/hr Vehicular B (Uplink)

6.8.2 Downlink

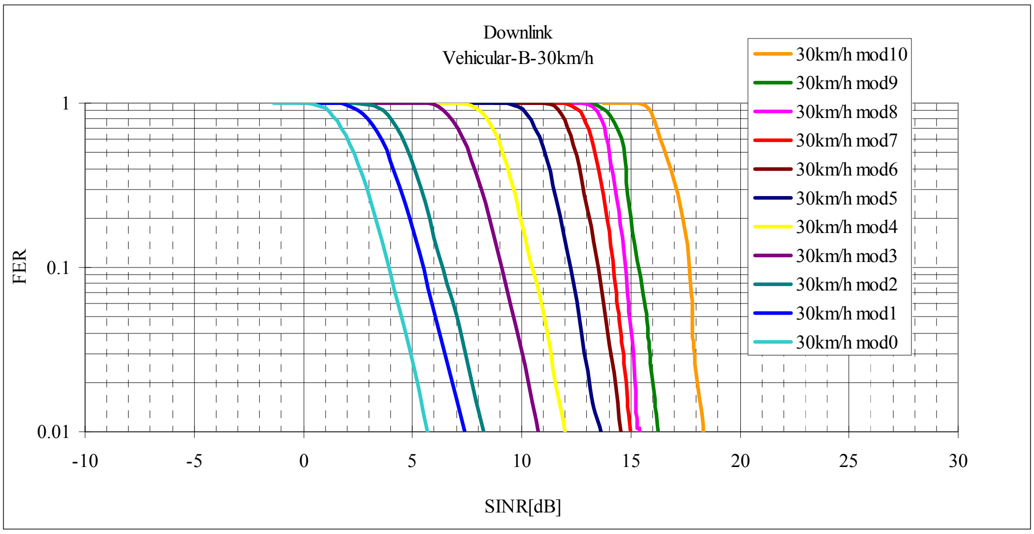

Figure 6-31 FER for 30km/hr Vehicular B (Downlink)

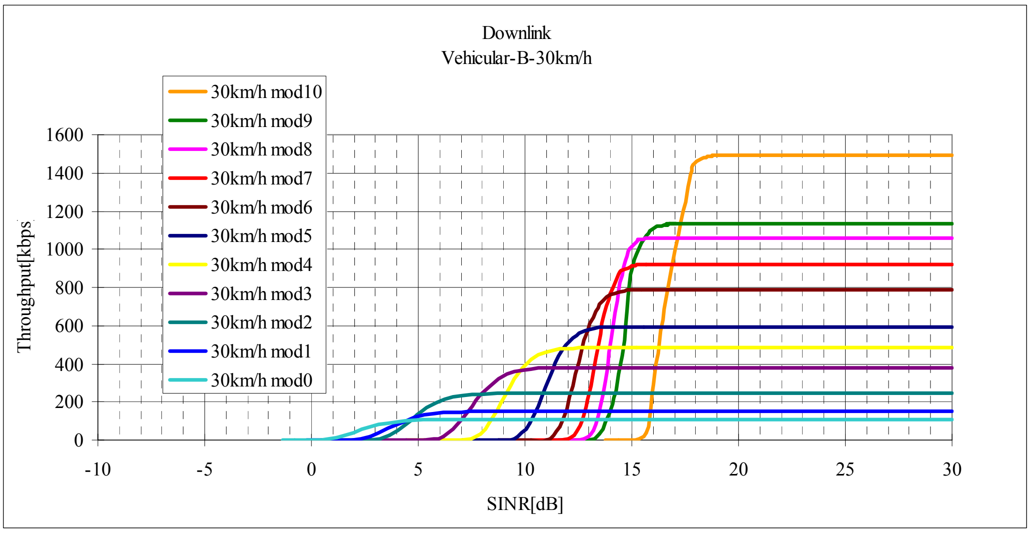

Figure 6-32 Throughput for 30km/hr Vehicular B (Downlink)

6.9 120 km/hr Vehicular B

6.9.1 Uplink

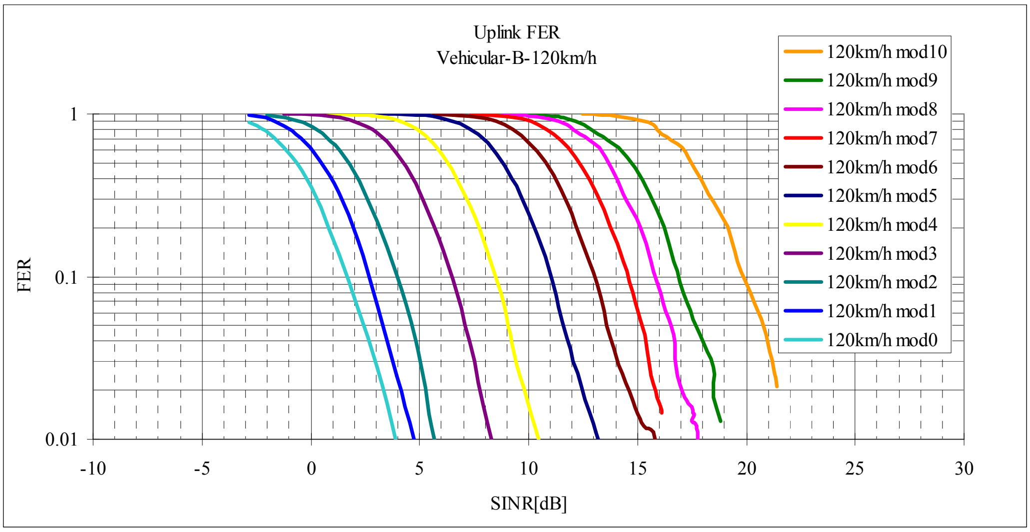

Figure 6-33 FER for 120km/hr Vehicular B (Uplink)

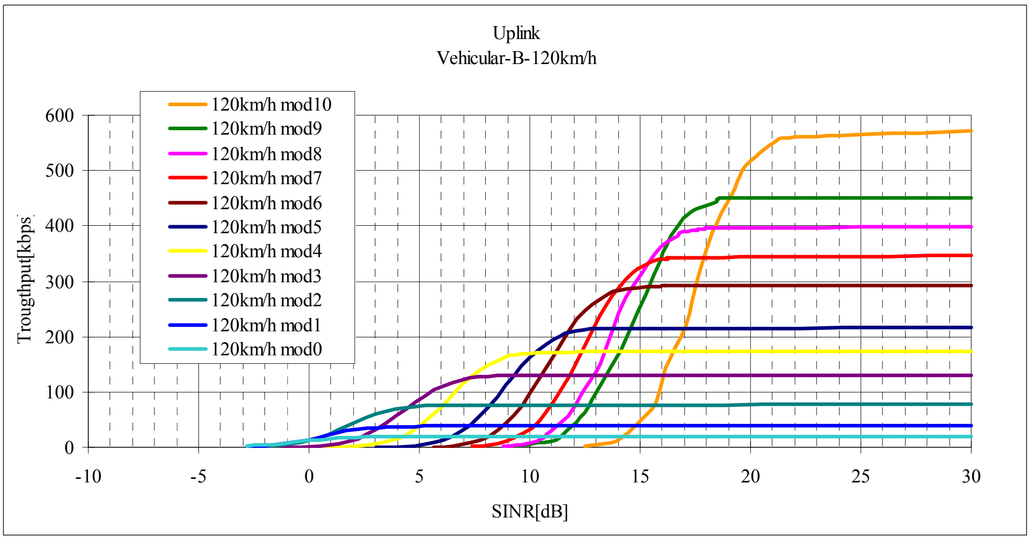

Figure 6-34 Throughput for 120km/hr Vehicular B (Uplink)

6.9.2 Downlink

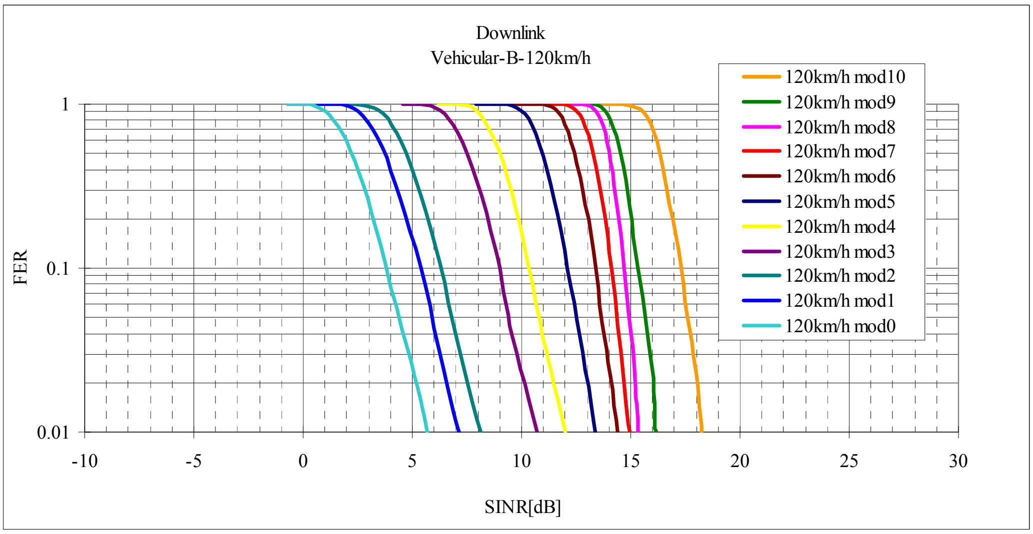

Figure 6-35 FER for 120km/hr Vehicular B (Downlink)

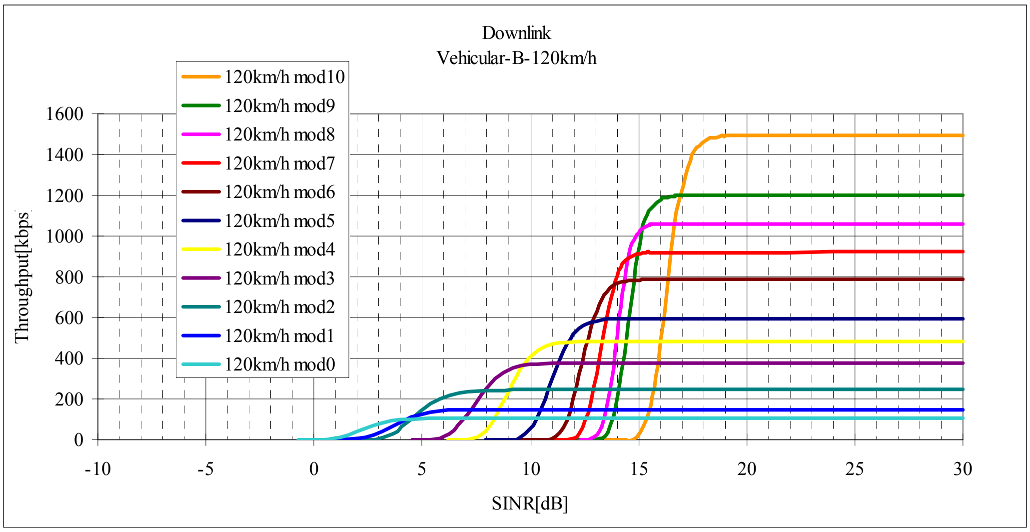

Figure 6-36 Throughput for 120km/hr Vehicular B (Downlink)

6.10 250 km/hr Vehicular B

6.10.1 Uplink

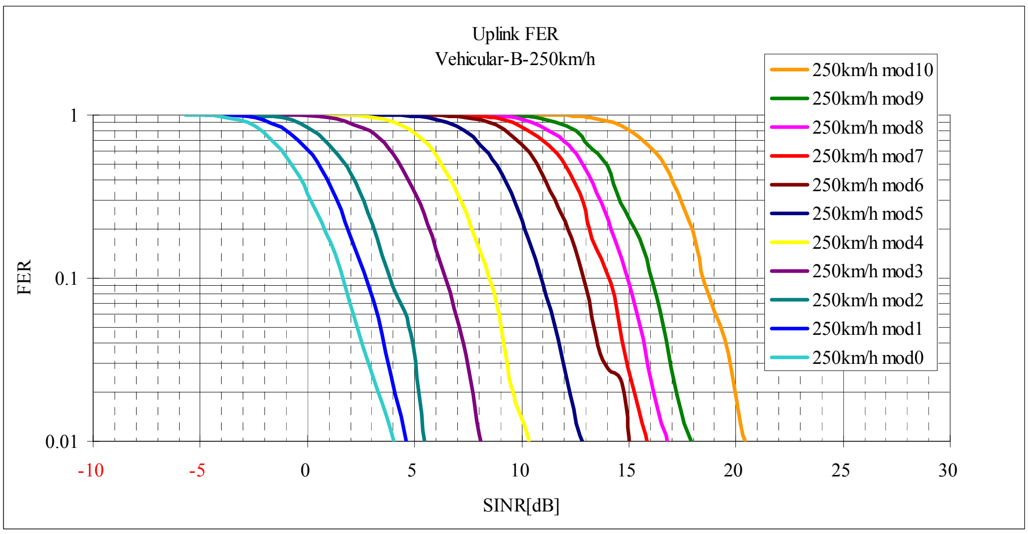

Figure 6-37 FER for 250km/hr Vehicular B (Uplink)

