| | | |
|---|---|---|
| **Project** | IEEE 802.20 Working Group on Mobile Broadband Wireless Access <http://grouper.ieee.org/groups/802/20/> | |
| **Title** | **UMBFDD Performance Report 1 Presentation** | |
| **Date Submitted** | 5 March 2007 | |
| **Source(s)** | Al Jette,<br>Shirish Nagaraj,<br>Val Oprescu | 1-847-632-4201, A.Jette@motorola.com<br>1-847-632-2362, Shirish.Nagaraj@motorola.com<br>1-847-435-0053, voprescu@motorola.com |
| **Re:** | MBWA Call for Proposals (802.20 - 07/02) | |
| **Abstract** | This contribution contains the presentation of the UMBFDD Performance Report 1 results. | |
| **Purpose** | For consideration by 802.20 as it evaluates proposals for FDD MBWA. | |
| **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 <http://standards.ieee.org/guides/opman/sect6.html#6.3> and in *Understanding Patent Issues During IEEE Standards Development* <http://standards.ieee.org/board/pat/guide.html>. | |

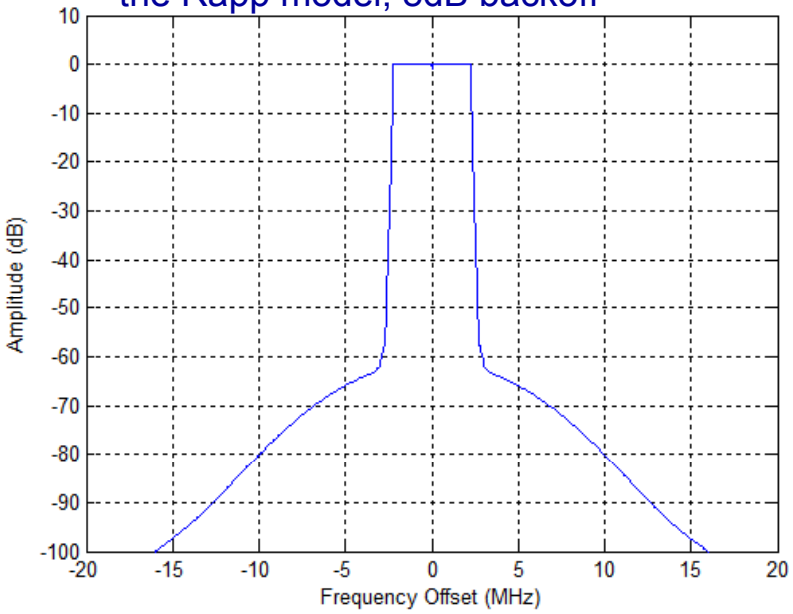
# UMBFDD Performance Report I Presentation

# Out-of-Band Emissions

- **Spectral shape of 5MHz transmitted, modulated carriers shown**
- **Both meet FCC emissions spec**

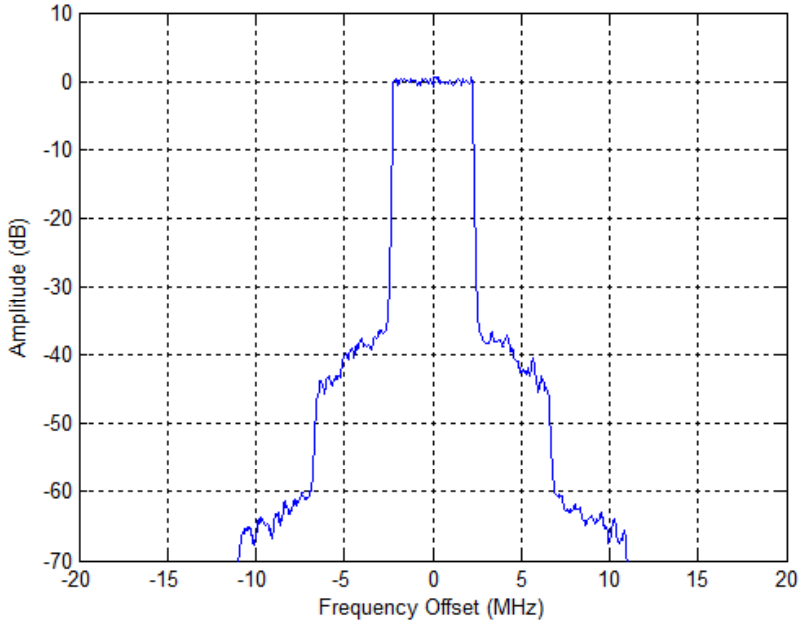
## Forward Link

- 512 sub-carriers spaced 9600Hz center-to-center, including 16 guard subcarriers on each side
- Remaining 480 sub-carriers are QPSK-modulated
- Feedforward power amplifier based on the Rapp model, 8dB backoff




## Reverse Link

- Full band hopping, two tiles of subcarriers
- Amp based on Rapp model, 6.5dB backoff

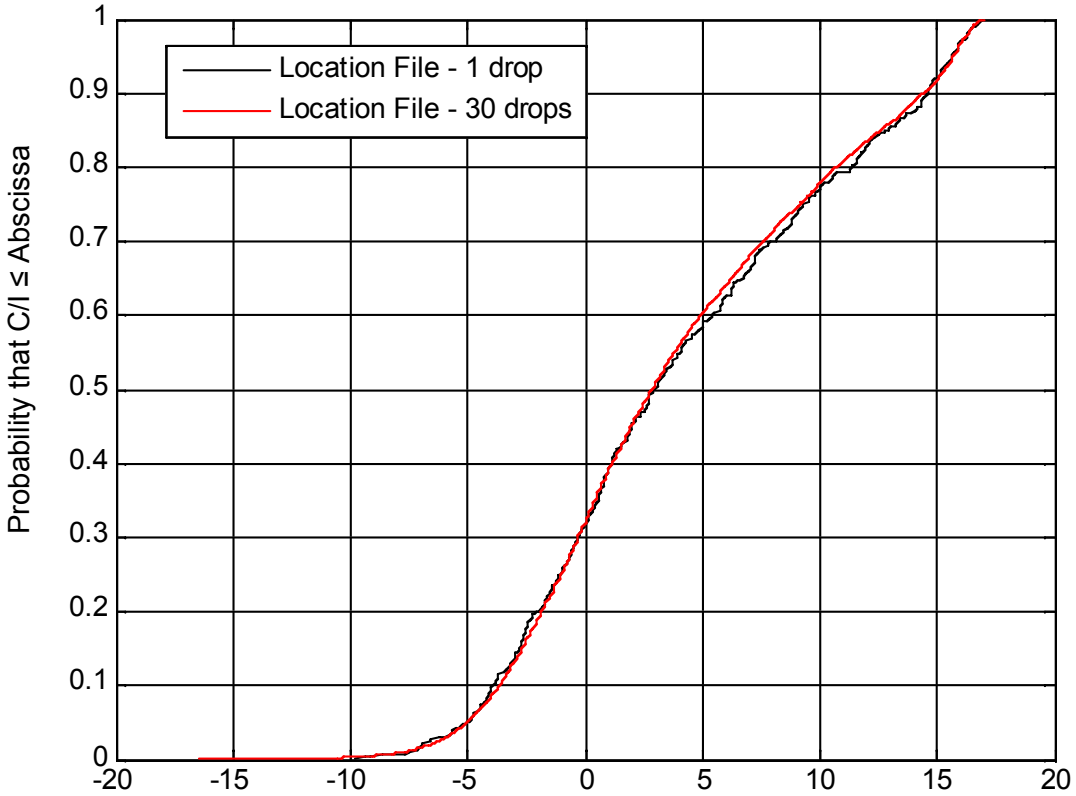


# Peak Data Rates

| *Parameter* | *Bandwidth* | | | |
|---|---|---|---|---|
| | *1.25 MHz* | | *5 MHz* | |
| | *Downlink* | *Uplink* | *Downlink* | *Uplink* |
| *Peak User Data Rate Requirement* | *4.5 Mbps* | *2.25 Mbps* | *18 Mbps* | *9 Mbps* |
| *UMBFDD Peak User Data Rate Achieved* | *17Mbps* | *4Mbps* | *87Mbps* | *21Mbps* |

# Location Calibration

- **Performed in accordance with the procedures given in Evaluation Criteria document.**
- **Smoother thirty-drop curve is a consequence of having many more random lognormal draws.**



