



HSPA+ and Mobile WiMAX Network Performance Benchmark Results and Analysis

November 4, 2009

A quick introduction to Signals Research Group, LLC.

- Signals Research Group, LLC offers thought-leading field research and proprietary consulting services on the wireless telecommunications industry.
- Our flagship research product, a research newsletter entitled “Signals Ahead,” includes more than 70 corporate subscribers on five continents across the entire wireless ecosystem.

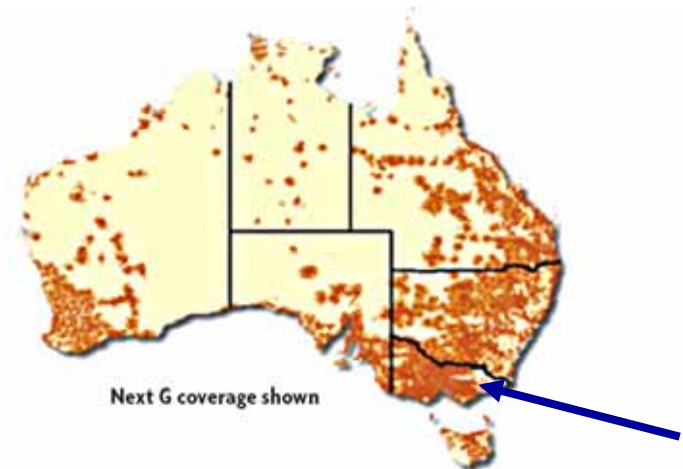


Presentation Outline

- Present methodology and results for the HSPA+ drive test from Melbourne, Australia in May 2009 (results published in July 2009).
- Present methodology and results for the Mobile WiMAX drive test from Portland, Oregon in July 2009 (results published in September 2009).
- Compare and contrast the results.
- Discuss what it means for the operator competitive landscape in North America.

HSPA+ Drive Test Background

- In May 2009 we conducted an independent performance benchmark test of HSPA+ (DL = 21Mbps; UL = 5.7Mbps).
- The tests leveraged Telstra's Next G HSPA+ network in Melbourne, Australia.
- Telstra provided access to an in-network server and loaned us a couple of the devices/SIM cards but otherwise did not participate in our benchmark tests.
- Out of necessity, some vendors were aware of the tests, but they had no influence on the test/test methodology.



Source: Telstra Website

HSPA+ Drive Test Objectives

- Determine the real-world performance capabilities of HSPA+ in a commercial network under a multitude of conditions.
- Capture underlying KPIs to determine not only the data rates, but how they were achieved and how frequently they were available.
 - downlink and uplink physical layer data rates
 - modulation scheme utilization rates
 - Average CQI
 - # of assigned HS-PDSCH codes
 - etc
- Compare the performance of Cat 14 (64 QAM/15 codes : 21Mbps), Cat 9 (15 codes : 10.2Mbps) devices and Cat 8 (10 codes, 7.2Mbps) devices.

HSPA+ Drive Test Methodology

- We used sophisticated drive test tools to capture and analyze the data.
 - QxDM
 - PCTEL scanner interfaced into the TEMS diagnostic tool
 - Garmin GPS receiver
 - Nokia and Spirent Communications engineering support
- We tested four devices during our five day stay in Australia.
- All test results were recorded and reported unless the file was corrupted.

Manufacturer	Model	Form Factor	Status	Chipset	Downlink Capability	Uplink Capability
Sierra Wireless	USB306	USB dongle	commercial	QC MDM8200	Cat 14 (21Mbps)	Cat 5 (2Mbps)
Sierra Wireless	Compass 888	USB dongle	pre-commercial	QC MSM6290	Cat 8 (7.2Mbps)	Cat 6 (5.7Mbps)
Nokia	Nokia Reference Mobile	handset	development platform	Nokia	Cat 8 (7.2Mbps)	Cat 5 (2Mbps)
Nokia	6270	handset	pre-commercial	Nokia	Cat 9 (10.2Mbps)	Cat 5 (2Mbps)