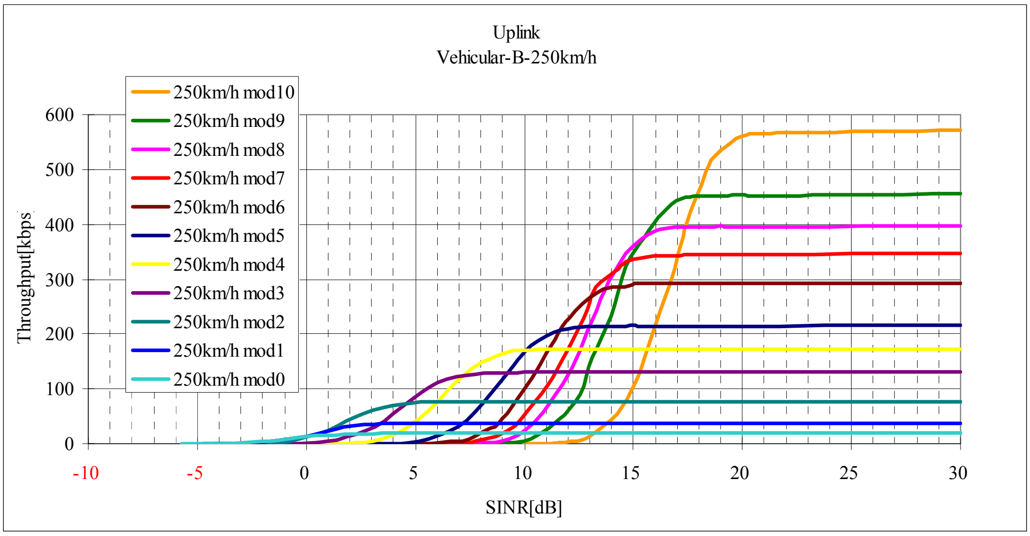

Figure 6-38 Throughput for 250km/hr Vehicular B (Uplink)

6.10.2 Downlink

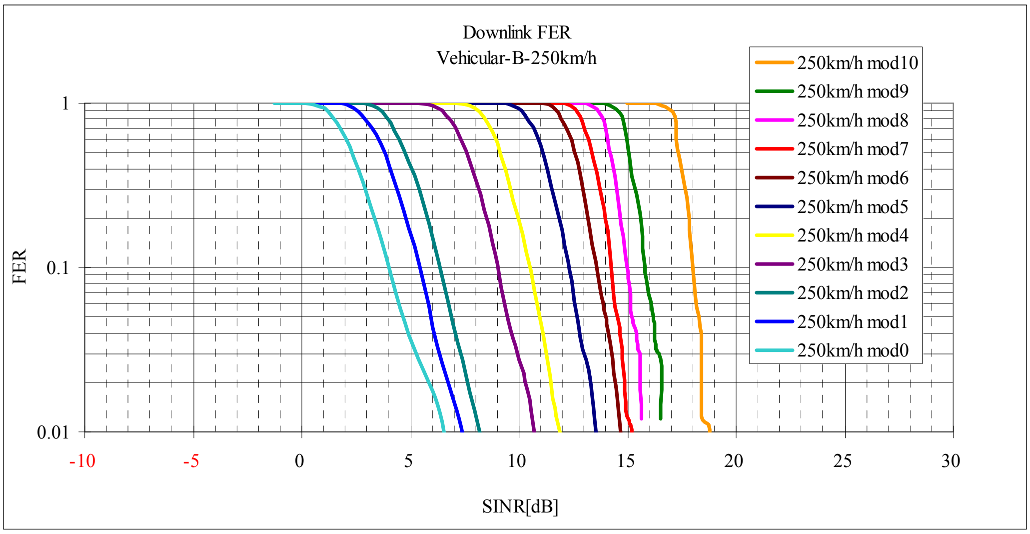

Figure 6-39 FER for 250km/hr Vehicular B (Downlink)

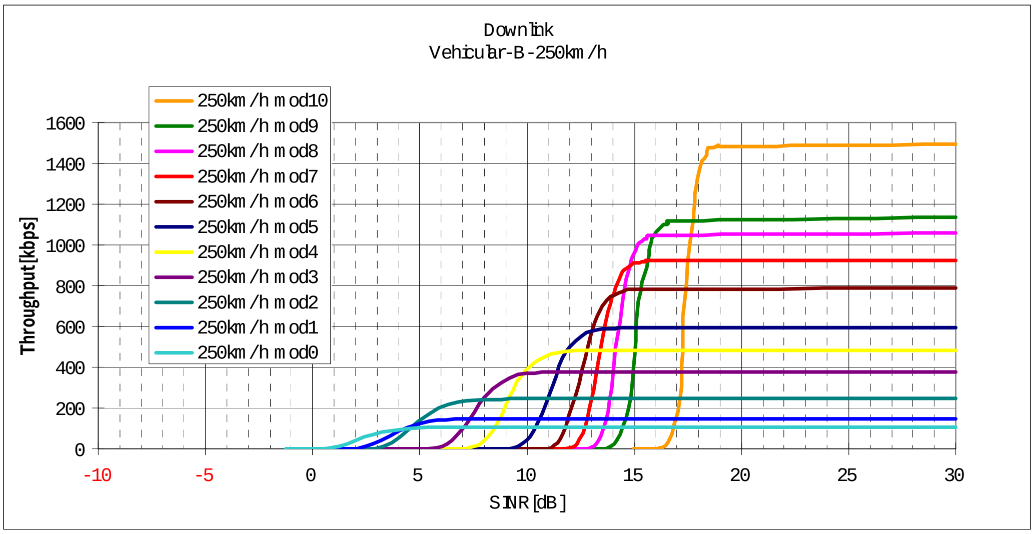

Figure 6-40 Throughput for 250km/hr Vehicular B (Downlink)

7 System Level Simulations

7.1 Traffic model Performance

7.1.1 Traffic Model Calibration

This section constitutes the calibration of the traffic models as required by the evaluation criteria document. Traffic was generated for a length of time such that 10^6 instances of each parameter occurred. The statistics for these parameter were then measured. The considered traffic models are: HTTP, FTP, VoIP and near real time video.

Table 7-1 shows the parameters to consider and the measured mean compared to the expected theoretical value. Figure 7-1 to Figure 7-11 show the cumulative density function (cdf) of all the random parameters involved in the generation of the different traffic models.

Table 7-1 Traffic model parameters

	Parameter	Theoretical	Measured (from $1x10^6$ samples)
HTTP			
Main File Object size (bytes)	Mean	10710	10734
Embedded Object size (bytes)	Mean	7758	7821
No Embedded Objects per page	Mean	5.64	5.628
Reading Time (sec)	Mean	30	29.94
Parsing Time (sec)	Mean	0.13	0.1301
FTP			
File Size (bytes)	Mean	$2x\ 10^6$	$2x10^6$
Reading Time (sec)	Mean	180	179.9065
NRTV			
Packet (Slice) size	Mean	50	50.6658
Interarrival time	Mean	6	5.9399
Network Delay			
Domestic	Mean	10	10.001
International	Mean	110	109.9995