# Simulation Parameters (1)

| | Units | Downlink | Uplink |
|---|---|---|---|
| Carrier Frequency | Ghz | 1.9 | 1.9 |
| Bandwidth of Operation | MHz | 5 | 5 |
| Site Layout | | 19 cells/57 sector hex grid with wraparound | 19 cells/57 sector hex grid with wraparound |
| Site separation | km | 1, 2.5 | 1, 2.5 |
| Minimum separation between AT and BTS | m | 35 | 35 |
| Subcarrier Spacing | kHz | 9.6 | 9.6 |
| Sampling Rate | Mcps | 4.9152 | 4.9152 |
| FFT size | | 512 | 512 |
| Guardband | subcarriers | 32 | 32 |
| Cyclic Prefix | μs | 6.51 | 6.51 (pedB)<br>13.02 (vehB) |
| OFDM symbol length | μs | 113.93 | 113.93 (pedB)<br>120.44 (vehB) |
| # of OFDM symbols per frame | | 8 | 8 |
| # of subcarriers per symbol per subchannel | | 16 | 16 |
| # of HARQ Interlaces | | 8 | 8 |
| Max Number of HARQ attempts | | 6 | 6 |
| Source Model | | Full Buffer | Full Buffer |
| Pilot Overhead | % | 14.84 | 14.06 |
| Control overhead | % | 10 | 10 |

# Simulation Parameters (2)

| | Units | Downlink | Uplink |
|---|---|---|---|
| ITU Channel Model Usage | | 100% pedB/3 kph<br>100% vehB/120 kph<br>(no mix) | 100% pedB/3 kph<br>100% vehB/120 kph<br>(no mix) |
| Propagation model | | Hata, 31.5 intercept, 35 dB slope | Hata, 31.5 intercept, 35 dB slope |
| Lognormal Shadowing standard deviation | dB | 10 | 10 |
| Site-to-site correlation coefficient | | 0.5 | 0.5 |
| Noise Floor | dBm/Hz | -174 | -174 |
| Receiver noise figure | dB | 10 | 5 |
| Max Tx Power | dBm | 50 | 27 |
| Penetration Loss | dB | 10 | 10 |
| Body Loss | dB | 3 | 3 |
| Antenna pattern - BTS - Horizontal | | 3dB bandwidth: 70 deg, 20 dB max atten | 3dB bandwidth: 70 deg, 20 dB max atten |
| Antenna pattern - BTS - Vertical | | not modeled | not modeled |
| Antenna height - BTS | m | 32 | 32 |
| Antenna height - AT | m | 1.5 | 1.5 |
| Antenna gain - BTS (including cable loss) | dBi | 14 | 14 |
| Antenna gain - AT | dBi | 0 | 0 |
| Maximum C/I per antenna | dB | 30 | 30 |
| # of Tx Antennas | | 4 | 1 |
| # of Rx Antennas | | 4 | 2, 8 |
| Scheduler | | Proportional Fair | Proportional Fair |

# Downlink Packet Formats

| Packet Format Index | Spectral Efficiency on First Transmission | Modulation Order For Each Transmission | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6+ |
| 0 | 0.33 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 0.67 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 0.94 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1.5 | 4 | 3 | 3 | 3 | 3 | 3 |
| 4 | 2.0 | 4 | 3 | 3 | 3 | 3 | 3 |
| 5 | 2.5 | 6 | 4 | 4 | 3 | 3 | 3 |
| 6 | 3.0 | 6 | 4 | 4 | 4 | 4 | 4 |
| 7 | 3.5 | 6 | 4 | 4 | 4 | 4 | 4 |
| 8 | 4.0 | 6 | 6 | 4 | 4 | 4 | 4 |
| 9 | 4.5 | 6 | 6 | 4 | 4 | 4 | 4 |
| 10 | 5.0 | 6 | 6 | 4 | 4 | 4 | 4 |
| 11 | 6.0 | 6 | 6 | 4 | 4 | 4 | 4 |
| 12 | 7.0 | 6 | 6 | 6 | 4 | 4 | 4 |
| 13 | 8.0 | 6 | 6 | 6 | 4 | 4 | 4 |
| 14 | 9.5 | 6 | 6 | 6 | 6 | 4 | 4 |
| 15 | NULL | | | | | | |

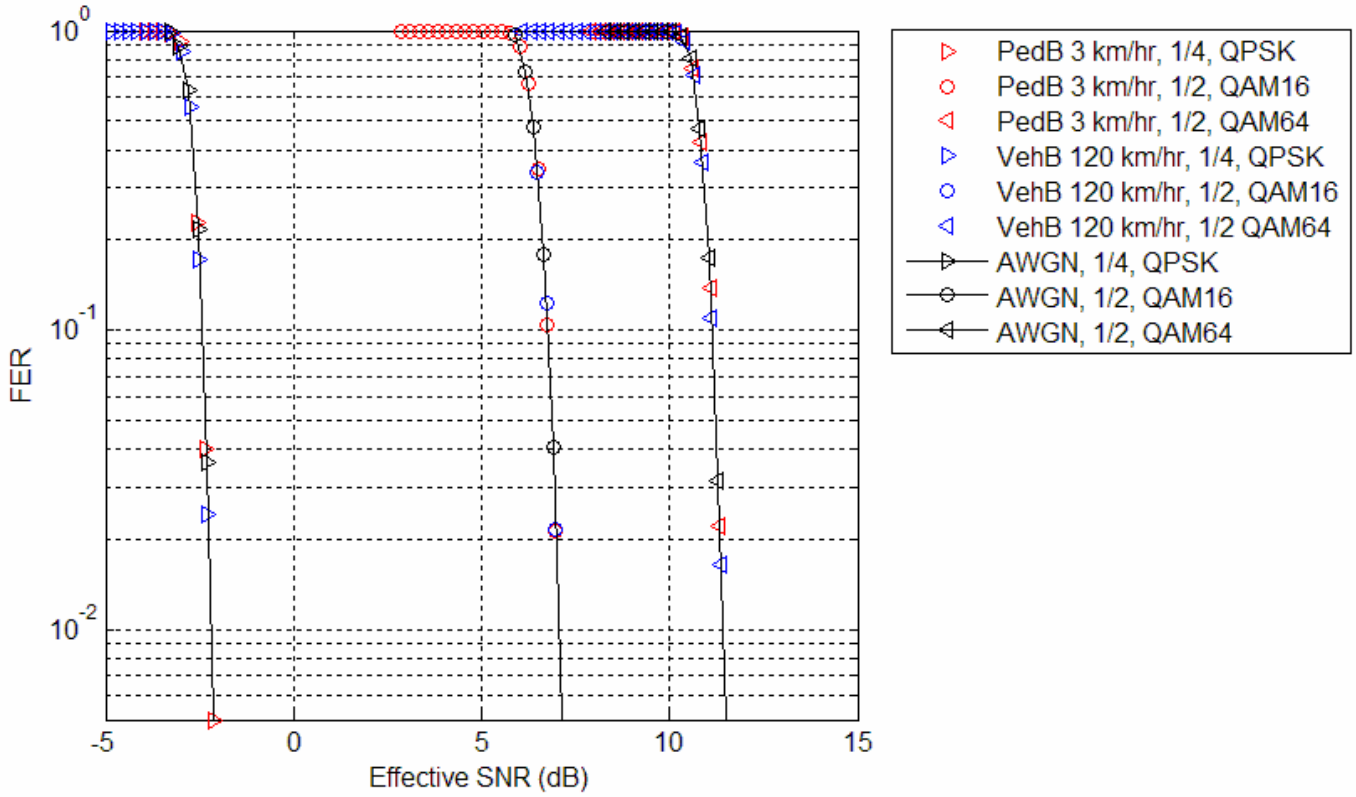
# Uplink Packet Formats

- 64 QAM not modeled
- Modulation step-down not modeled
  - packet formats were modified to accommodate

| Packet Format Index | Spectral Efficiency on First Transmission | Modulation Order For Each Transmission | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6+ |
| 0 | 0.36 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 0.71 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 1.07 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1.4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4 | 1.8 | 3 | 3 | 3 | 3 | 3 | 3 |
| 5 | 2.13 | 4 | 4 | 4 | 4 | 4 | 4 |
| 6 | 2.5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 7 | 3.0 | 4 | 4 | 4 | 4 | 4 | 4 |