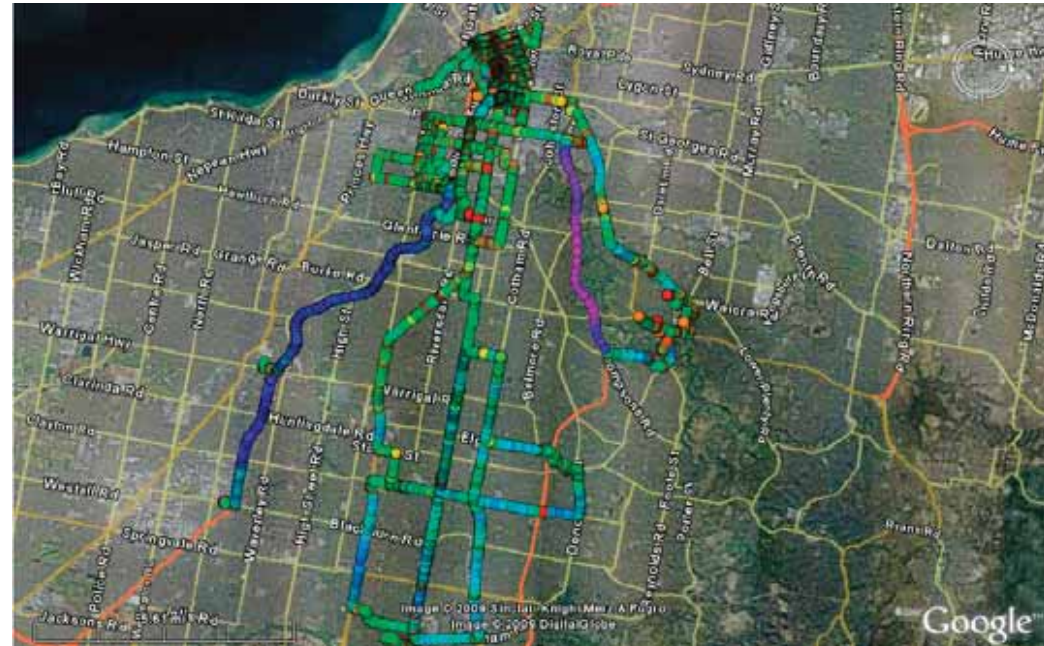
Source: Signals Research Group, LLC

HSPA+ Drive Test Methodology (cont'd)

- During our tests we transferred ~41GB of data.
 - \$214,164.10 in international roaming charges (if we had used our own SIM cards)
- We drove 400km while conducting tests.
 - 90% of all capture data occurred in vehicular mode
- Testing occurred from as early as 0400 until as late as 1900.

Oh The Places We Did Go!

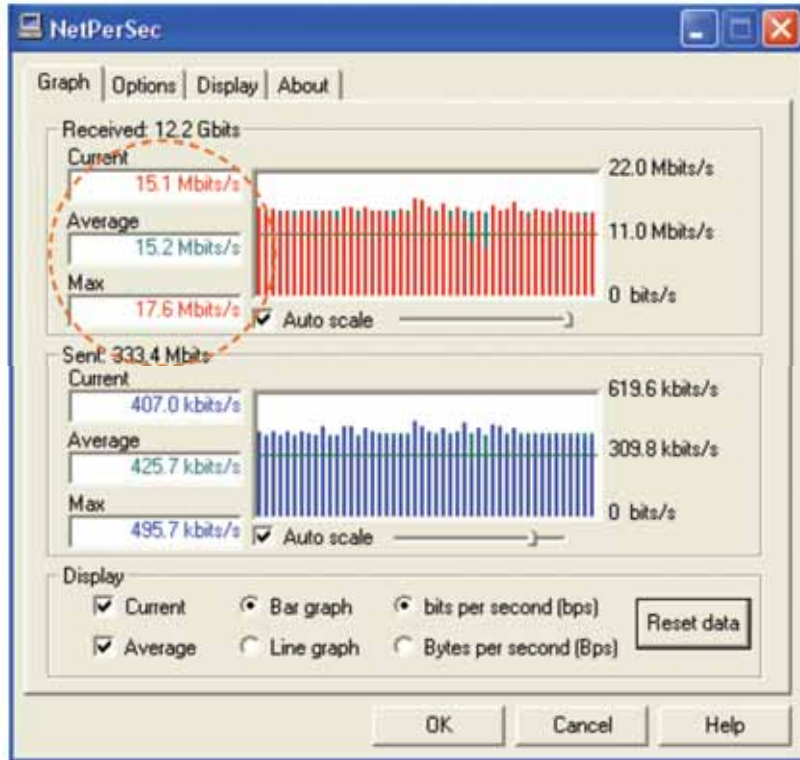
Geo plot of all test routes with speed (km/h)