7.1.1.1 HTTP

7.1.1.1.1 HTTP Main File Object Size

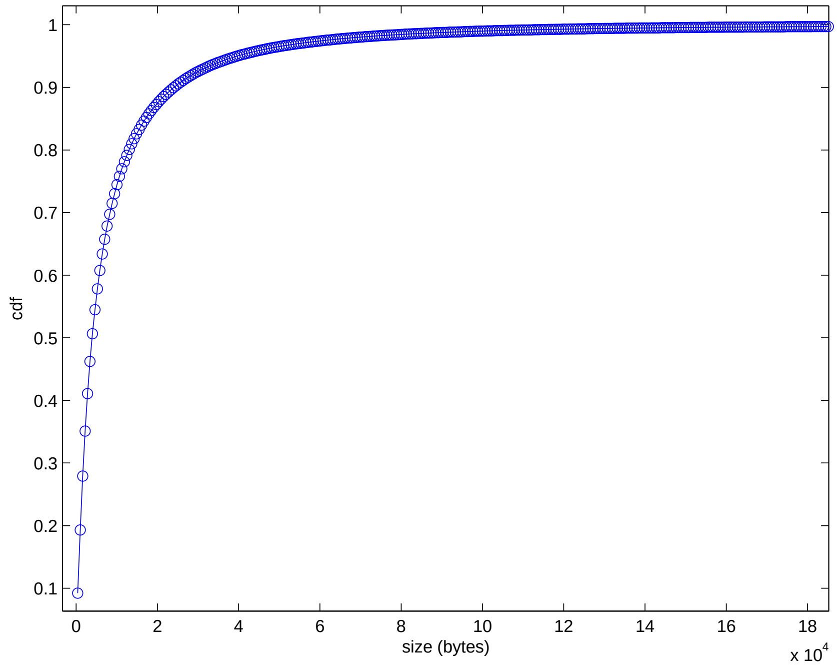

Figure 7-1 HTTP Main File Object size

7.1.1.1.2 HTTP Embedded Object Size

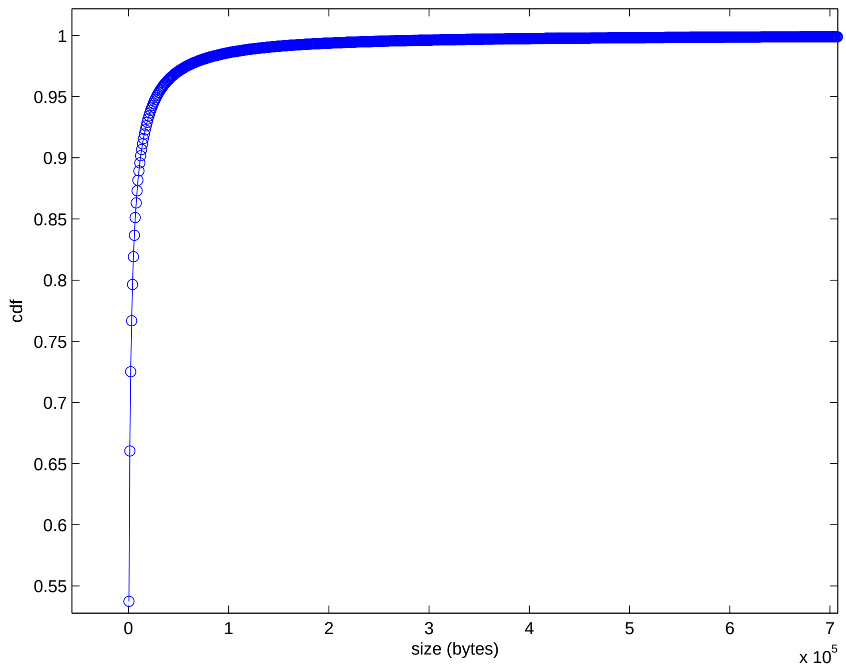

Figure 7-2 HTTP Embedded Object size

7.1.1.1.3 HTTP Number of Embedded Objects per Page

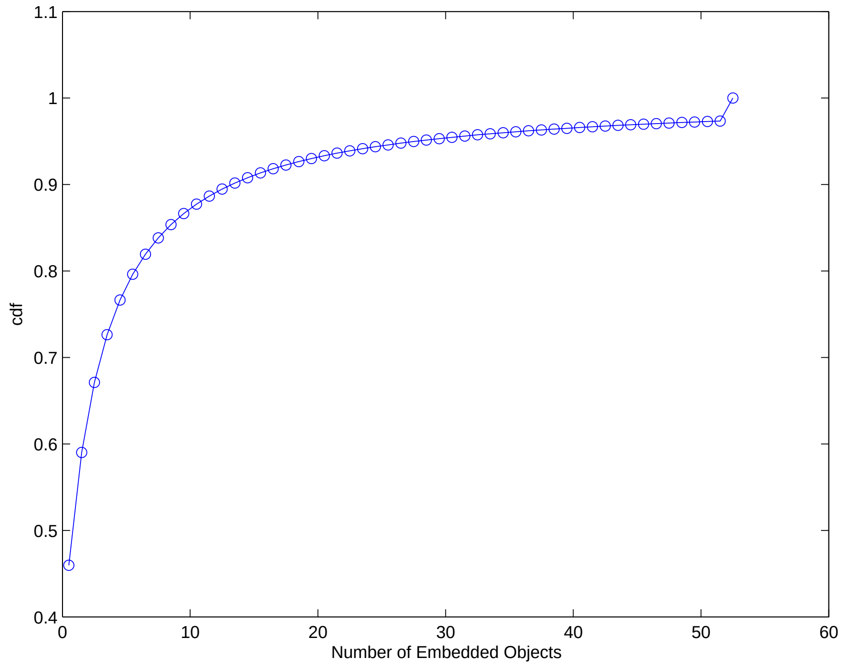

Figure 7-3 HTTP Embedded Object per Page

7.1.1.1.4 HTTP Reading Time

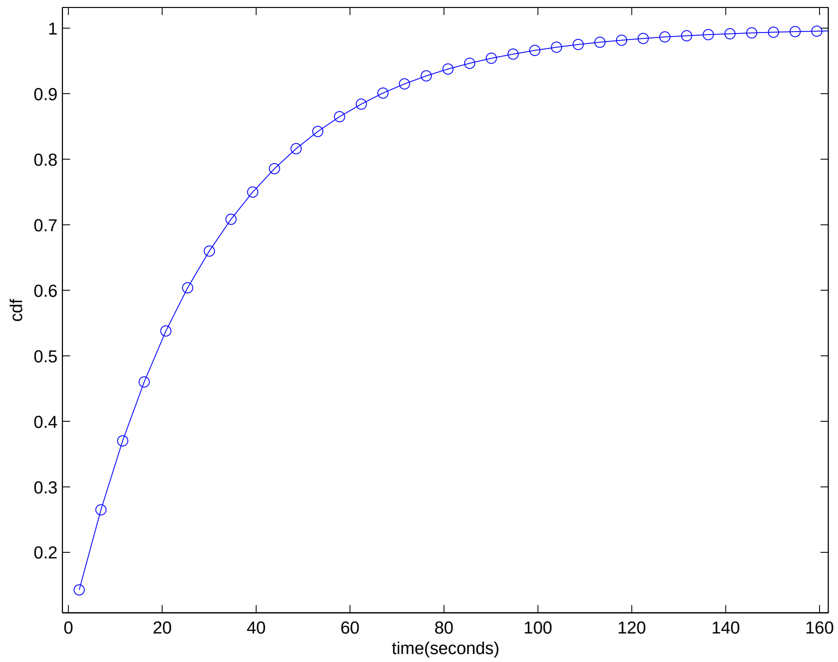

Figure 7-4 HTTP Reading time

7.1.1.1.5 HTTP Parsing Time

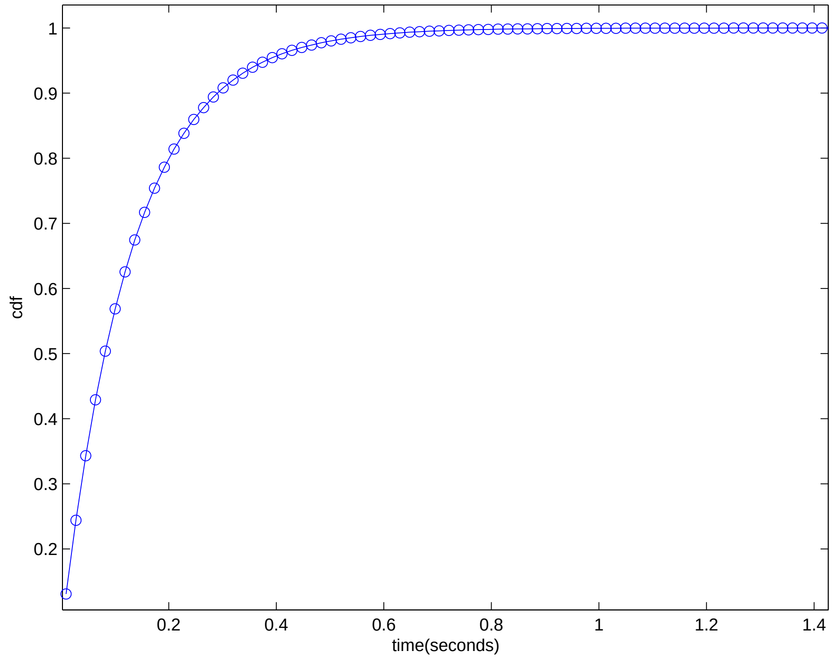

Figure 7-5 HTTP Reading time

7.1.1.2 FTP

7.1.1.2.1 FTP File Size

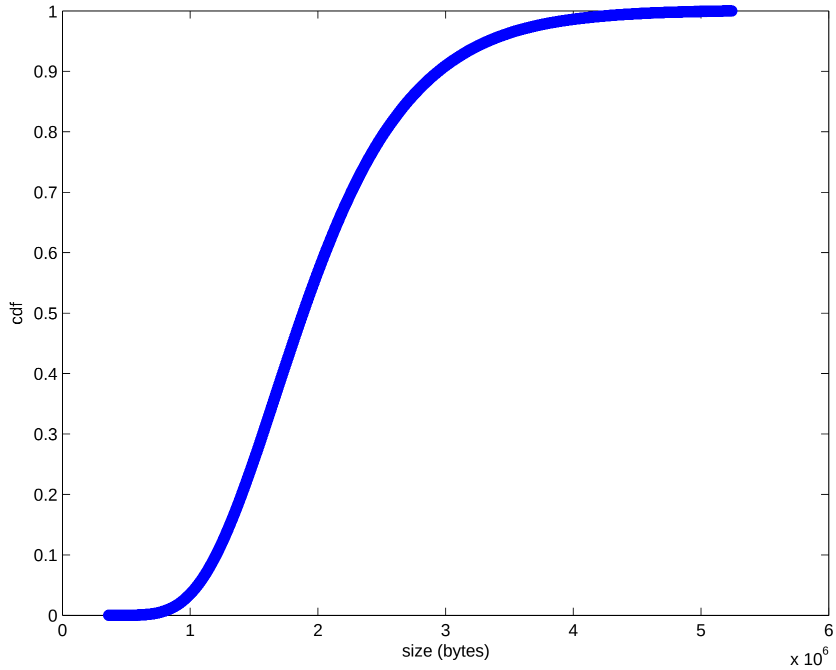

Figure 7-6 FTP file size

7.1.1.2.2 FTP Reading Time

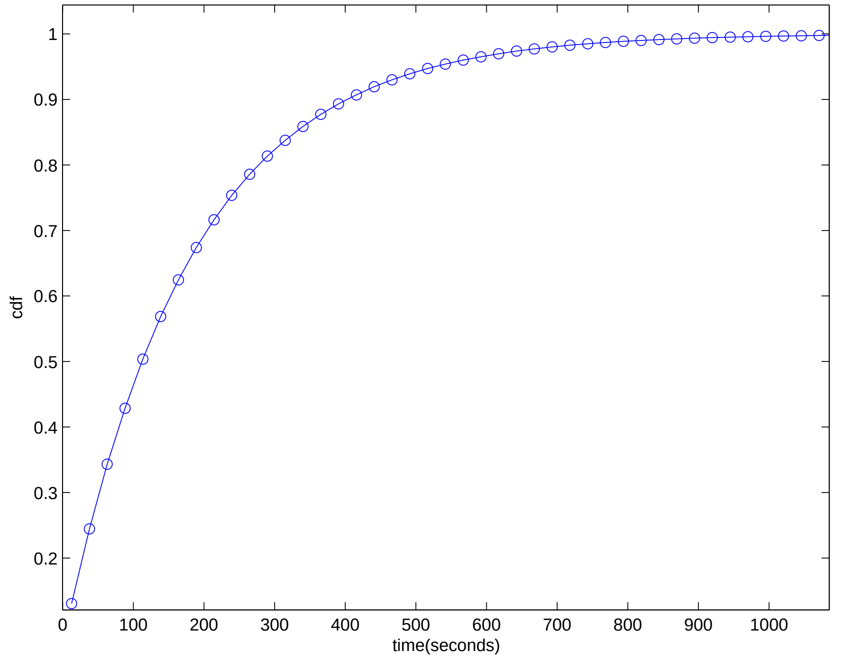

Figure 7-7 FTP reading time

7.1.1.3 NRTV

7.1.1.3.1 NRTV Packet Size

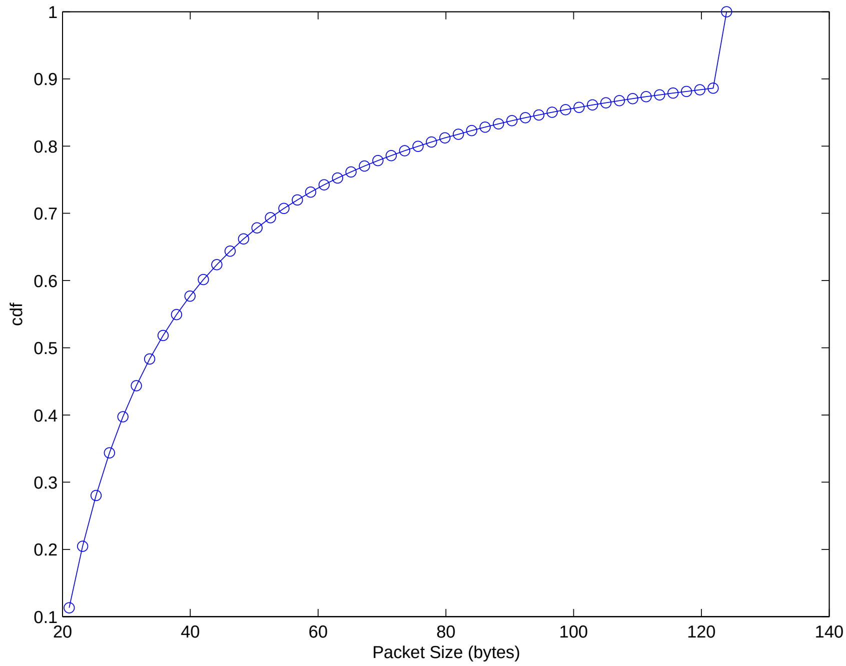

Figure 7-8 NRTV packet size

7.1.1.3.2 NRTV Inter-arrival Time

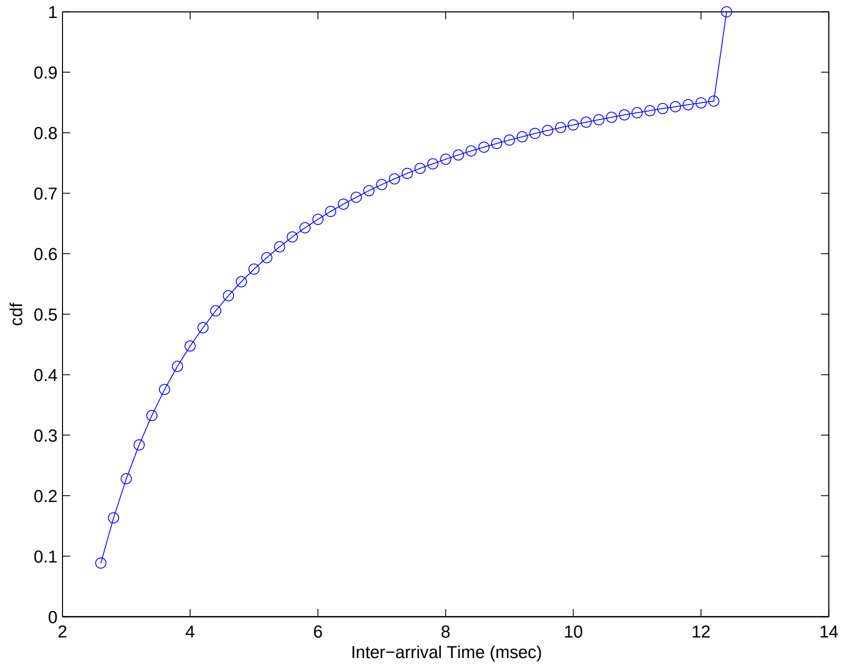

Figure 7-9 NRTV inter-arrival time

7.1.1.4 Network Delay

The Domestic and International delay cdfs are shown in Figure 7-10 and Figure 7-11, respectively.

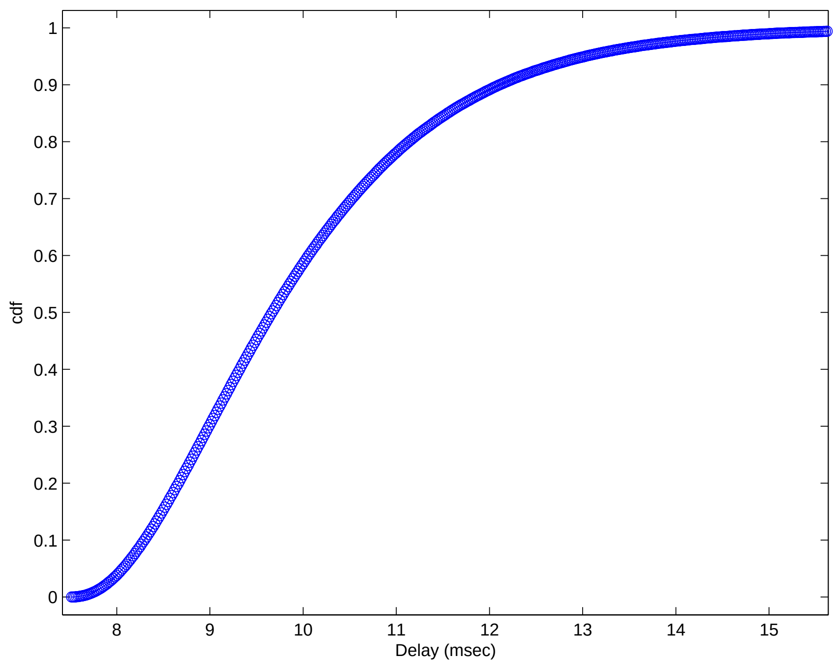

Figure 7-10 Domestic network delay

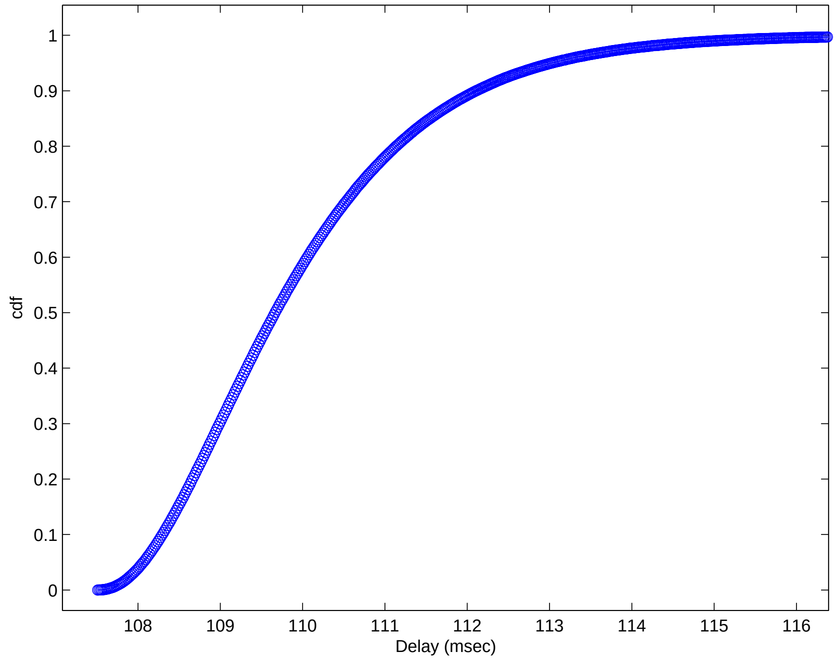

Figure 7-11 International network delay

7.1.2 VoIP Performance

VoIP performance is presented by the R values generated as a result of simulating voice traffic. R values are obtained for the forward and reverse links.
The R-value is computed as a function of delay and packet loss probability using the following formula (as defined in G.107):