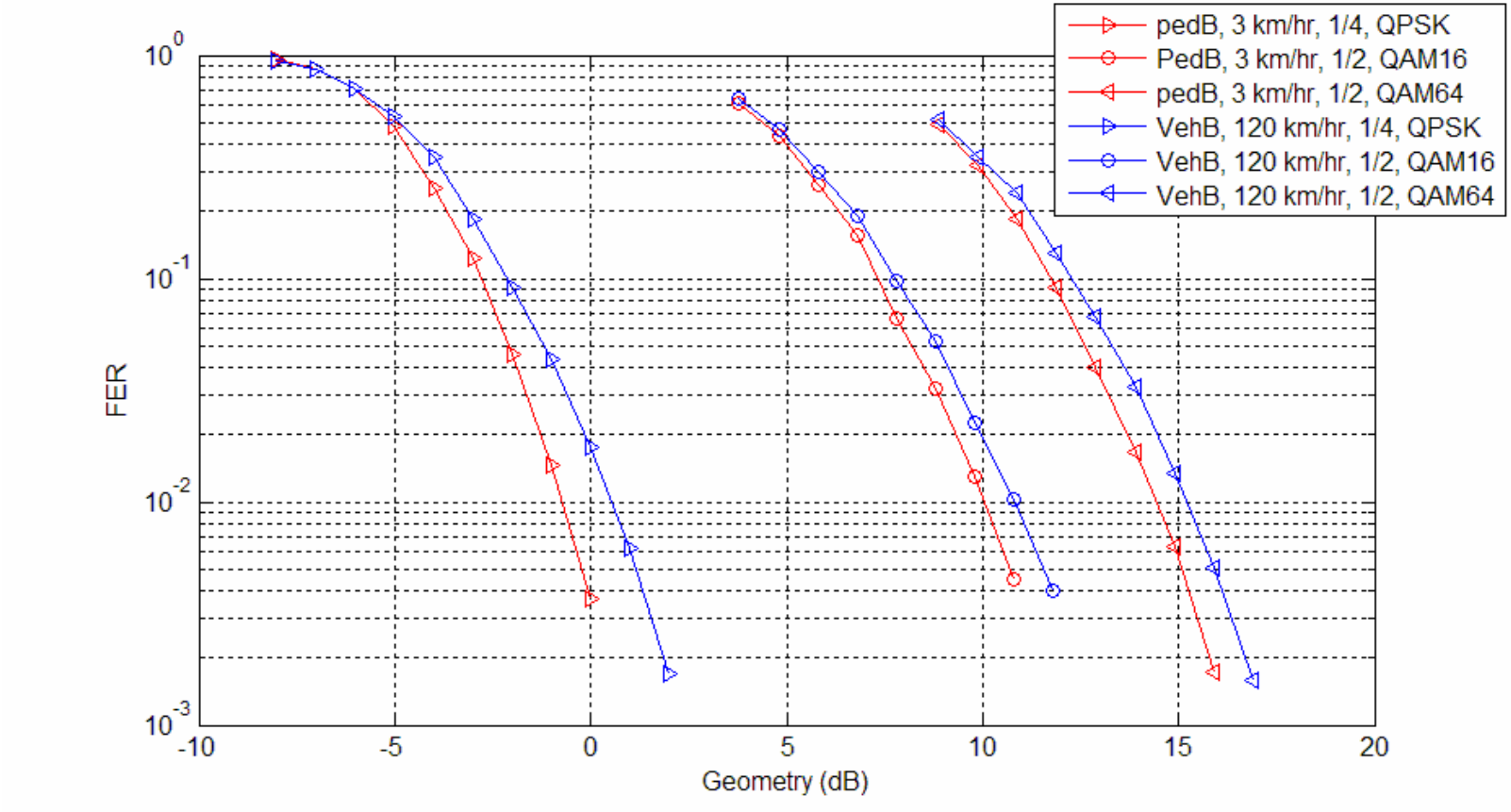
# ECM Validation Curves

- Link-to-system mapping used is **E**quivalent SNR Method based on **C**onvex **M**etric (ECM)
- Effectively same as one proposed to the 802.20 working group: Effective SNR
- Validated with AWGN, Ped B and Veh B, for SIMO transmissions
- Result: mapping method is accurate - all channel models show near-identical results for FER vs. Effective SNR



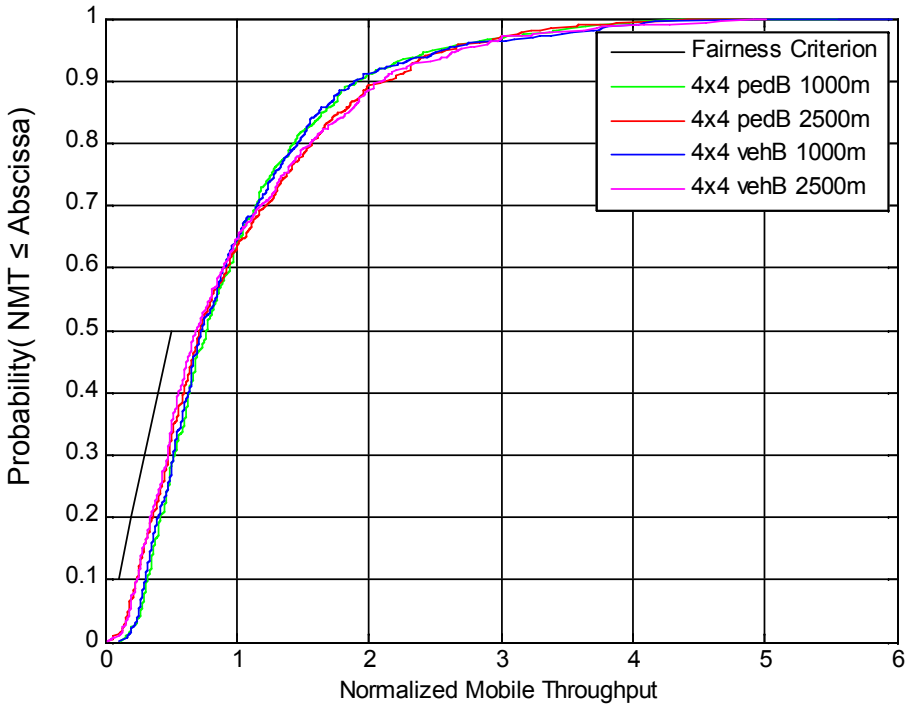
# Geometry Curves

- Shown are long-term results of FER vs. geometry for:
  - two models of the system with
  - three levels of modulation and coding
- Ideal channel estimation is used