Source: Signals Research Group, LLC

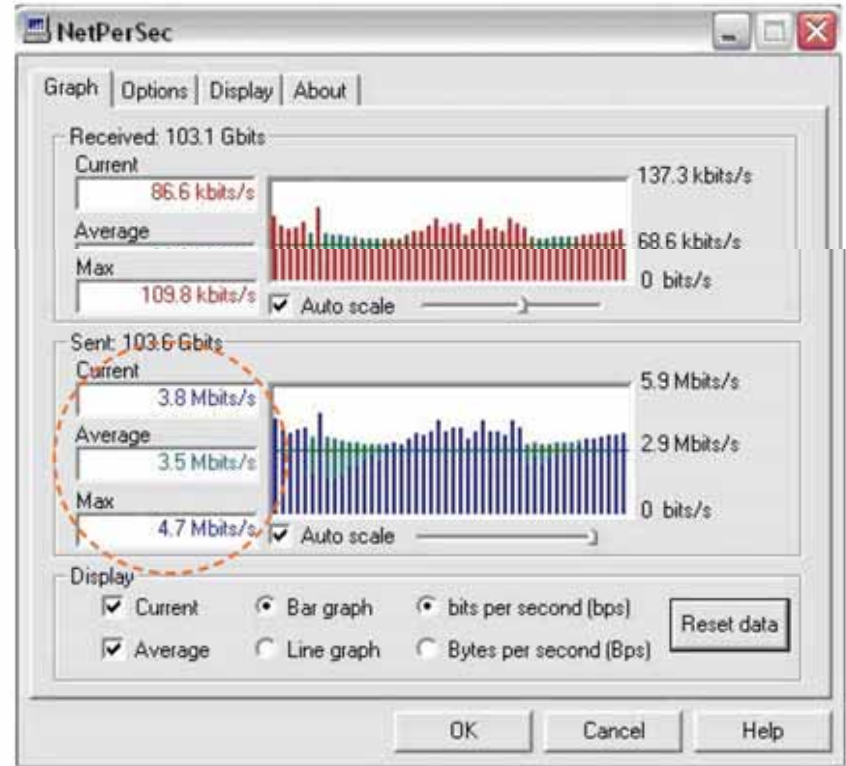
Headline Results (from our Hotel Room)

Observed Application Layer Data Rates from the Westin Hotel Room (05/08, 0400hrs)



Source: Signals Research Group, LLC

Observed Application Layer Uplink Data Rates from the Westin Hotel Room SWIR 888 USB dongle (05/05, 0900hrs)



Source: Signals Research Group, LLC

Peak DL = 17.6Mbps; Average DL = 15.2Mbps
Peak UL = 4.7Mbps; Average UL = 3.5Mbps

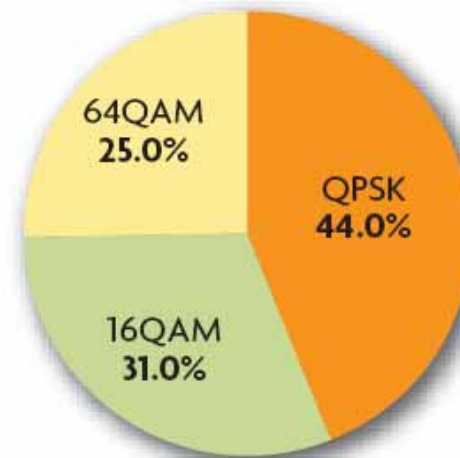
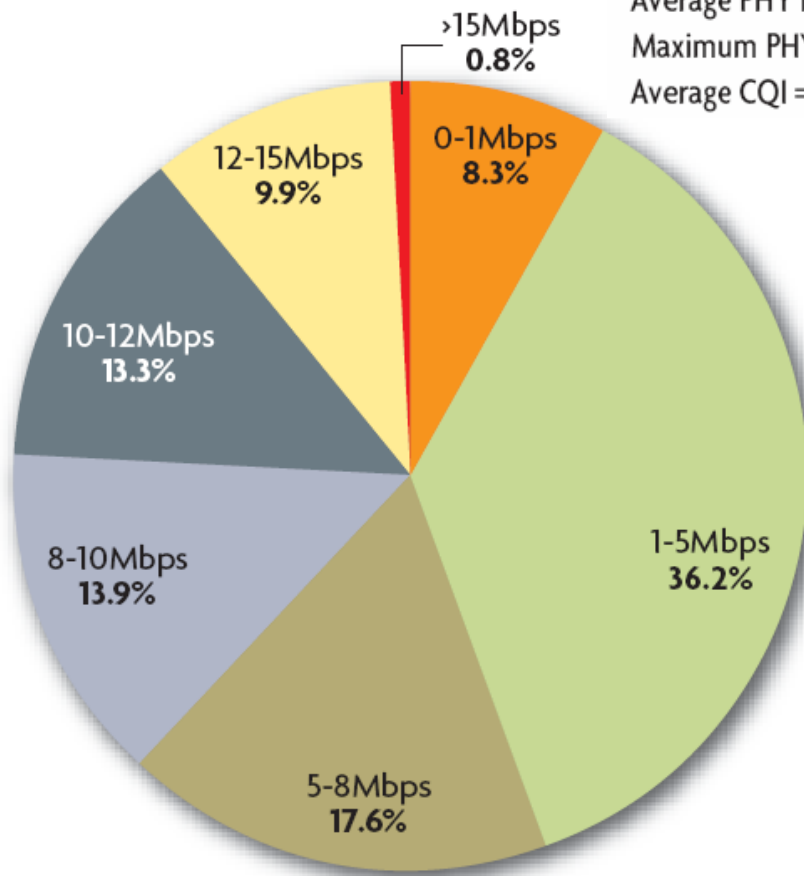
HSPA+ Drive Test – downtown Melbourne during Rush Hour