$$R_{MBWA} = 93.2 - I_d - I_{e\text{-}eff}$$

The quantity I_d is defined as given below

$$I_d = I_{dd}$$

For mean delay Ta < 100 ms:

$$I_{dd} = 0$$

For mean delay Ta > 100 ms:

$$Idd = 25\left\{\left(1+X^{6}\right)^{\frac{1}{6}} - 3\left(1+\left[\frac{X}{3}\right]^{6}\right)^{\frac{1}{6}} + 2\right\}$$

with:

$$X = \frac{\lg\left(\frac{Ta}{100}\right)}{\lg 2}$$

Further, $I_{e\text{-}eff}$ is defined as shown below, with I_e=11 and Bpl = 19% (note that Bpl is measured in percents based on random packet loss probability Ppl).

$$Ie - eff = Ie + (95 - Ie)\frac{Ppl}{Ppl + Bpl}$$

The R-value when G.729 Codec is used are presented in Figures---.

Figure 7-12 plots the R-value for the different received BCH level at the UT. Figure 7-13. plots the R-value for different end-to-end delay. End to end delay is the sum of one-way delay, packetization delay and jitter buffer delay. The packetization error (encode and decode) is 25ms and the jitter buffer delay is 40ms. The BCH receive level is fixed at –65dBm. Figure 7-14 plots the R-value for various packet loss in the network.

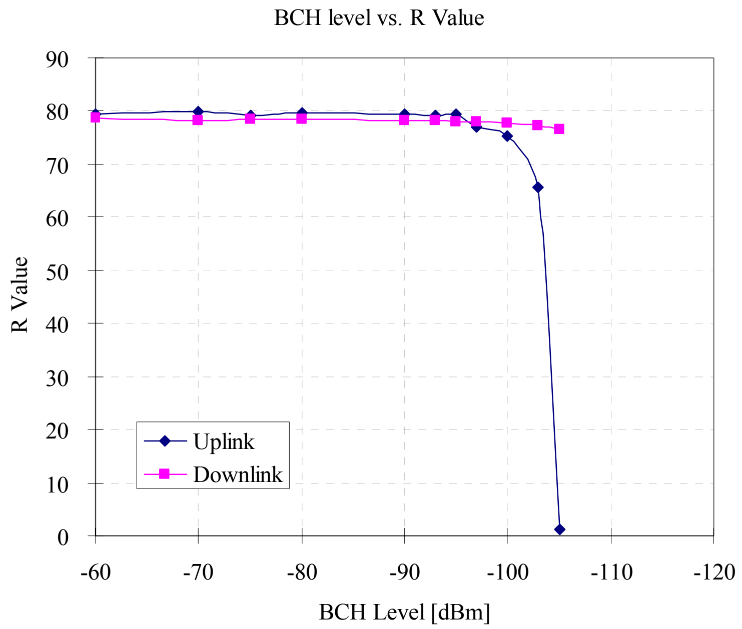

Figure 7-12 R-value for different BCH level

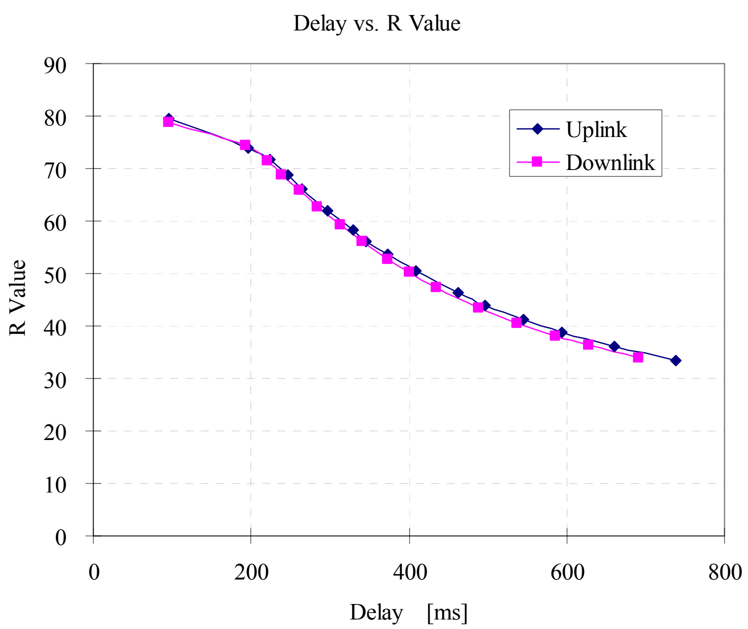

Figure 7-13 R-value for different delay

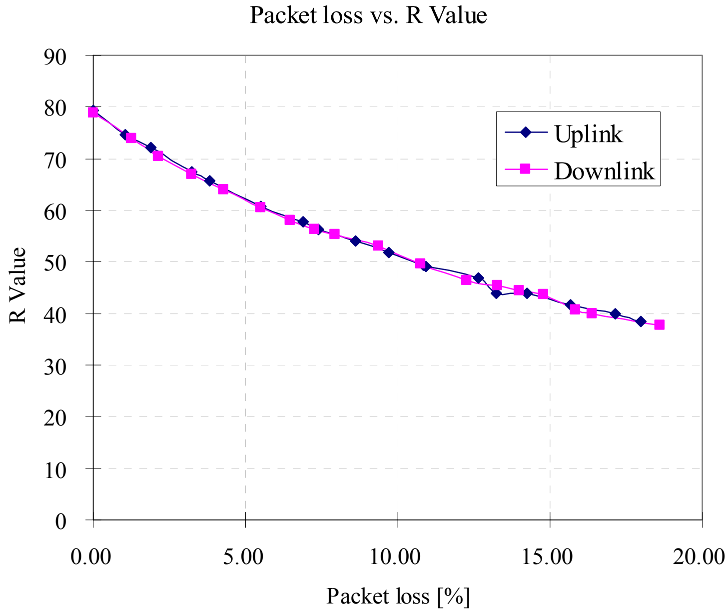

Figure 7-14 R-value for different packet loss

7.1.3 VoIP and HTTP user performance

This section presents the performance when enhancements techniques are used in a system with coexisting VoIP and HTTP users. 625k-MC allows 11 ModClasses giving a higher data rate with higher ModClass. However, VoIP users need a much lower data rate. Hence it is useful to limit the peak modulation class for VoIP sessions. Limiting peak modulation class reduces transmit power (for non-cell edge users). This helps in reducing system interference level for both uplink and downlink and increase the battery life on the uplink. Figure 7-15 plots the cdf of the data rate of the HTTP users, when the ModClass for VoIP is not restricted (red dashed line) and restricted to 0 (blue solid line).

A prevalent voice coding scheme is G.729 with VAD/CNG and a common mode within this scheme is 8kbps coded voice bit rate with two coded speech samples per RTP packet. Adding in RTP/UDP/IP/625k-MC header, this results in a maximum voice stream bit rate of 25.2kbps.

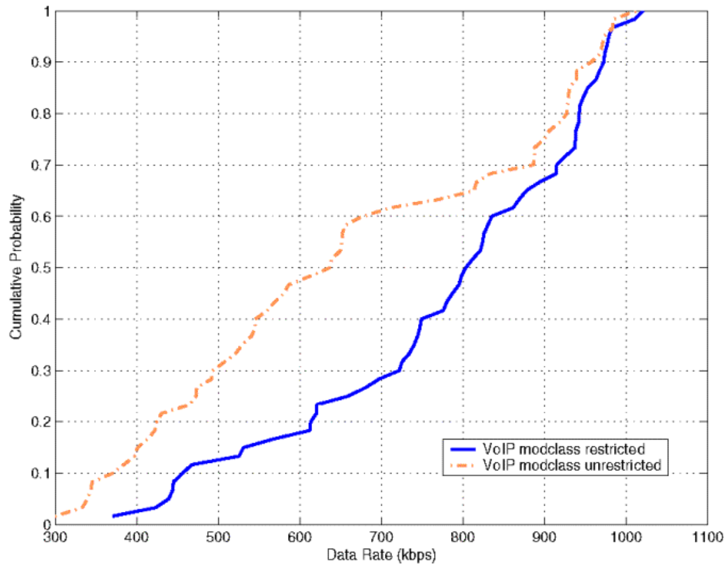

Figure 7-15 HTTP user throughput in the presence of VoIP users

Figure 7-16 and Figure 7-17 plot the percentile distribution results of uplink and downlink voice quality for 24 users as HTTP users varies. The voice quality remains almost same irrespective of the number of HTTP users. Network dealy is not considered. ModClass restriction is used for VoIP users.

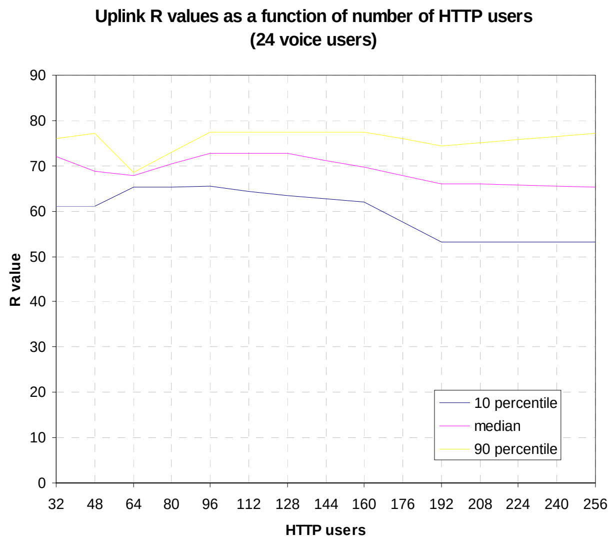

Figure 7-16 Uplink R-values for VoIP users

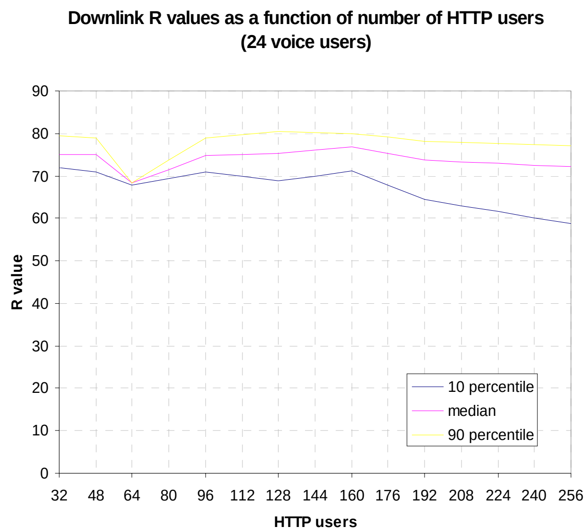

Figure 7-17 Downlink R-values for VoIP users

7.1.4 FTP And HTTP

Figures 7-18 below present the aggregate BS downlink throughput as a function of the number of users registered on the BS. Here, the throughput is defined in terms of data delivered from the client TCP stack to the client FTP stack, i.e., in terms of useful FTP application data delivered to the user. Figures 7-19 below present the aggregate BS downlink throughput as a function of the number of FTP users registered on the BS when HTTP and FTP users exist. In all of these simulations, for ease of presentation, there were exactly 4 HTTP users. The aggregate throughput results with mixed traffic look almost exactly like the aggregate throughput results for the FTP-only traffic scenarios presented in Fig. 7-18. This is because the HTTP users have very bursty traffic but a very small average data rate when compared with the FTP users. Therefore the HTTP users neither degrade nor contribute much to the aggregate capacity in these mixed traffic scenarios.