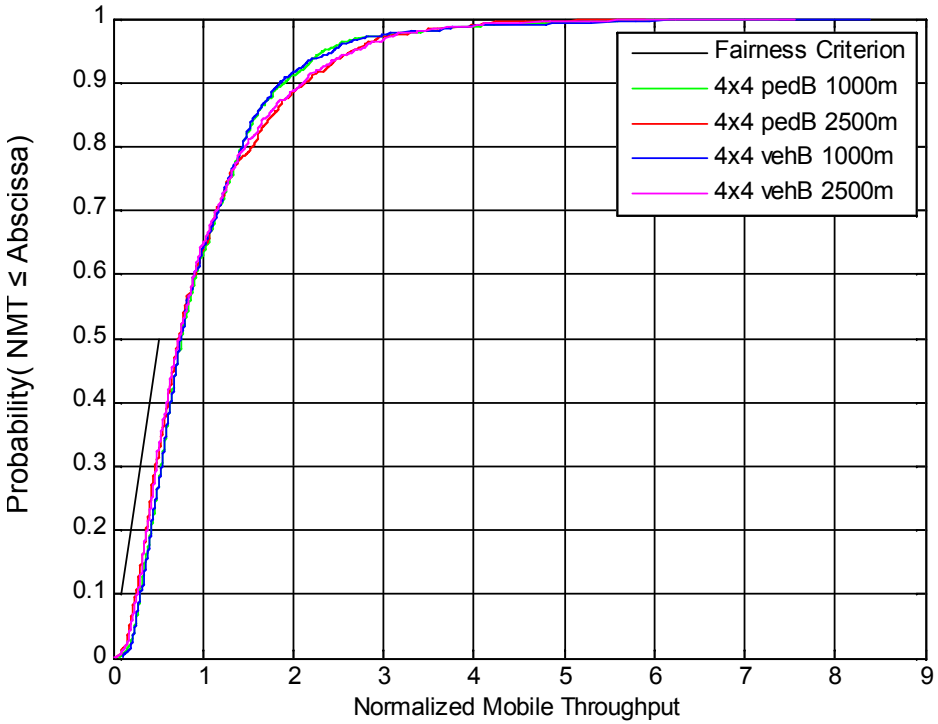


# Downlink System Simulation Results

# Downlink Fairness



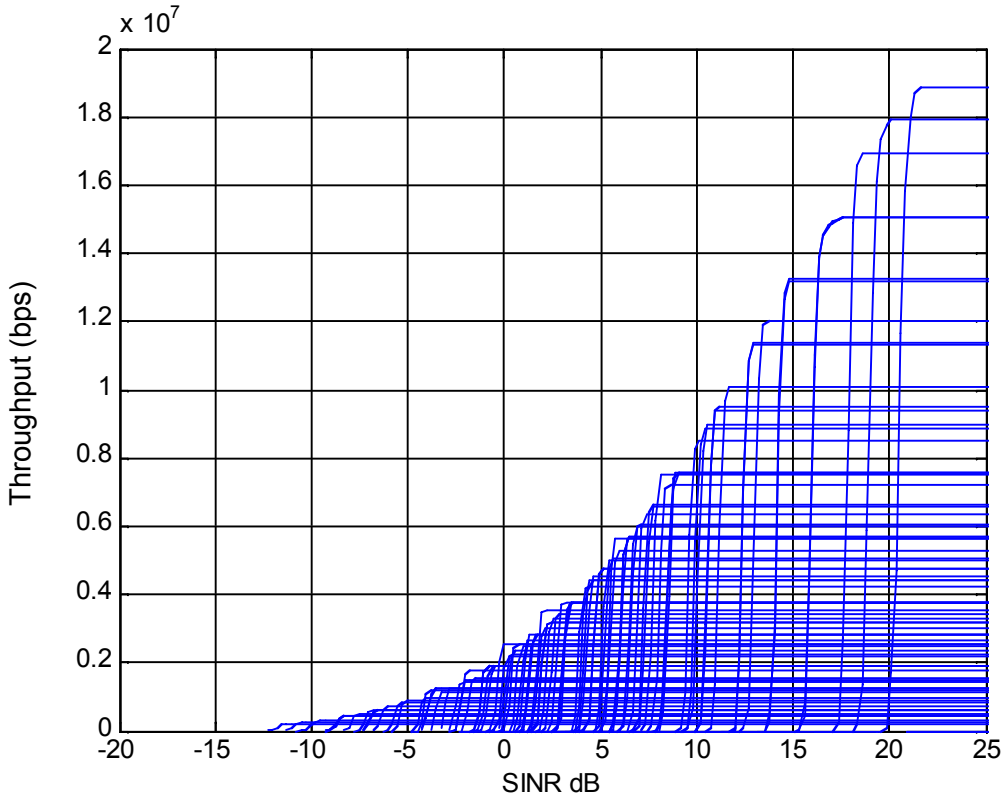

8 Users/Sector




16 Users/Sector

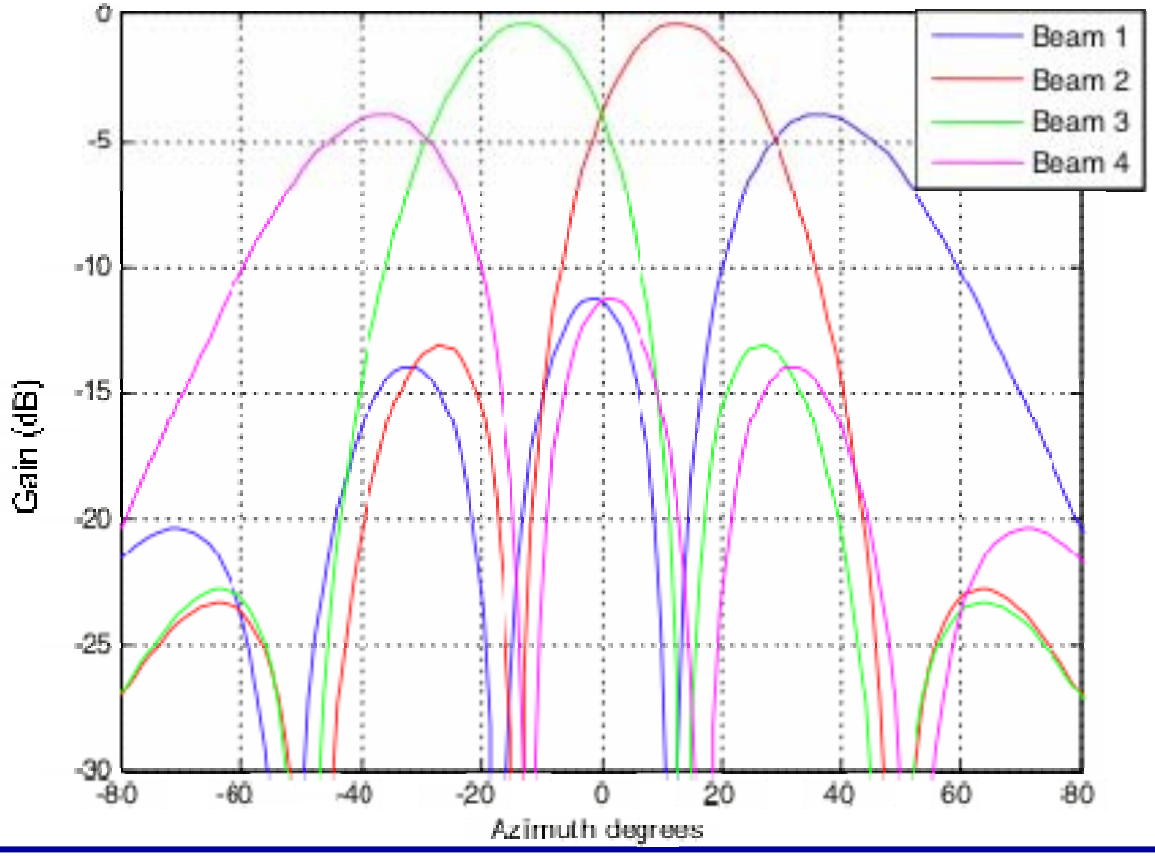
# Throughput vs. SINR

- Throughput derived from FER vs. SINR
- Each packet format produces particular throughput for given number of required transmissions.
- All of these packet format throughputs are presented in hull curves below



# BTS Antenna System

- Is a uniform linear 4-element array, producing four fixed beams.
- Switched beams have been shown to be a good choice for achieving high capacity
- Each element has Gaussian antenna pattern
- Half-power beamwidth is 70 degrees,
- Front-to-back ratio is 20dB.



# Downlink Aggregate Throughput

- Four fixed beams were used in each sector.

| # of Antennas | Channel Model | # of Users/Sector | Site-to-Site Separation (km) | Sector Throughput (kbps) |
|---|---|---|---|---|
| 4x4 | 3kph/PedB | 8 | 1 | 16241 |
| 4x4 | 120kph/VehB | 8 | 1 | 13111 |
| 4x4 | 3kph/PedB | 16 | 1 | 19969 |
| 4x4 | 120kph/VehB | 16 | 1 | 15431 |
| 4x4 | 3kph/PedB | 8 | 2.5 | 15542 |
| 4x4 | 120kph/VehB | 8 | 2.5 | 12687 |
| 4x4 | 3kph/PedB | 16 | 2.5 | 18731 |
| 4x4 | 120kph/VehB | 16 | 2.5 | 13454 |

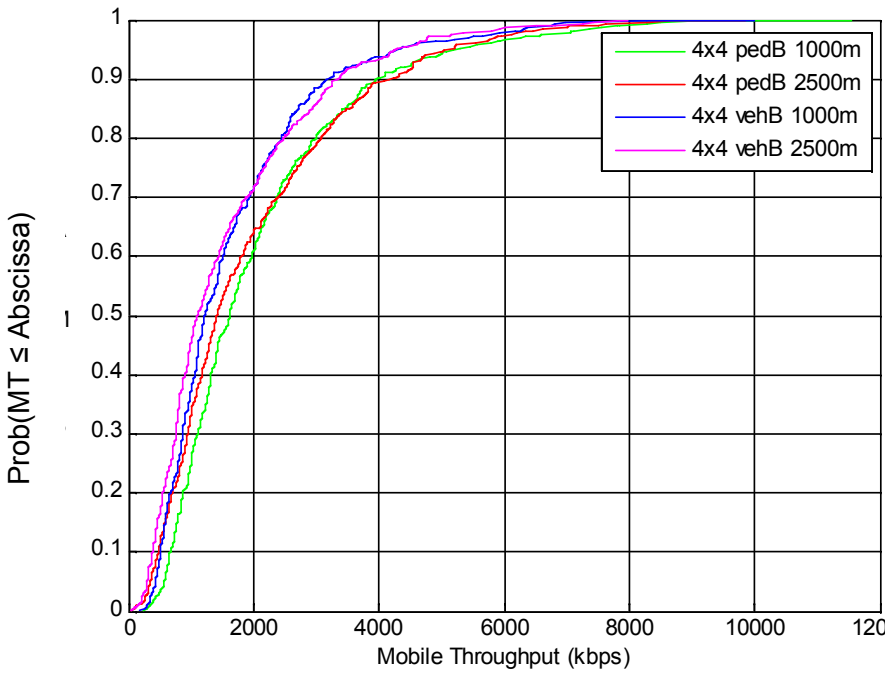
# Downlink Spectral Efficiency

- **Assumes a 5 MHz bandwidth assignment and a 1km site separation**
- **Minimum requirements (per PAR):**
  - **3 kph, PedB → 2.0 (b/s/Hz/sector)**
  - **120 kph, VehB → 1.5**
- **Achieved:**
  - **3 kph, PedB → 3.99**
  - **120 kph, VehB → 3.09**