Melbourne CBD Cat 14 versus Cat 9 Drive test (Cat 14 only results)

Distribution of normalized throughput and modulation schemes (05/05, 1845hrs)

Average PHY Data Rate = 5.53Mbps
Maximum PHY Data Rate = 16.5Mbps
Average CQI = 22.6

Average Number of Assigned Codes = 11.8
Percentage >10 codes assigned = 81.8%
Capture Period = ~ 9.1 minutes



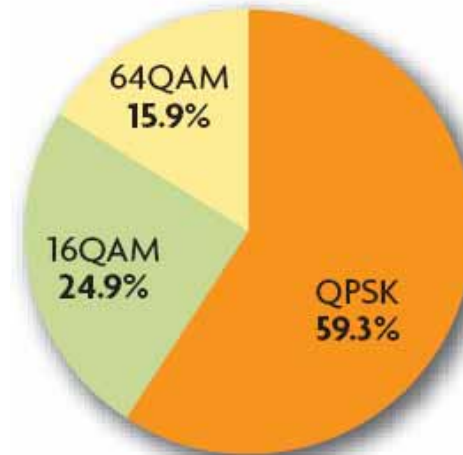
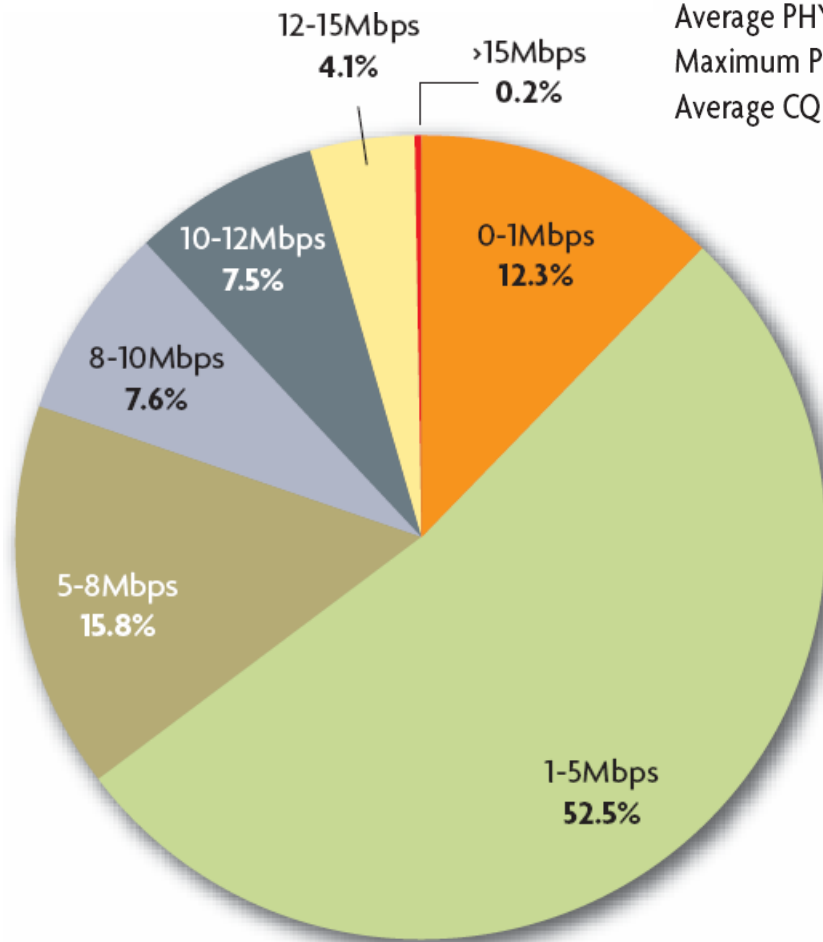
Source: Signals Research Group, LLC

HSPA+ Pedestrian Test – downtown Melbourne mid afternoon

Melbourne CBD Cat 14 Pedestrian Mode Distribution of normalized throughput and modulation schemes (05/05, 1500hrs)