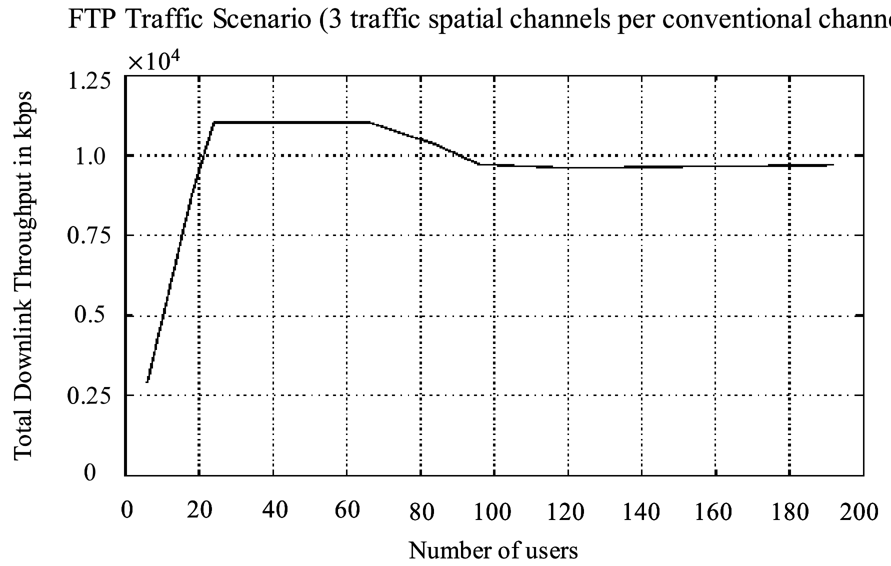

Figure 7-18 Aggregate BS FTP data throughput for heavy downlink traffic

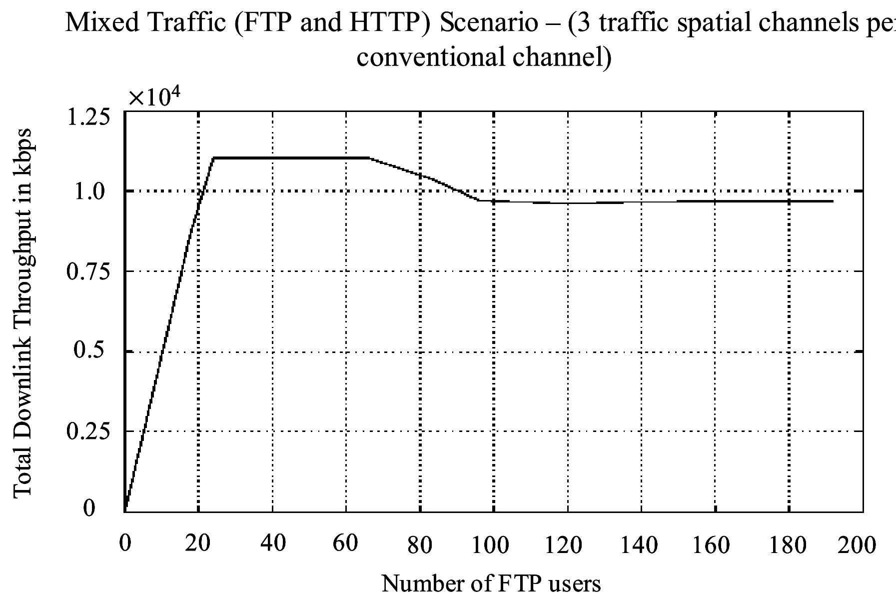

Figure 7-19 Aggregate BS FTP data throughput for heavy downlink traffic

7.1.5 TCP – HTTP

Figures 7-20 and 7-21 below present the HTTP web page response time as a function of the number of users registered on the BS for uplink and downlink.

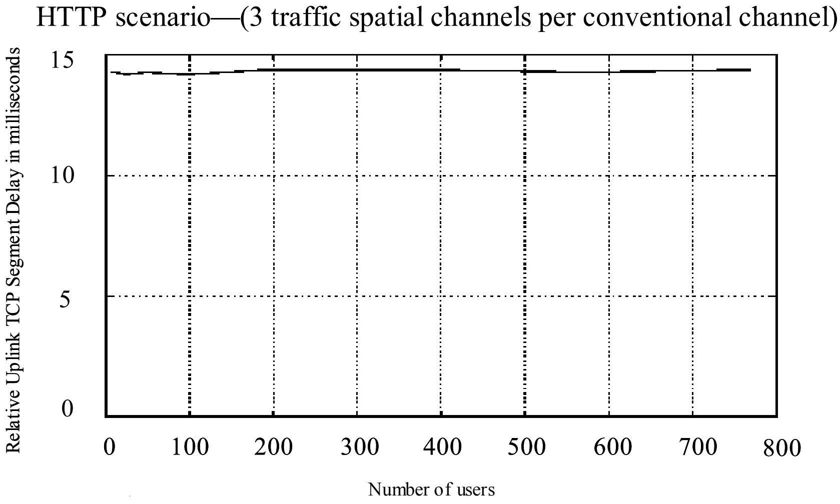

Figure 7-20 Relative uplink TCP segment delay

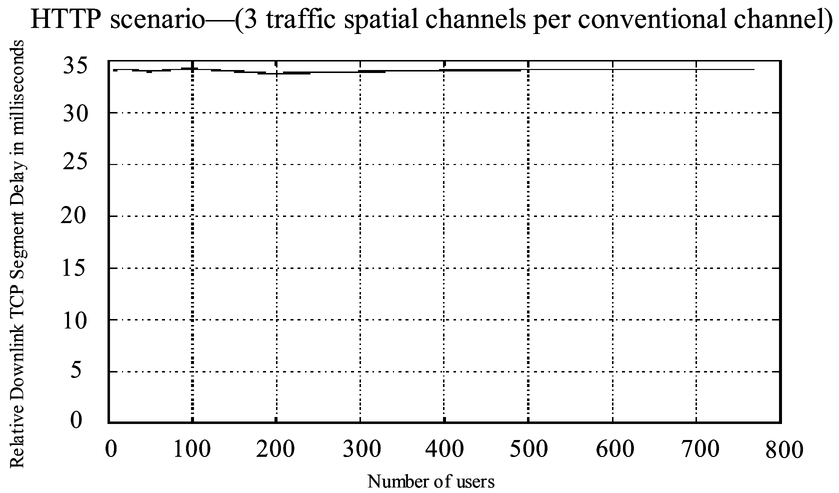

Figure 7-21 Aggregate BS FTP data throughput for heavy downlink traffic

7.2 Traffic mix

Traffic mix as shown in Table 7-2 is used.

Table 7-2 Traffic mix: percentage of different Traffic Types

Traffic Category	Application	Percentage (%)
Best Effort	FTP	30
Interactive	Web browsing	30
Streaming	Video streaming	30
Real-time	VoIP	10

The simulation parameters for this evaluation are given in Table 7.3. The channel model parameters are given in Table 5-1 and 5-2..

Table 7-3 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)

The suburban macro 3km/hr, 120km/hr and the channel mix scenario are considered [5]. The channel mix percentage is as specified in Table 7.4 and Table 7.5 [5].

Table 7-4 Suburban macro channel mix

Channel PDP Models	**I**			**II**			**III**	**IV**		
User speed (km/h)	3	30	120	30	120	250	3	30	120	250
Probability	0.20	0.12	0.08	0.12	0.08	0.0	0.20	0.12	0.08	0.0

Table 7-5 Urban micro channel mix

Channel PDP Models	**I**			**II**			**III**	**IV**		
User speed (km/h)	3	30	120	30	120	250	3	30	120	250
Probability	0.29	0.14	0	0.14	0	0	0.29	0.14	0	0

The per user average throughput and packet delay for the various application under the traffic mix scenario are plotted in Figure 7-22 and Figure 7-23. There are 21 users in each sector.

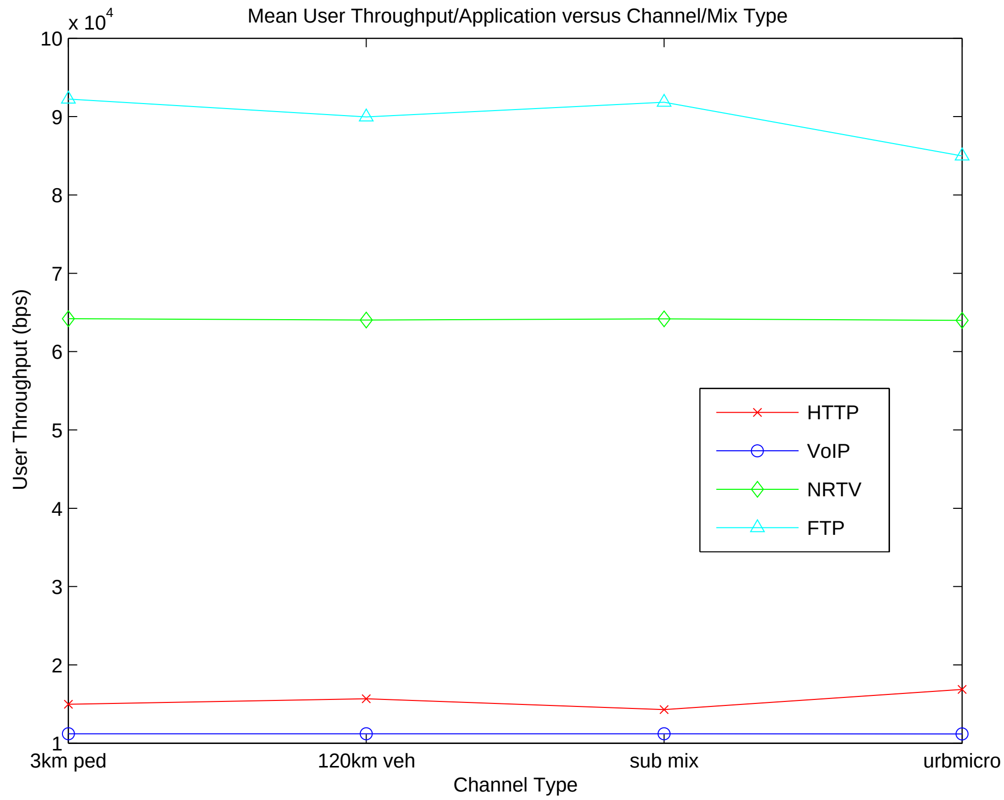

Figure 7-22 User throughput under traffic mix scenario

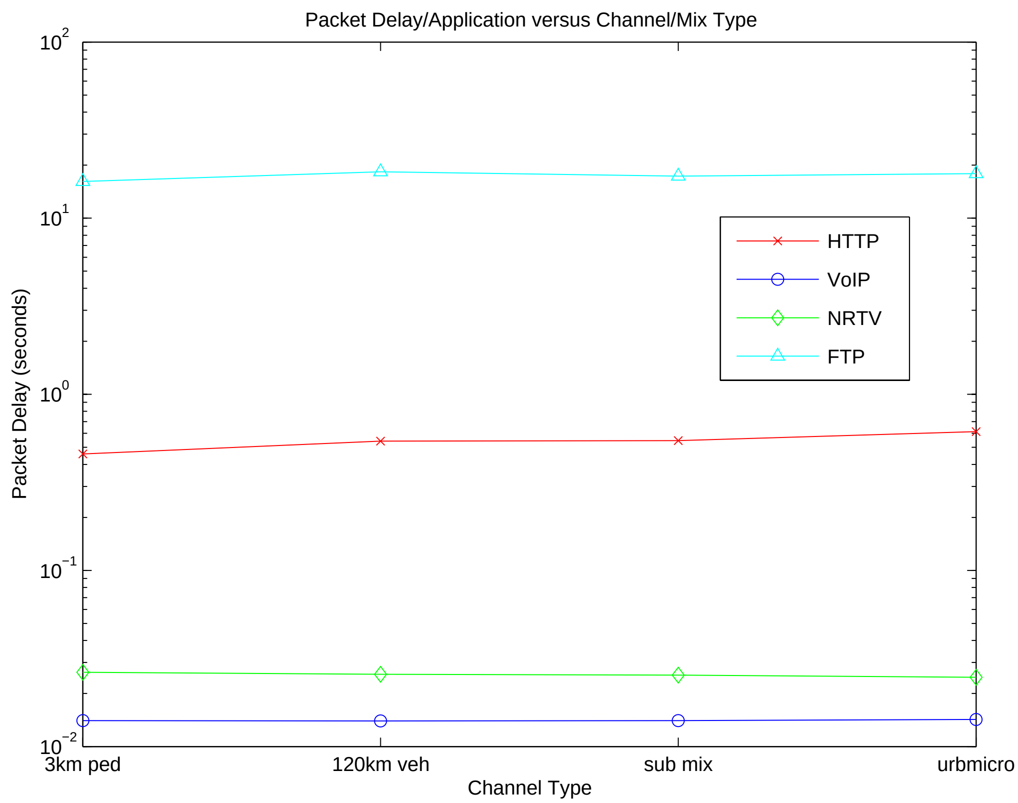

Figure 7-23 Packet delay under traffic mix scenario

The R-factor cdf for the VoIP user in a traffic mix scenario is plotted in Fig. 7-24. The R-value was found to be greater than 78.