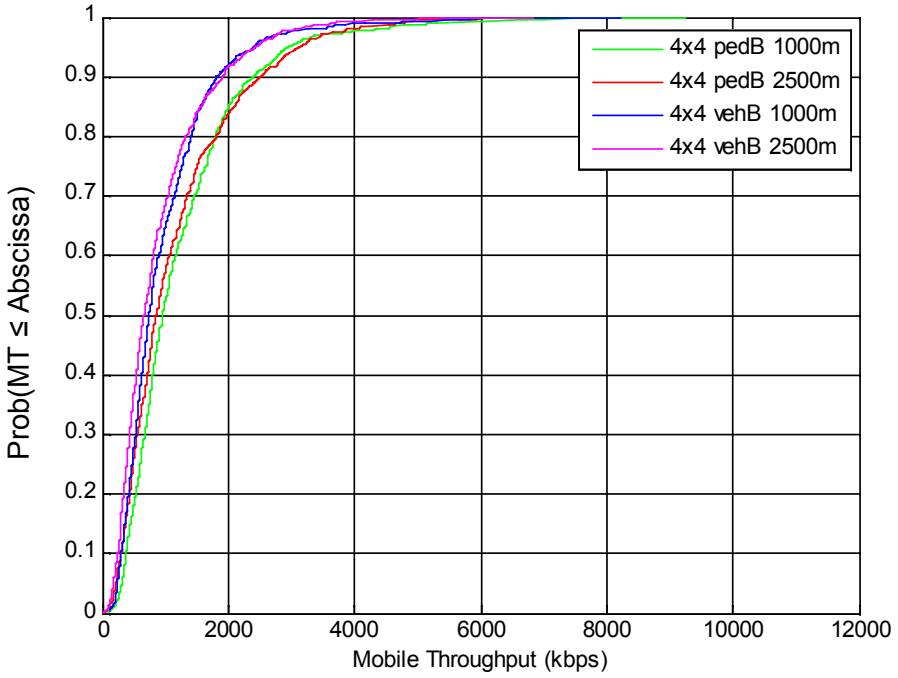
# Downlink Mobile Throughput

- CDF of Mobile Throughput shown

## 8 Users/Sector

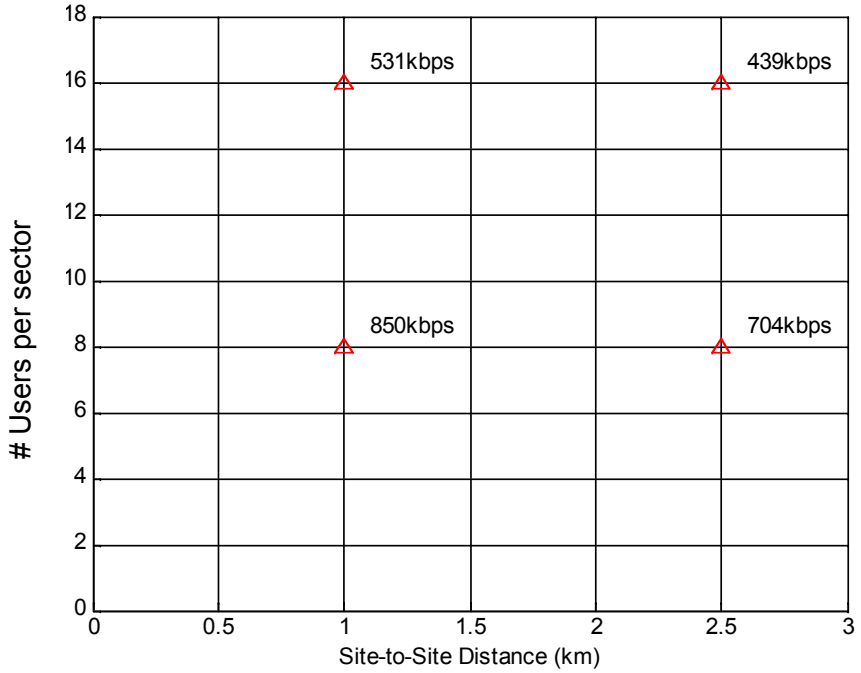



## 16 Users/Sector

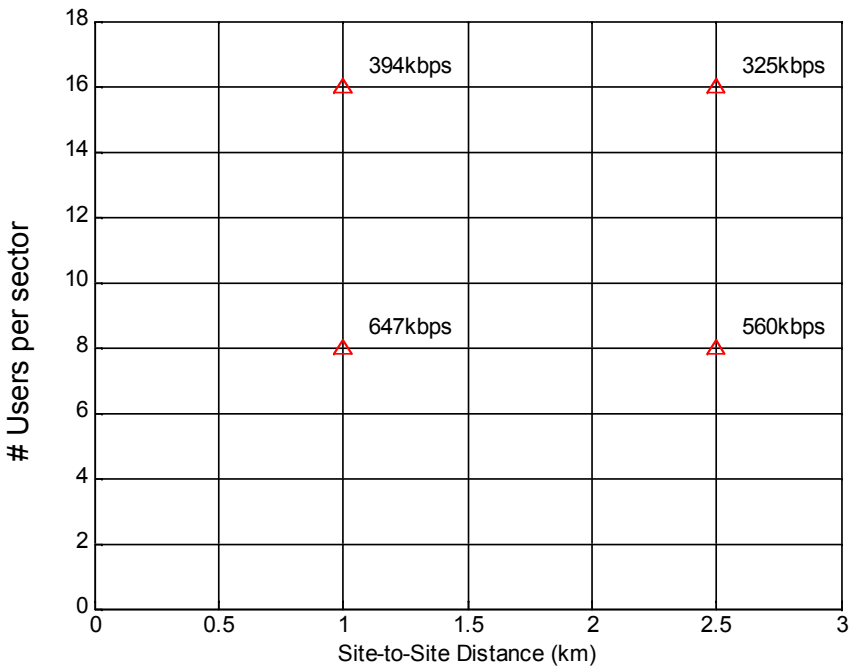


# Number of Users vs BTS separation at Minimum Service Level

## 3kph/Pedestrian B

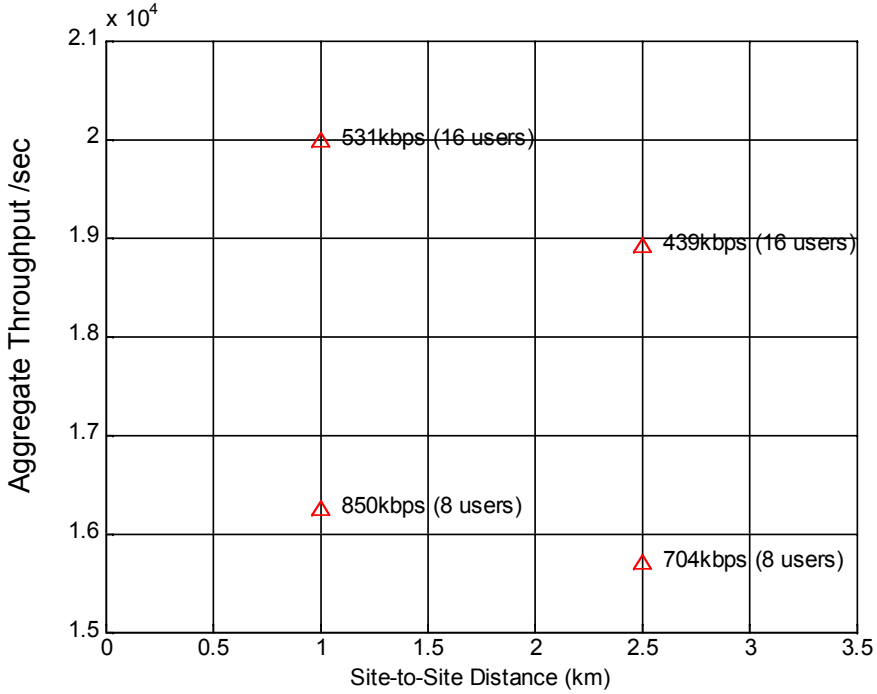



## 120kph/Vehicular B

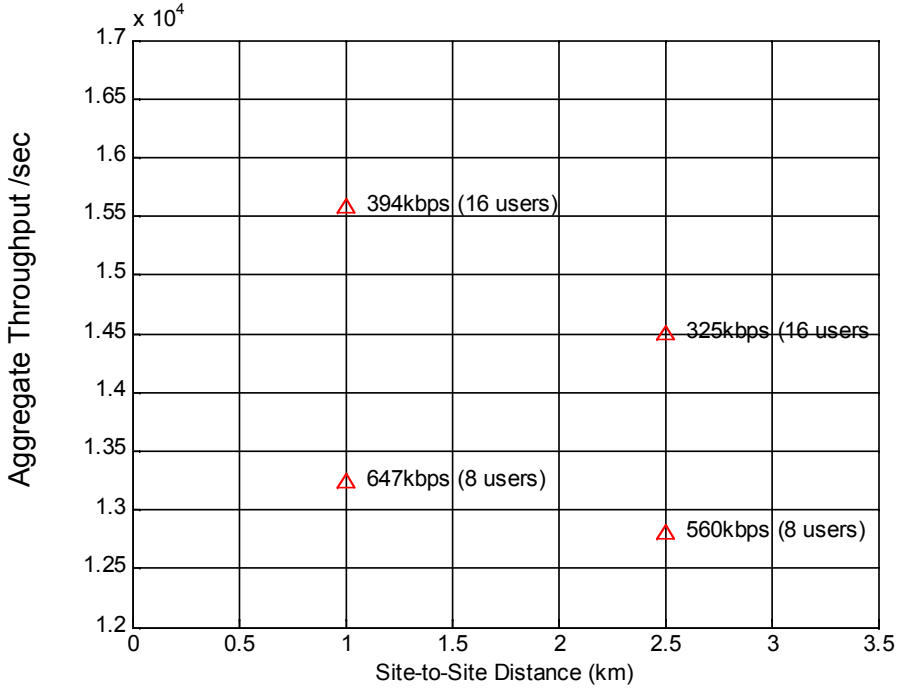


# Aggregated Throughput vs. Base Station Separation at Minimum Service Level

## 3kph/Pedestrian B

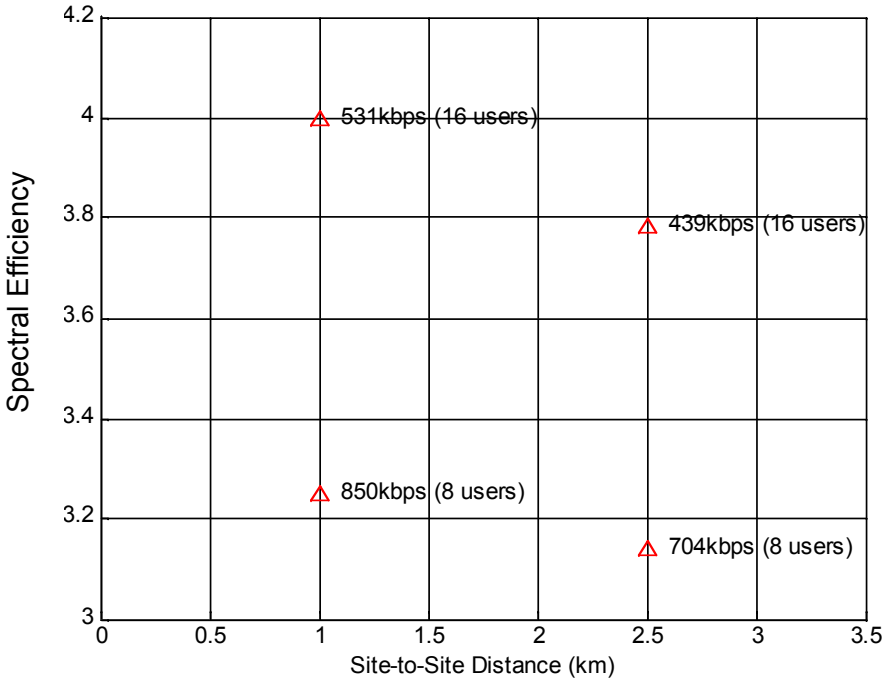



## 120kph/Vehicular B

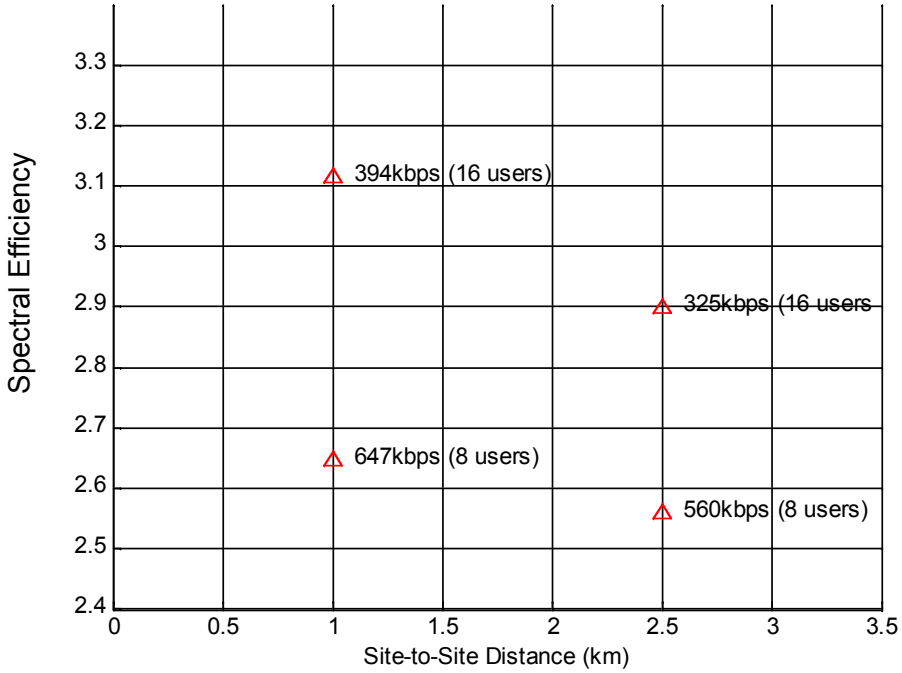