Average PHY Data Rate = 3.82Mbps
Maximum PHY Data Rate = 15.4Mbps
Average CQI = 20.5

Average Number of Assigned Codes = 10.4
Percentage >10 codes assigned = 62.8%
Capture Period = ~ 23.7 minutes

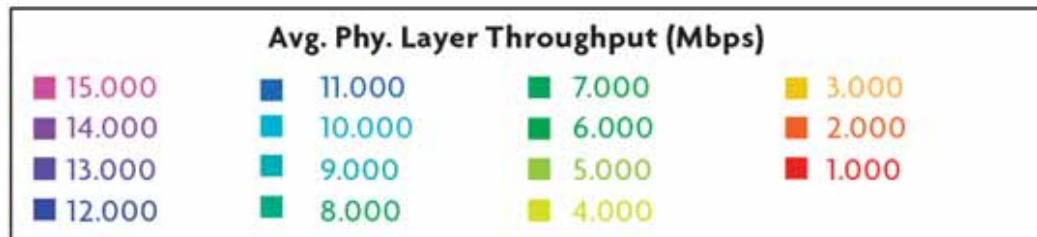
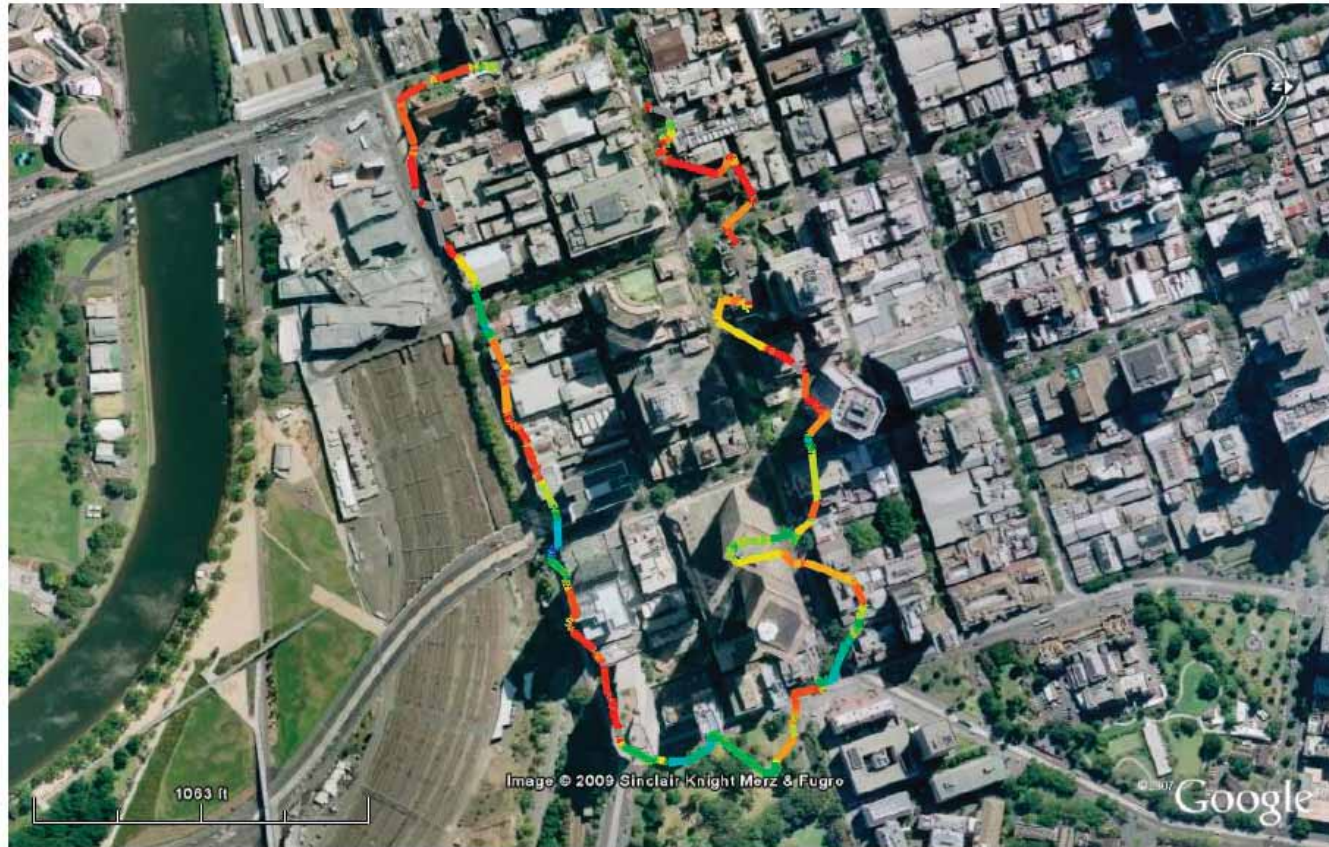