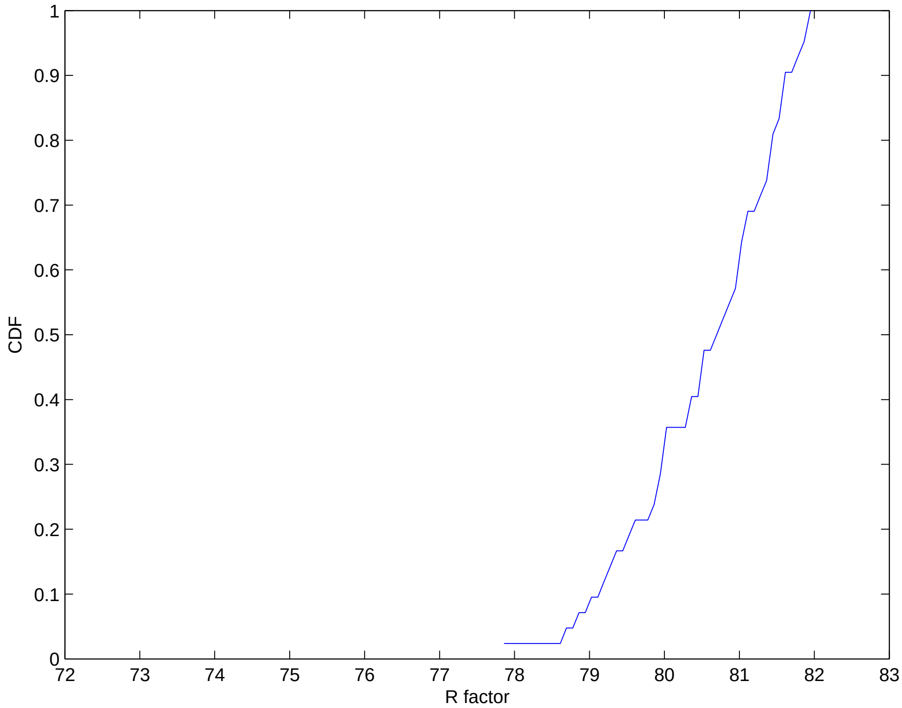

Figure 7-24 R-value cdf

7.3 <u>Mobility Model</u>

7.3.1 Handover procedure

Handover is performed as described in Chapter 22 of [8] and a minimum of 6 frames will be necessary for handover. The handover procedure for UT in connected state and UT in not-connected state is the same. UT continuously monitors the signal level from surrounding BSs. When the UT finds signal level form a BS to which the UT is not currently registered to be higher that the signal level from the BS to which it is registered, handover occurs.

7.3.2 Mobility direction

A 19 cell system is considered. Only one UT is assumed to be moving while the rest of the UT are assumed stationary as specified in [5].The UT moving in the direction as shown in Fig. 7.25 is considered. The UT is connected to the center BS.

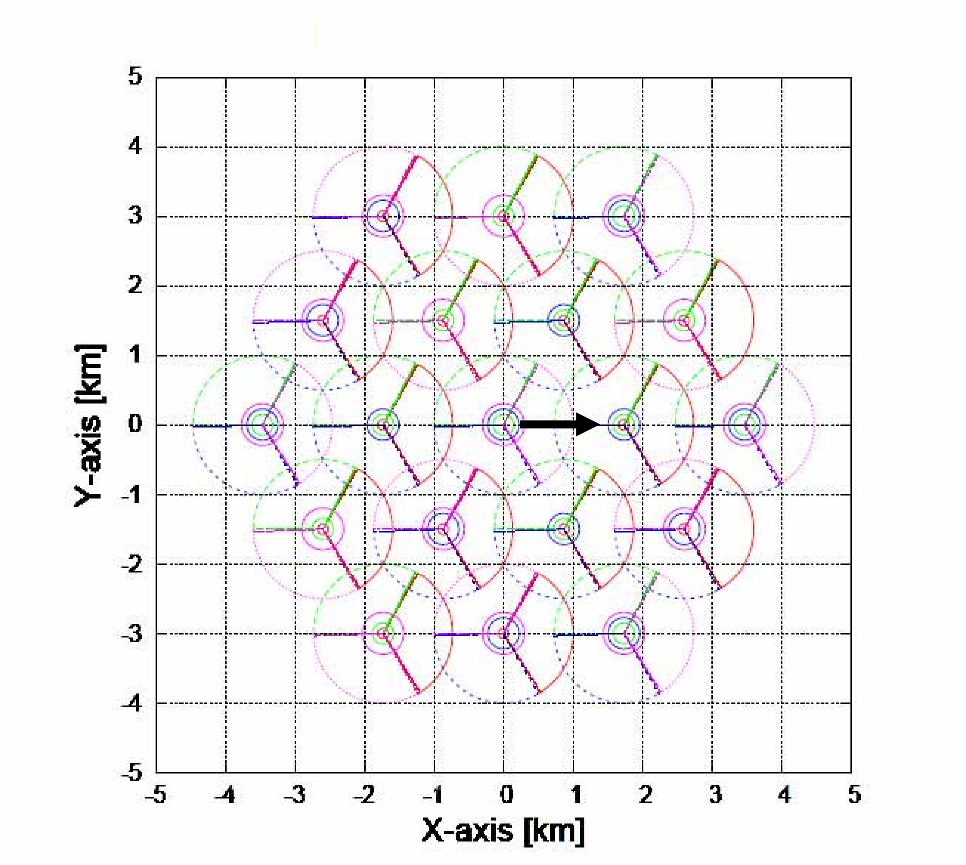

Figure 7-25 Mobility direction

7.3.3 Handover distance

The distance from the originating BS at which handover occurs is plotted in Fig. 7-26, 7-28 and Fig. 7-30 for UT velocity of 3km/hr, 30km/hr and 120km/hr, respectively. An edge loss of 9dB was incurred around the distance where the maximum number of handover occurred. The red line in Figs 7-27, 7-29 and 7-31 show the distance from the originating BS where the 9dB edge loss was enforced. When edge loss is enforced, probability of handover at the edge loss location increases. In all the simulations performed there was no handover failure.

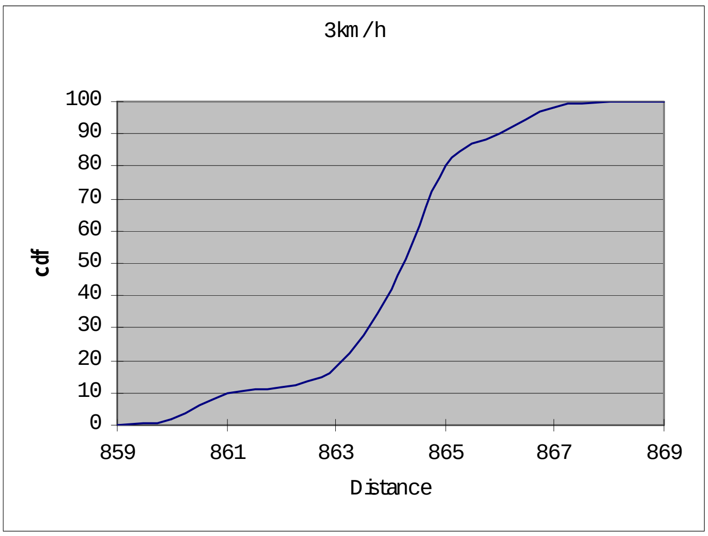

Figure 7-26 Handover distance for 3km/hr

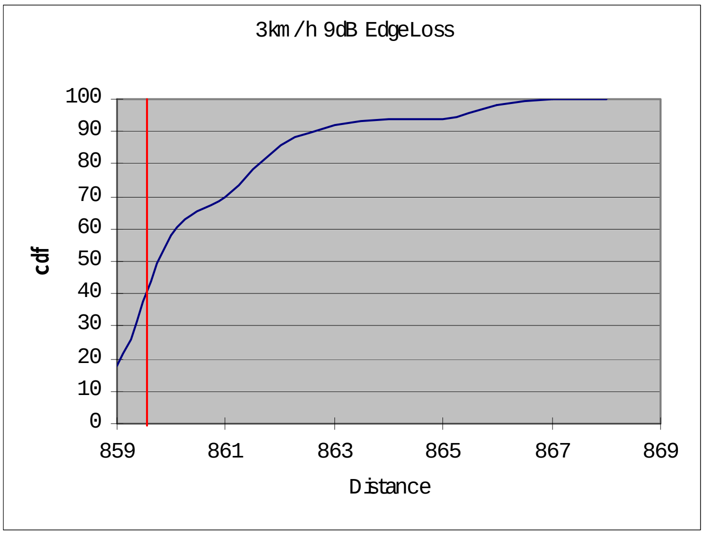

Figure 7-27 Handover distance for 3km/hr with edge loss

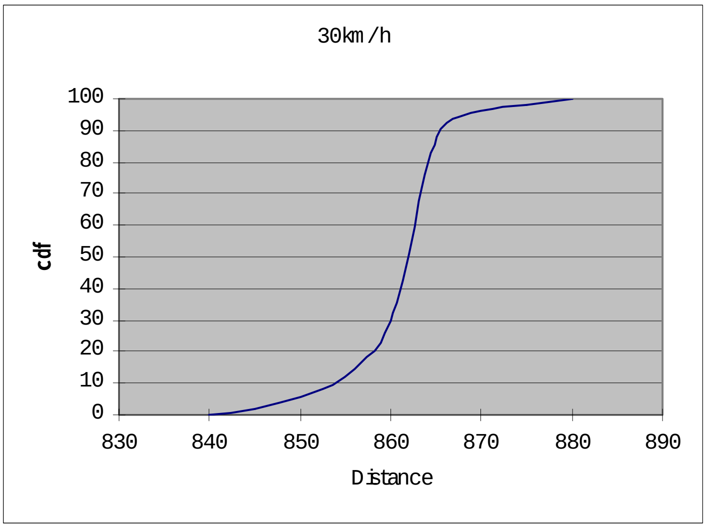

Figure 7-28 Handover distance for 30km/hr

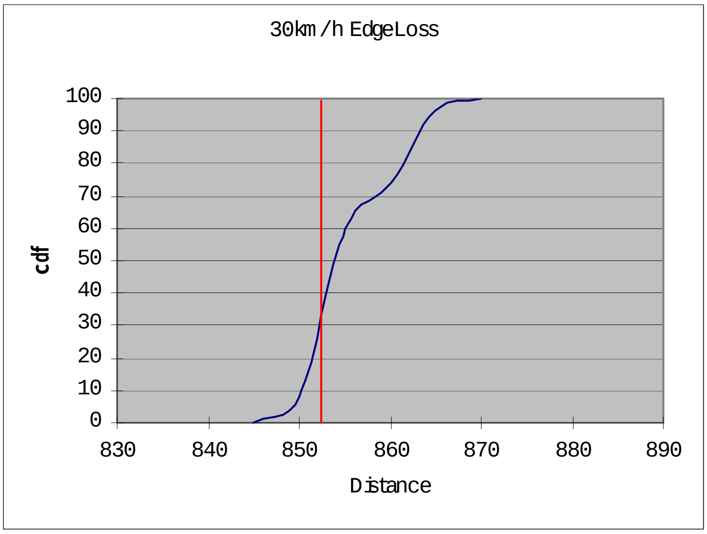

Figure 7-29 Handover distance for 30km/hr with edge loss

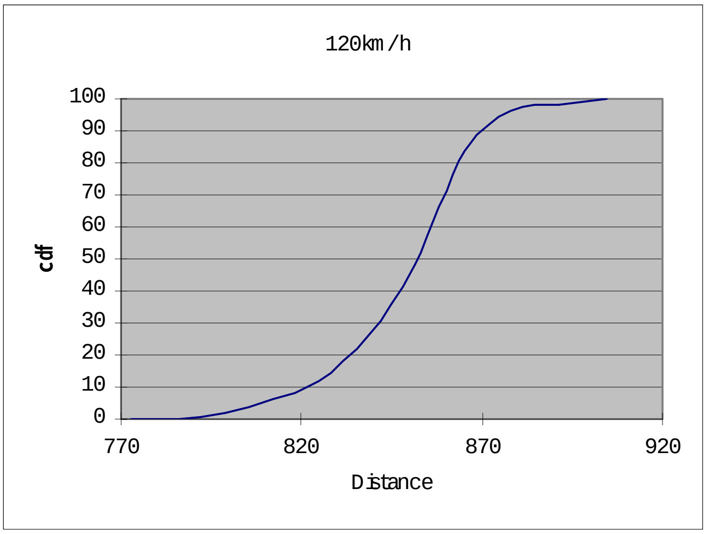

Figure 7-30 Handover distance for 120km/hr

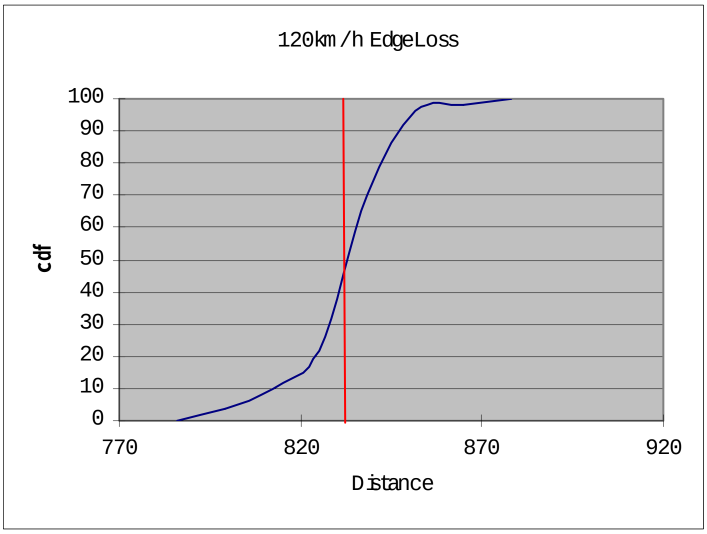

Figure 7-31 Handover distance for 120km/hr with edge loss

Figure 7.32 shows the distance from the handover start point over which the handover is performed. For 3km/hr, 90% of the users perform handover within 10m.