# Spectral Efficiency vs. Base Station Separation at Minimum Service Level

## 3kph/Pedestrian B

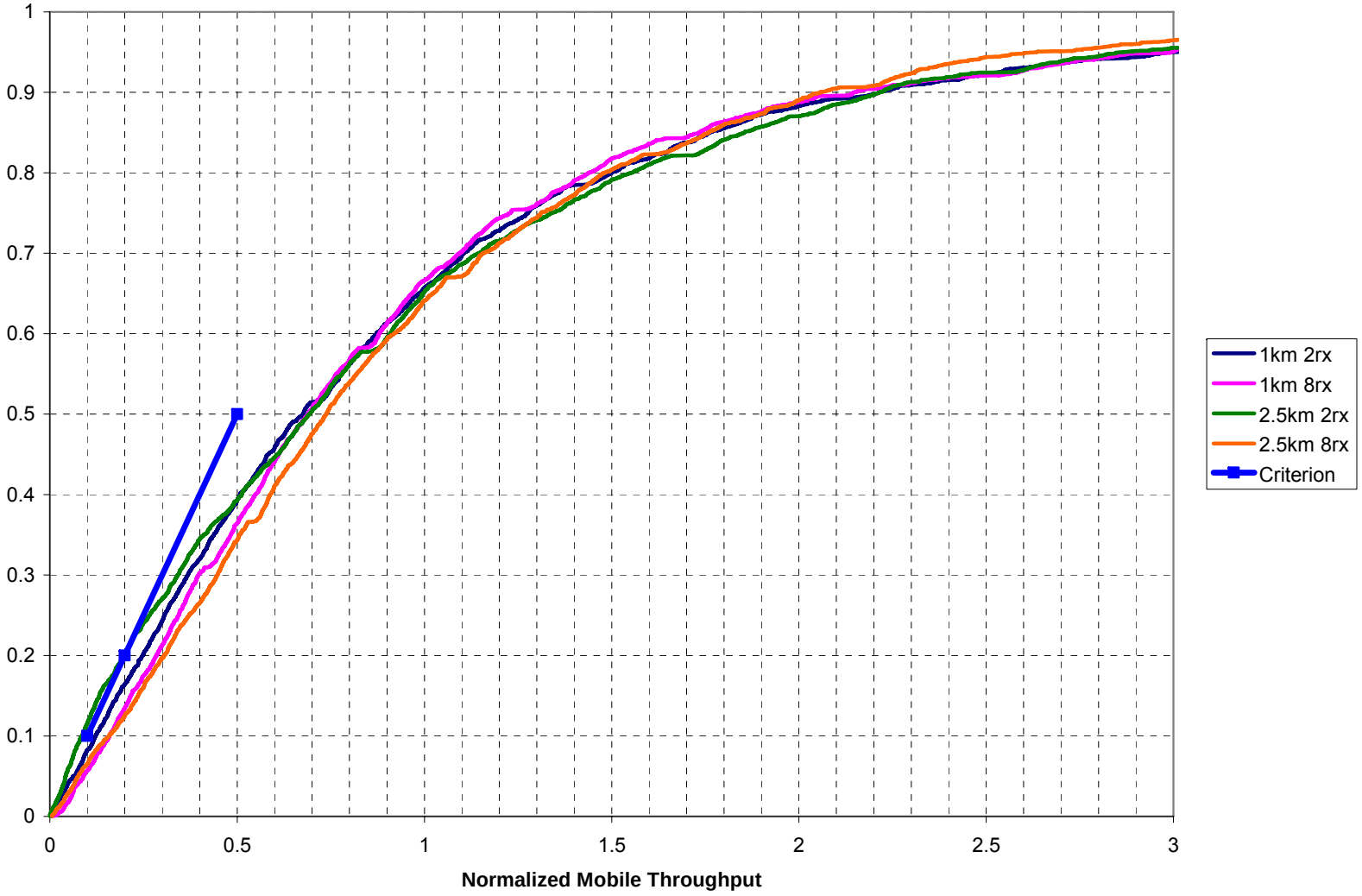



## 120kph/Vehicular B



# Uplink System Simulation Results

# Uplink Fairness



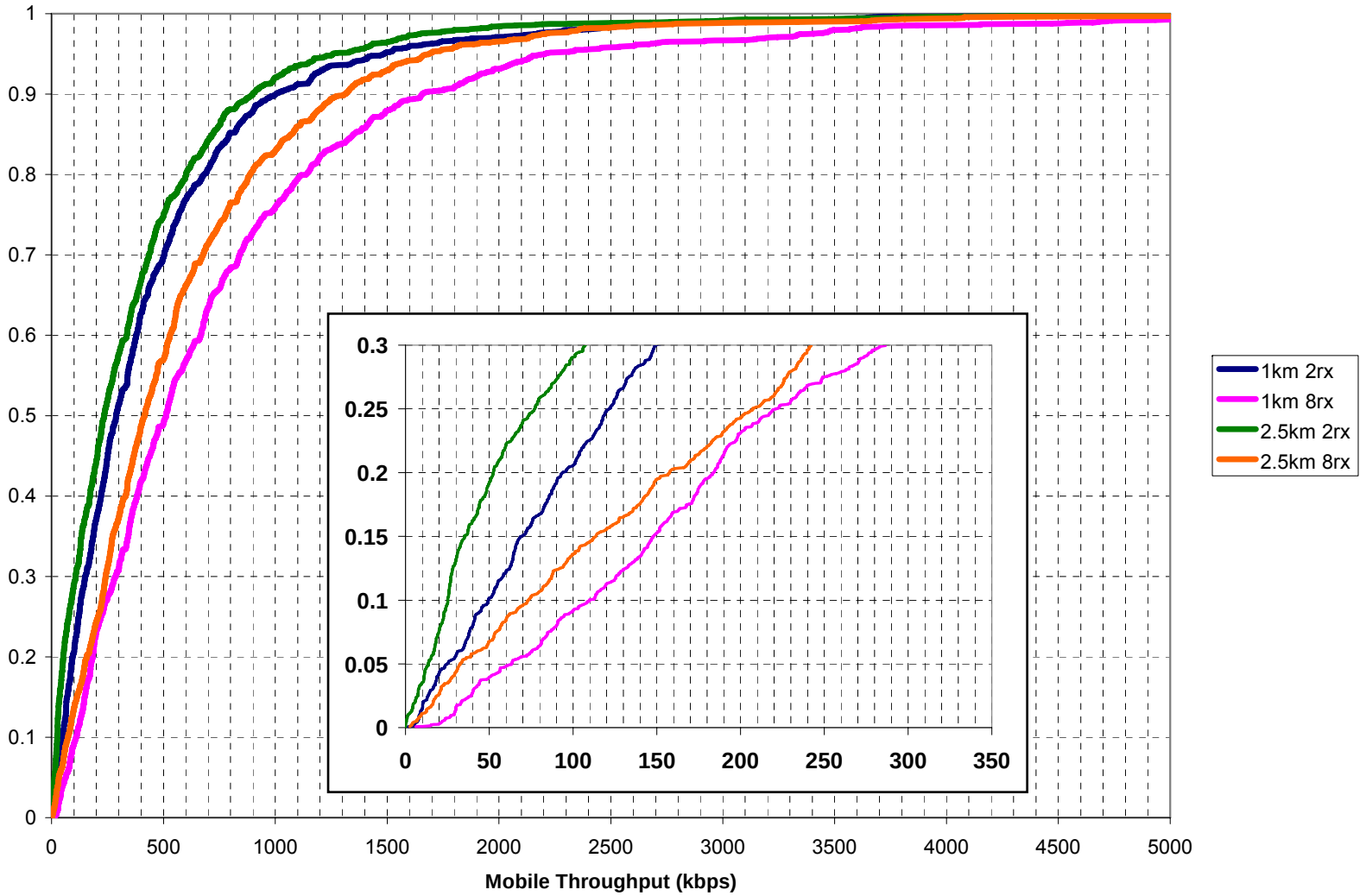
## Uplink Spectral Efficiency

- **Assumes a 5 MHz bandwidth assignment and a 1km site separation**
- **Minimum requirements (per PAR):**
  - **3 kph, PedB → 1.0 (b/s/Hz/sector)**
  - **120 kph, VehB → 0.75**
- **Achieved:**
  - **3 kph, PedB → 1.23**
  - **120 kph, VehB → 1.02**

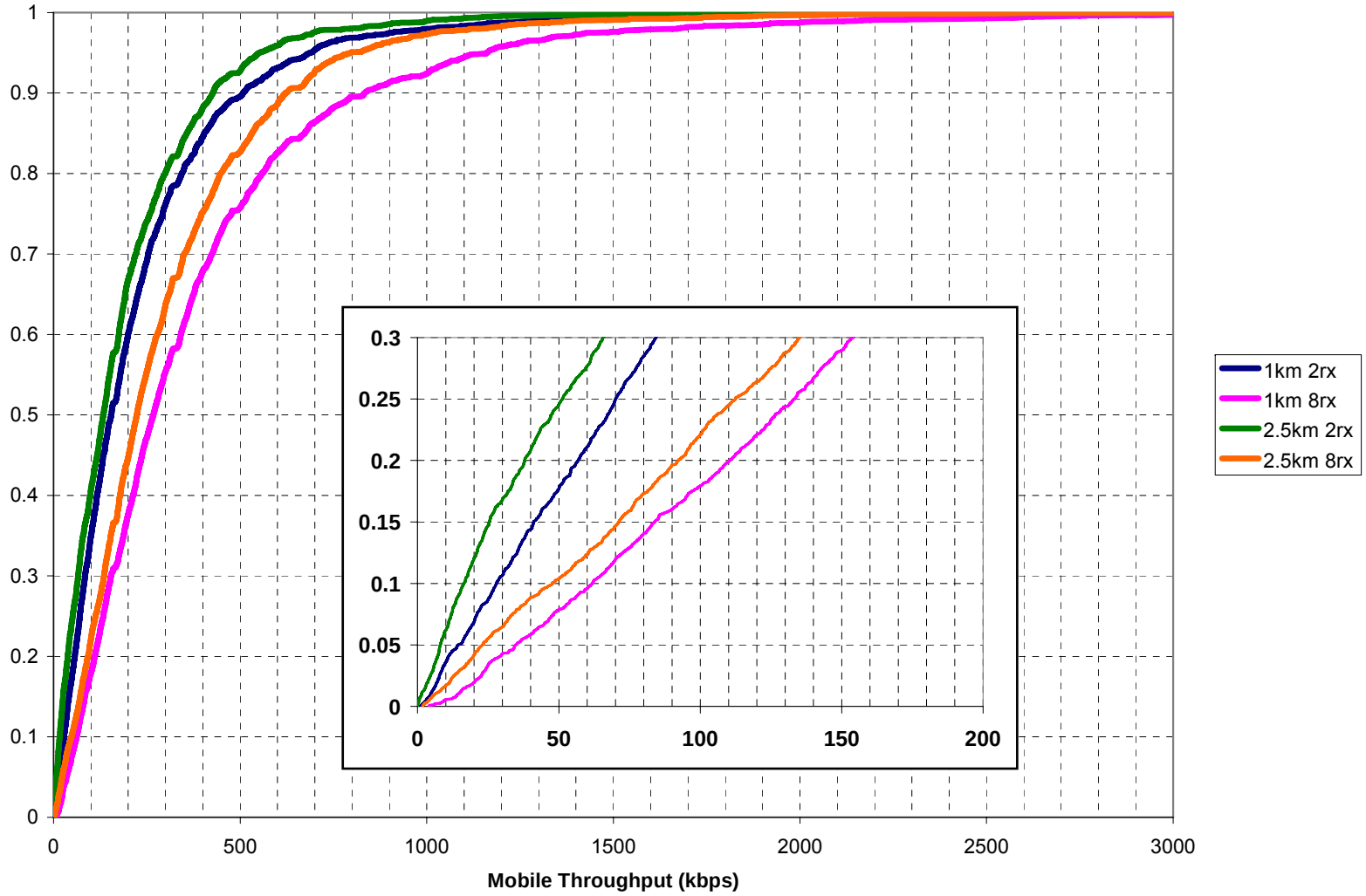
# Average Uplink Throughput per Sector

| # of Antennas | Channel Model | # of Users/Sector | Site-to-Site Separation (km) | Sector Throughput (kbps) |
|---|---|---|---|---|
| 2 | 3kph/PedB | 8 | 1 | 3701 |
| 2 | 120kph/VehB | 8 | 1 | 3189 |
| 8 | 3kph/PedB | 8 | 1 | 6095 |
| 8 | 120kph/VehB | 8 | 1 | 5118 |
| 2 | 3kph/PedB | 16 | 1 | 3641 |
| 2 | 120kph/VehB | 16 | 1 | 3121 |
| 8 | 3kph/PedB | 16 | 1 | 6173 |
| 8 | 120kph/VehB | 16 | 1 | 5103 |
| 2 | 3kph/PedB | 8 | 2.5 | 3163 |
| 2 | 120kph/VehB | 8 | 2.5 | 2747 |
| 8 | 3kph/PedB | 8 | 2.5 | 4781 |
| 8 | 120kph/VehB | 8 | 2.5 | 4004 |
| 2 | 3kph/PedB | 16 | 2.5 | 3063 |
| 2 | 120kph/VehB | 16 | 2.5 | 2646 |
| 8 | 3kph/PedB | 16 | 2.5 | 4806 |
| 8 | 120kph/VehB | 16 | 2.5 | 3984 |