Source: Signals Research Group, LLC

HSPA+ Pedestrian Test – downtown Melbourne mid afternoon

Melbourne CBD Cat 14 Pedestrian Mode

Geo plot of average throughput (05/05, 1500hrs)



Source: Signals Research Group, LLC

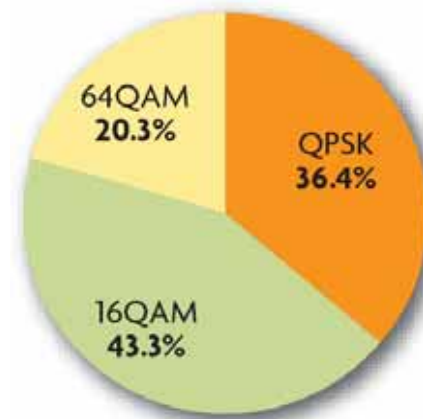
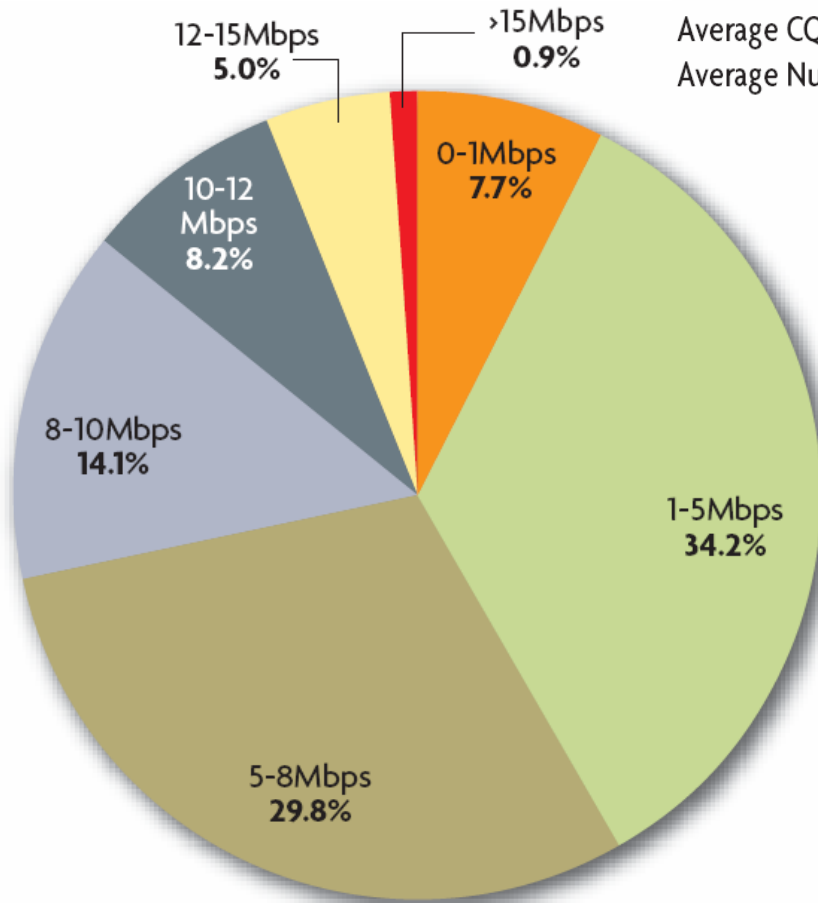
HSPA+ Drive Test – Box Hill #8

Box Hill #8 Cat 14 Drive Test

Distribution of normalized throughput and modulation schemes
(06/08, 0800hrs)

Average PHY Data Rate = 5.09Mbps
Maximum PHY Data Rate = 16.5Mbps
Average CQI = 22.6
Average Number of Assigned Codes = 11.3

Percentage >10 codes assigned = 58.5%
Capture Period = ~ 17.7 minutes
Average Vehicular Speed = 34.6km/h