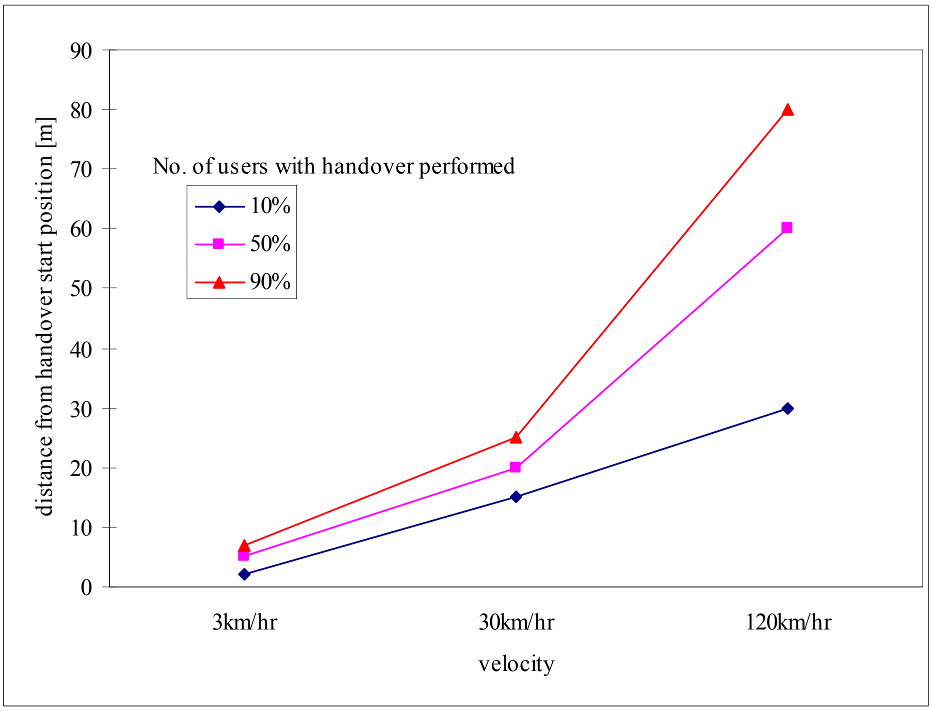

Figure 7-32 Handover range

7.3.4 Handover Delay

The handover delay shown in Fig. 7-33 is the cdf taken over all the velocities: 3km/hr, 30km/hr and 120km/hr. Minimum of 30ms (6 frames) is required for handover. However, due to frame error, the handover delay increases and the probability of delay between 40 to 45 ms was the highest. The average delay was found to be about 42ms.

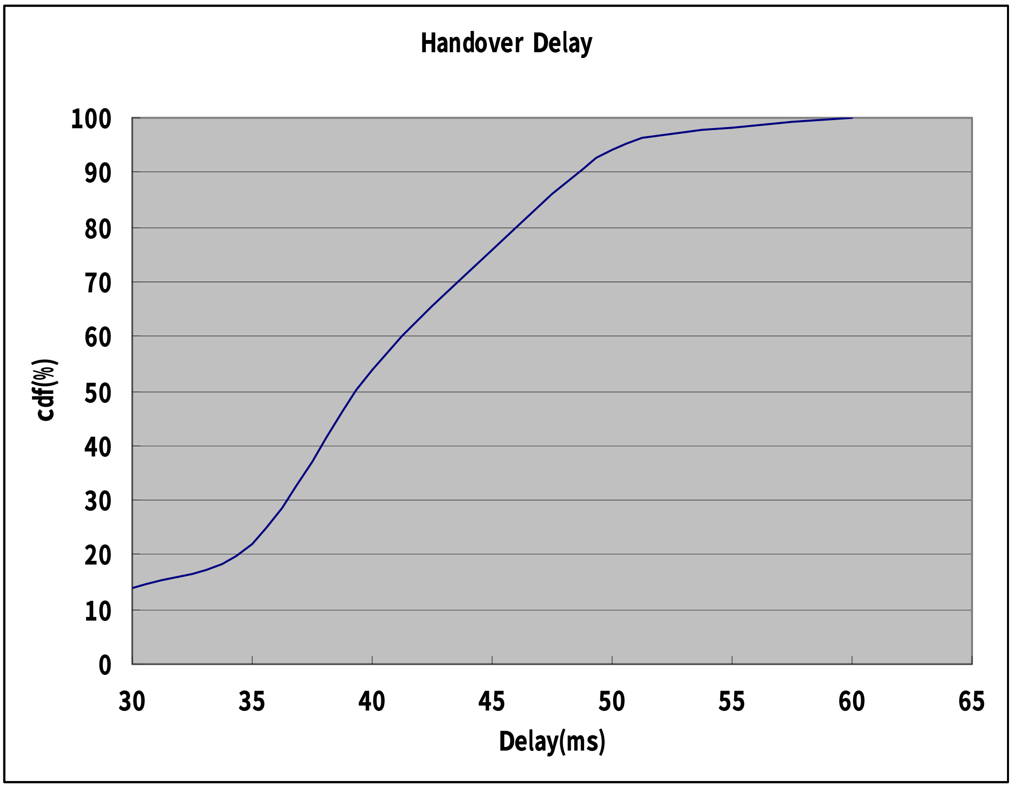

Figure 7-33 Handover delay

7.4 Overhead Channels

The UT receiver is expected to detect the desired page burst and reject undesired bursts always. Undesired bursts include noise-only case and page bursts intended for other users. Under certain channel conditions, UT can have a false detect or reject a valid page burst. False alarm increases RA (Random Access) interference whereas failure to detect valid page bursts increases latency. The UT receiver's ability to maximize detection probability and minimize false alarm rate (FAR) is an important performance measure.
625k-MC system has some mechanisms for improvement of data transmitting using overhead channels as following.

7.4.1 PCH Transmission

In a fading channel, if the page burst gets deeply faded, detection probability drops drastically. In order to improve the detection probability, it's better to have multiple representations of the burst with time diversity. Currently, 625k-MC supports two-slot selection diversity. Fig 7-34 shows the sub slots structure of PCH burst. PCH burst consist from implied resource and diversity resource as shown in Fig. 7-34.

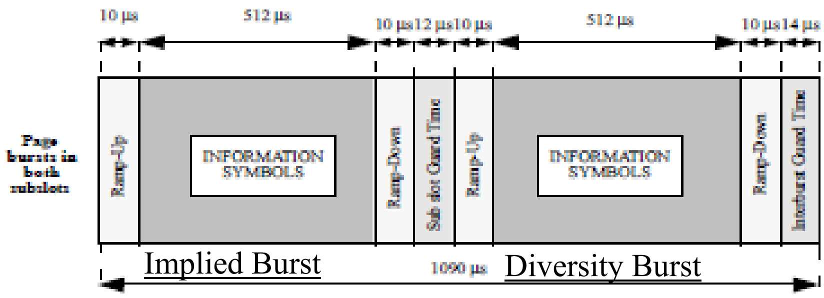

Figure 7-34 PCH physical burst structure

A page burst is detected if the normalized correlation between the received and the reference page bursts exceed the detection threshold. The detection threshold is calculated to achieve a fixed FAR. To achieve an FAR of 10^{-5}, the detection threshold is set to 0.2362 for the normalized correlation.
Desired page burst - single slot (0Hz Fading Channel) - Due to large spread in the distribution of the correlation ratio, a fading channel requires more power than the AWGN channel to achieve the same detection rate when only one slot is used. Figure 7-35 shows that we can achieve more than 90% detection at -2dB SNR.
Desired page burst - two slot diversity (0Hz Fading Channel) - In order to improve the detection probability in a fading channel, two-slot selection diversity is used in 625k-MC. Figure 7-36. shows that we can achieve more than 90% detection at -8dB SNR. This result is 6 dB better than the case when we use a single slot.

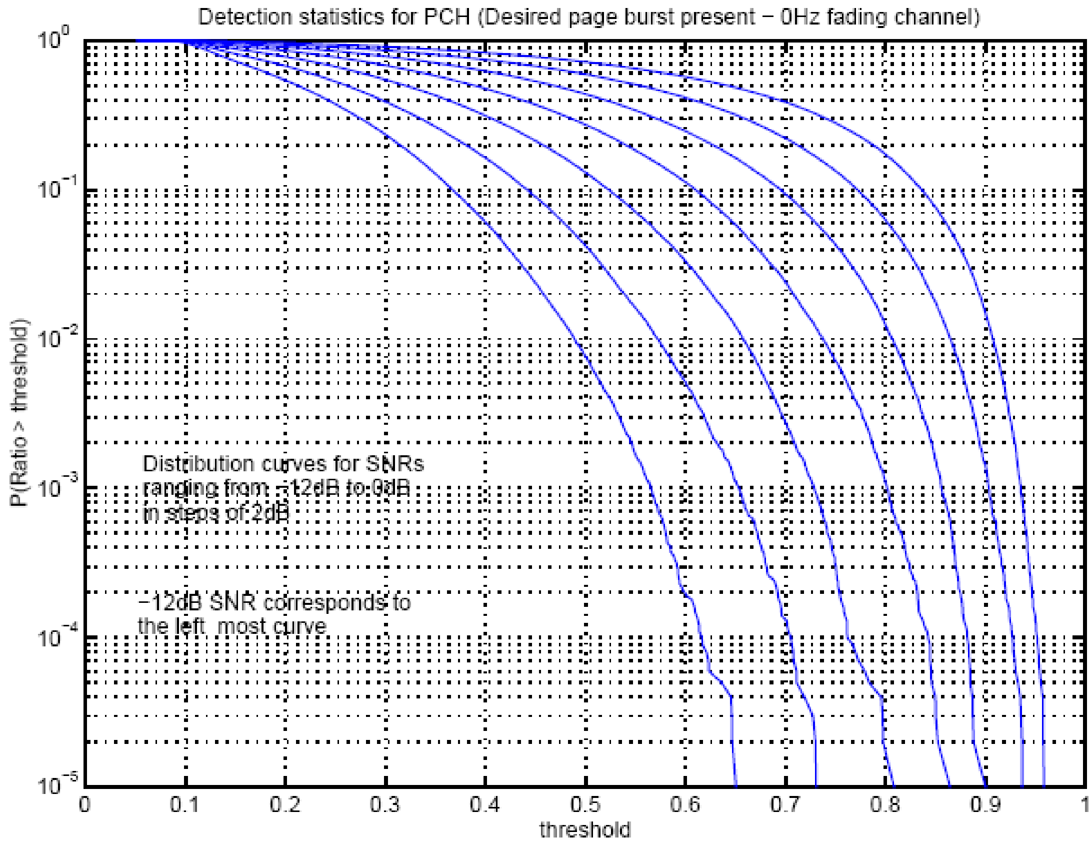

Figure 7-35 PCH detection statistics with one-slot diversity

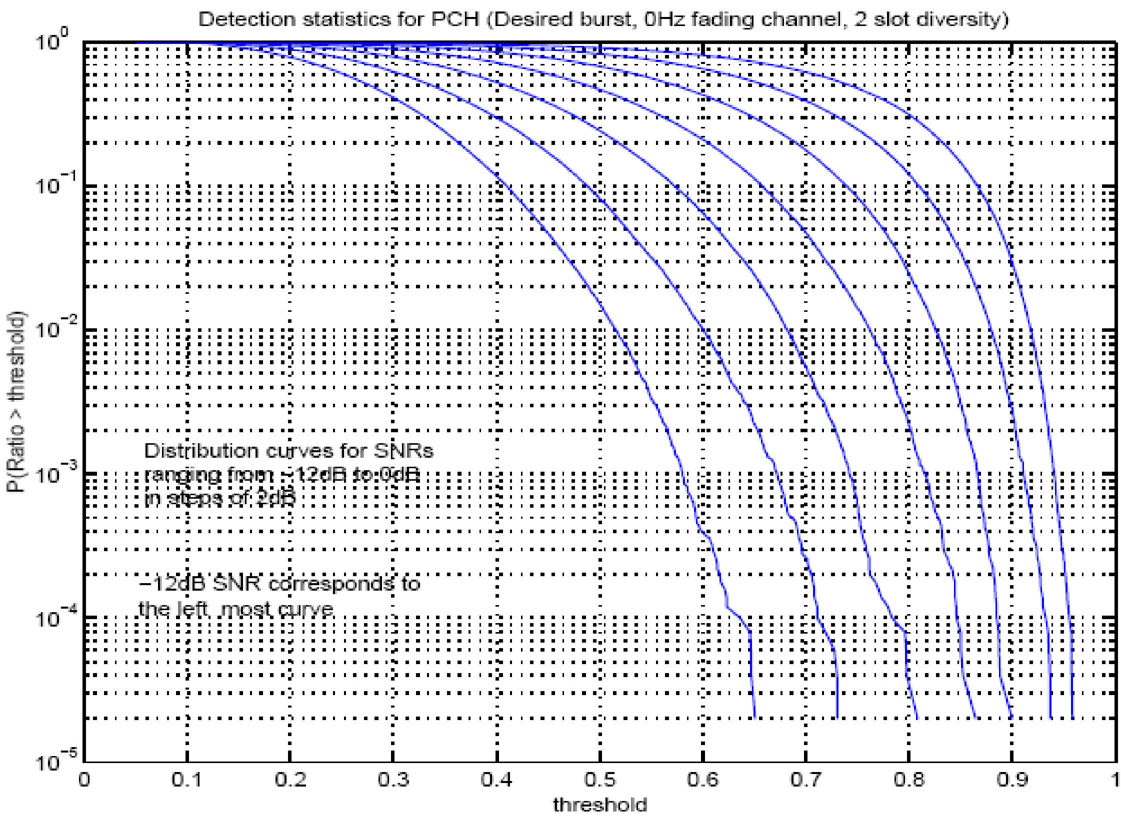

Figure 7-36 PCH detection statistics with two-slot diversity

8 Practical System Results

The proposed MBTDD 625k-MC (BEST-WINE)'s base system HC-SDMA [1] has been implemented and tested in some countries. Few snapshots of experimental results from the experimental set up in Yokohama, Japan are shown below. Figure 8-1 shows the average throughput of 1Mbps for 21 users, communicating simultaneously. The FTP throughput when the vehicle is moving at an average speed of 60km/hr and 100km/hr is shown in Figure 8-2. The handover result for a vehicle is moving at an average speed of 60km/hr is shown in Figure 8-3. A high average throughput is maintained in spite of the handover.