# Uplink Mobile Throughput – PedB, 8 users/sector

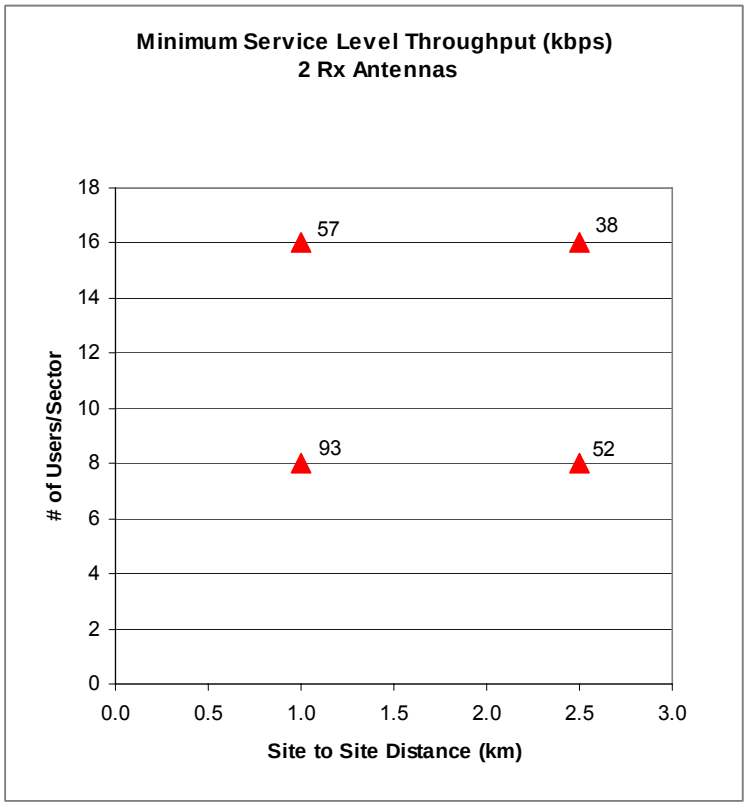


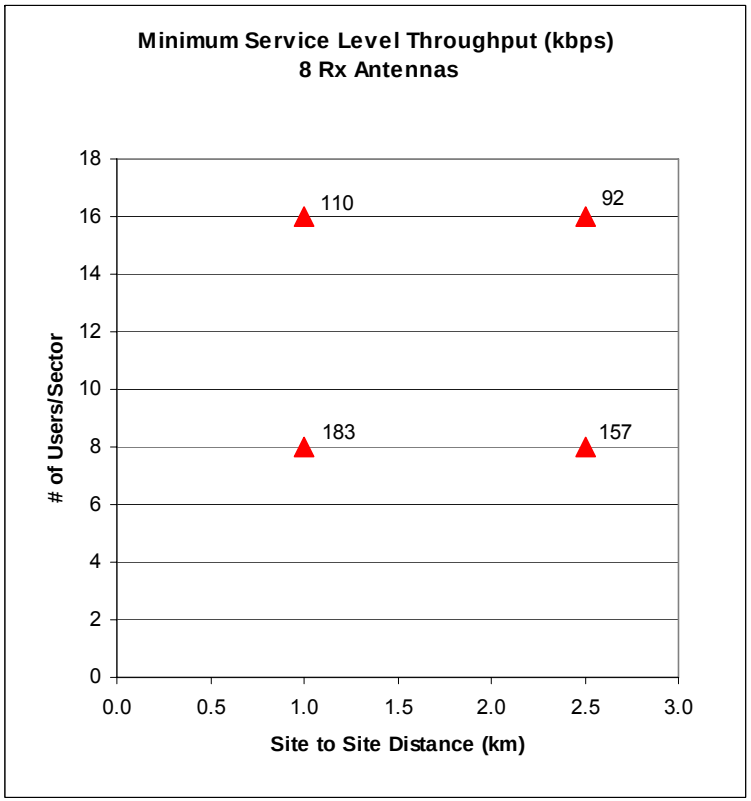
# Uplink Mobile Throughput – PedB, 16 users/sector



# Minimum Service Level Throughput – PedB

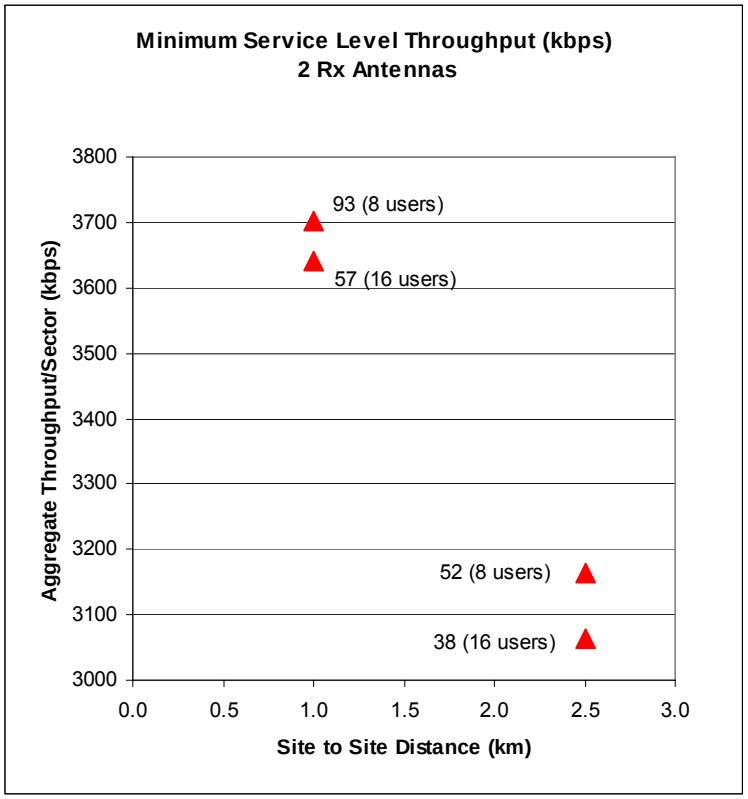
- 80% mobile throughput (red) vs. user load and site to site distance.

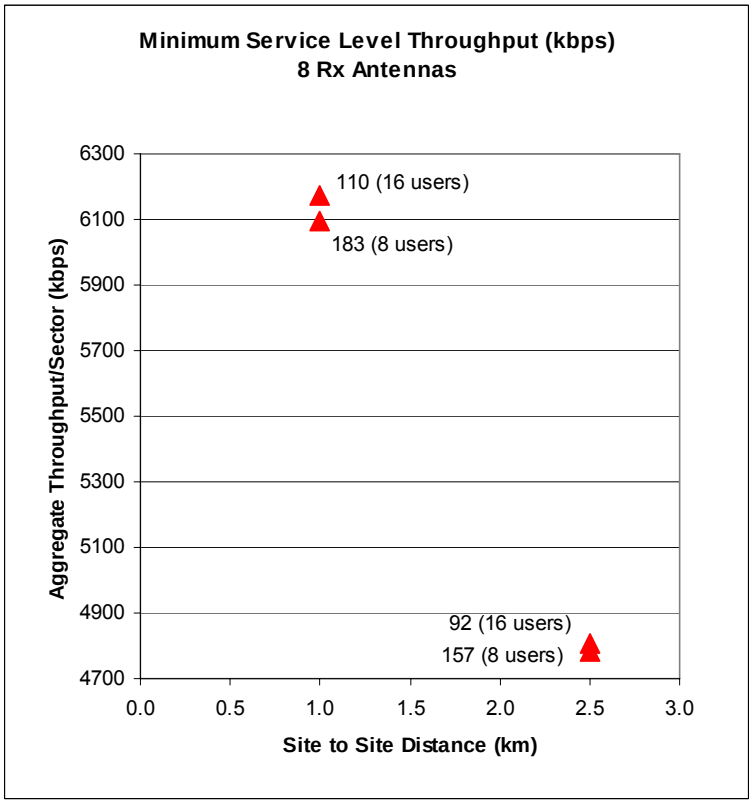


## Uplink Minimum Service Level Throughput vs. Aggregate Sector Throughput vs. Site Separation – PedB

- 80% mobile throughput (red) vs. average sector throughput and site to site distance.



# Uplink Minimum Service Level Throughput vs. Spectral Efficiency vs. Site Separation – PedB

- **80% mobile throughput (red) vs. spectral efficiency and site to site distance.**