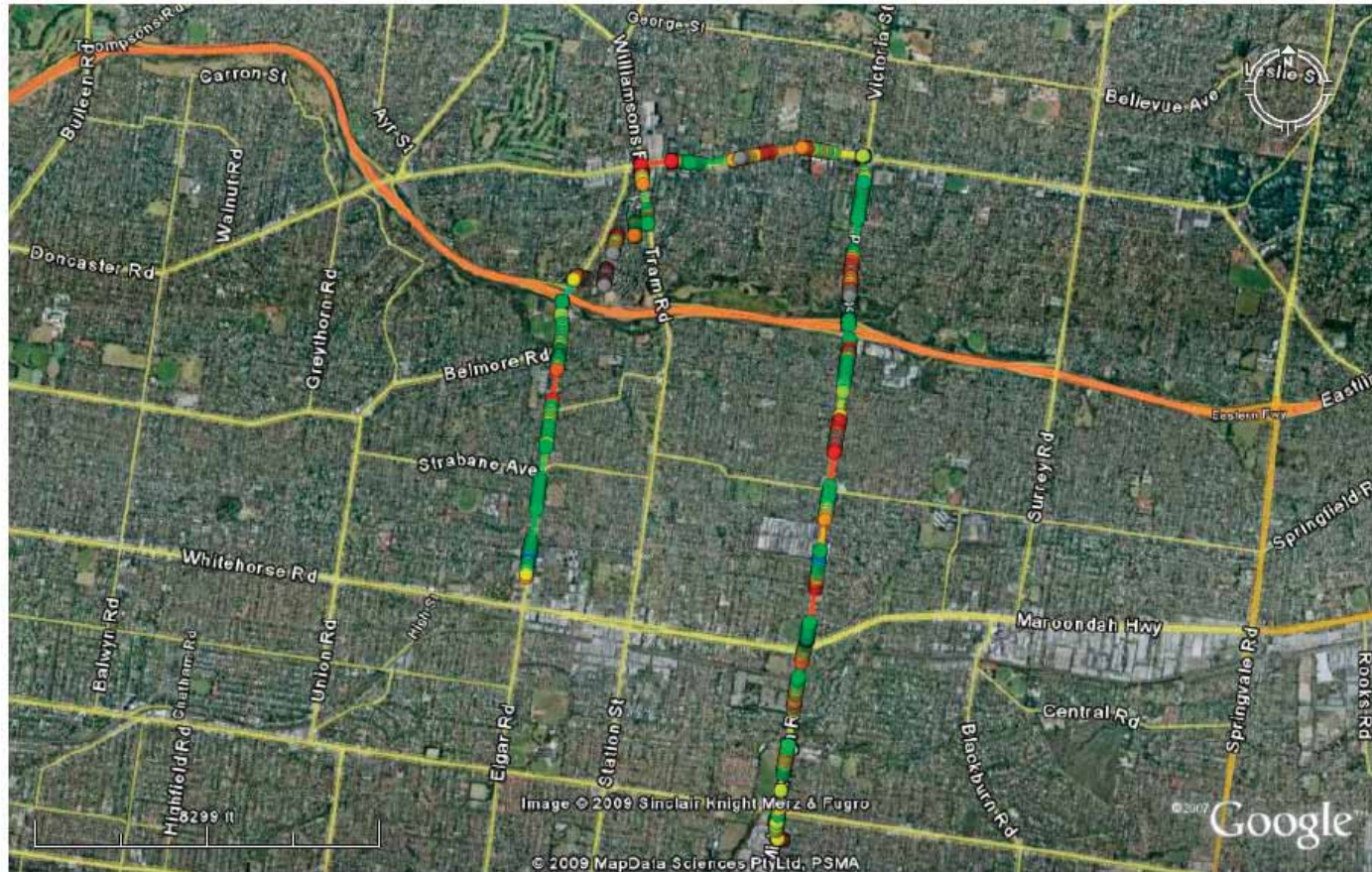


Source: Signals Research Group, LLC

HSPA+ Drive Test – Box Hill #8

Box Hill #8 Cat 14 Drive Test

Geo plot of average physical layer throughput (06/08, 0800hrs)