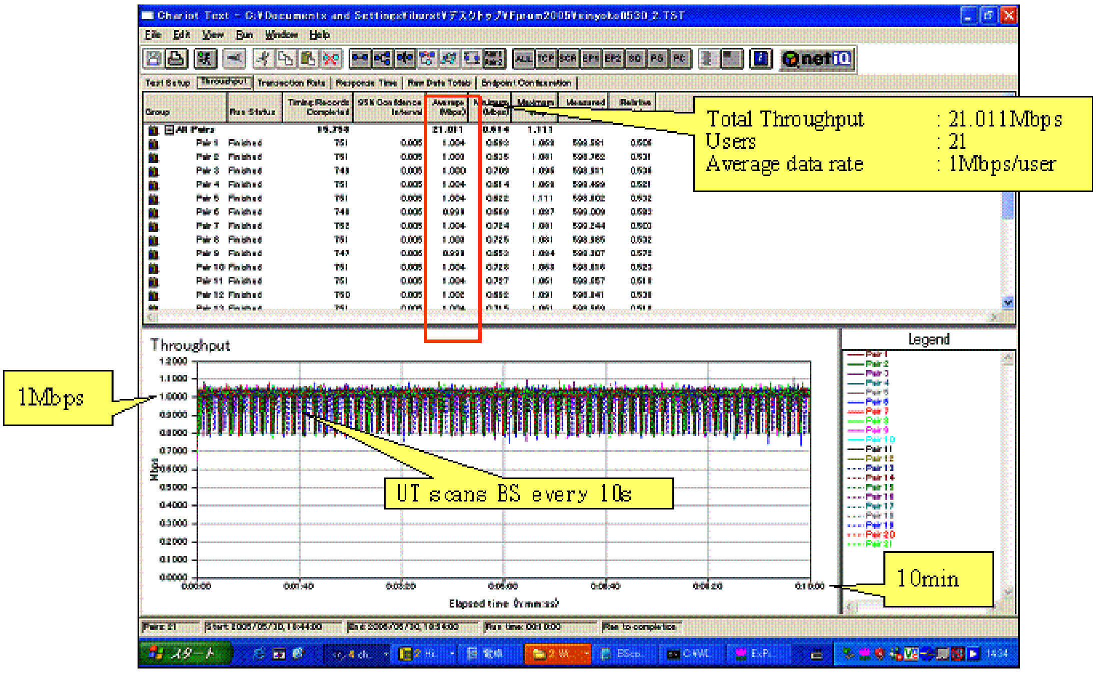

Figure 8-1 Data rate of 1Mbps for 21 simultaneously communicating users

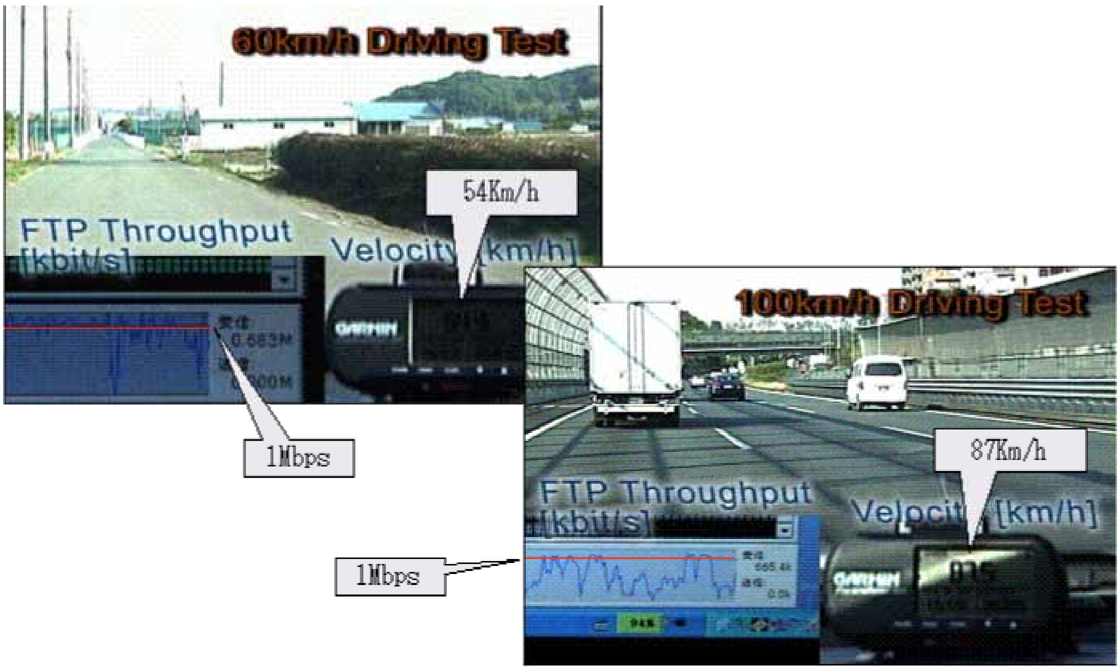

Figure 8-2 Throughput for 60km/hr and 100km/hr

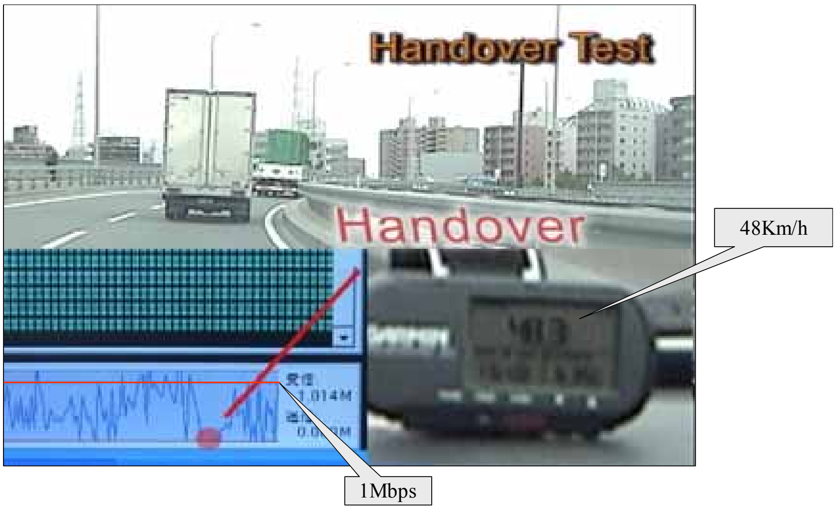

Figure 8-3 Handover test

Traffic mix results from field tests:

A field test for traffic mix with the same percentage of each application as that for simulation was performed. The conditions are as follows:

Carrier	4 (with 3 spatial channels)	
BS	1 (2.5MHz)	
UT	34	
Load	FTP	10 users
	Video Streaming (Video)	10 users
	Web browsing (HTTP)	10 users
	VoIP	4 users

Video: 5 mins of content requiring a data rate more than 450kbps was repeated viewed using real player.
Ftp: Data of 100Mbyte was continuously downloaded.
HTTP: The following 22 pages were viewed repeatedly. Each page was viewed for 6secs after being displayed.

1. http://homepage.mac.com/jinjin/applescript/
2. http://www.geocities.co.jp/SiliconValley/2627/
3. http://www02.so-net.ne.jp/~oable/okui/unix_howto.html#ftp/
4. http://www.atmarkit.co.jp/fnetwork/rensai/tcp05/01.html#5/
5. http://www2s.biglobe.ne.jp/~hig/ppp/ppp.html#PPP_5/
6. http://www.ne.jp/asahi/earth/stomomi/RFC/
7. http://www.ipc.kobe-u.ac.jp/contents/Kouhou/mage/mage24/terashima/node12.html/
8. http://www.allied-telesis.co.jp/library/nw_guide/index.html/
9. http://www.dive-in.to/~hideto/mtu/
10. http://www.yahoo.co.jp/
11. http://www.msn.co.jp/home.armx/
12. http://search.cqpub.co.jp/finder/Searchterm.asp?q1=ssi/
13. http://news.yahoo.co.jp/ranking/
14. http://homepage1.nifty.com/masawat/sen_html/pcdos.html/
15. http://www.atmarkit.co.jp/fwin2k/win2ktips/044nat/nat.html/
16. http://www.google.co.jp/

17. http://e-words.jp/
18. http://e-words.jp/
19. http://www.soi.wide.ad.jp/
20. http://www.princeton.co.jp/
21. http://www.kokuyo.co.jp/
22. http://www.hagitec.co.jp/

The result of the field test are presented in Fig. 8.4. From the experimental result it can be observed that a stable throughput has been achieved for the VoIP users. The R-value for VoIP was greater than 79.

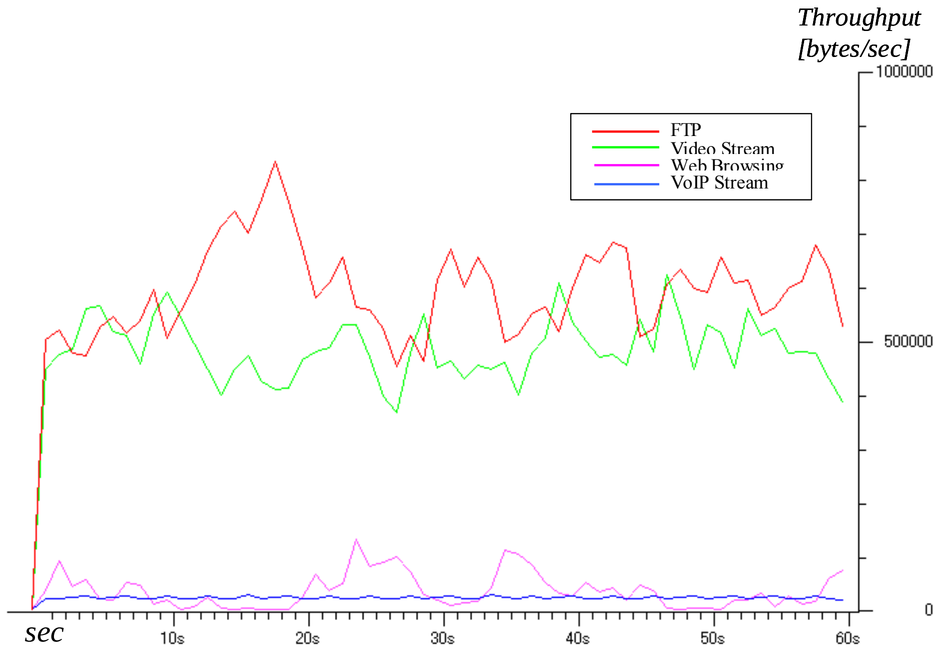

Figure 8-4 Field test result for traffic mix

Overhead Channel:

Table 8.1 shows the throughput obtained from the field test with 24 UT continuously downloading data.. Theoretically obtainable throughput can be calculated as follows:
Maximum obtainable downlink throughput: 1,061 kbps × 24 CH = 24.9 Mbps
Maximum obtainable uplink throughput: 346 kbps × 24 CH = 8.1 Mbps

The difference between the theoretical and field test throughput is due to the overhead channel and the channel. The loss is seen to be less than 10% for both uplink and downlink. Hence even for no loss in the channel, the loss due to overhead channels in a continuous download condition is seen to be less than 10%.

Table 8-1 Date rate and spectrum efficiency test results

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**