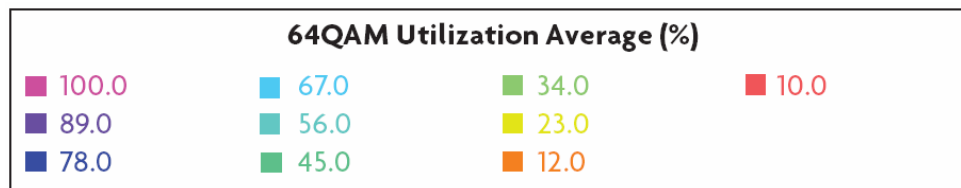
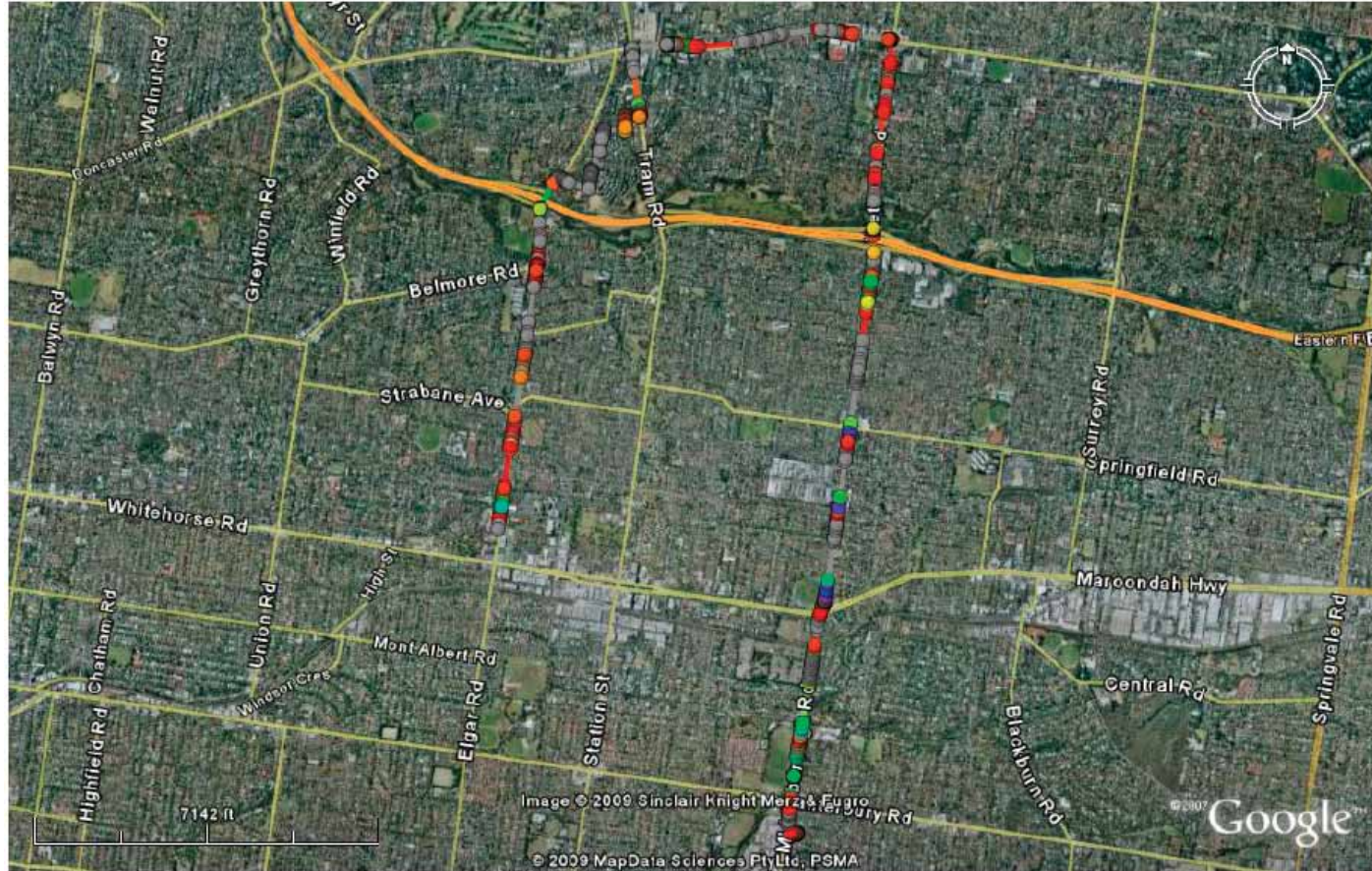


Source: Signals Research Group, LLC

HSPA+ Drive Test – Box Hill #8

Box Hill #8 Cat 14 Drive Test

Geo plot of 64QAM Availability (06/08, 0800hrs)



Mobile WiMAX Drive Test Background

- In July 2009 we conducted an independent performance benchmark test of Mobile WiMAX.
- The tests leveraged Clearwire's network in Portland, Oregon.
- Clearwire provided us access to its network and provided some of the devices that we tested.
- Intel provided us with access to a server for our throughput tests as well as some of the devices that we tested.
- Intel and Clearwire did not participate in our network testing nor did they have any influence on where we did our testing.

Clearwire Coverage in the Portland Area



Source: Clearwire

Mobile WiMAX Drive Test Methodology

- We used sophisticated drive test tools to capture and analyze the data.
 - Rohde&Schwarz (R&S) TSMW Universal Radio Network Analyzer
 - R&S ROMES drive test software and engineering support
 - Intel FiDO (Field Deployment Optimization) drive test tool
- We tested five devices during our four day stay in Portland.
 - simultaneous downlink and uplink
- All test results were recorded and reported unless the file was corrupted.

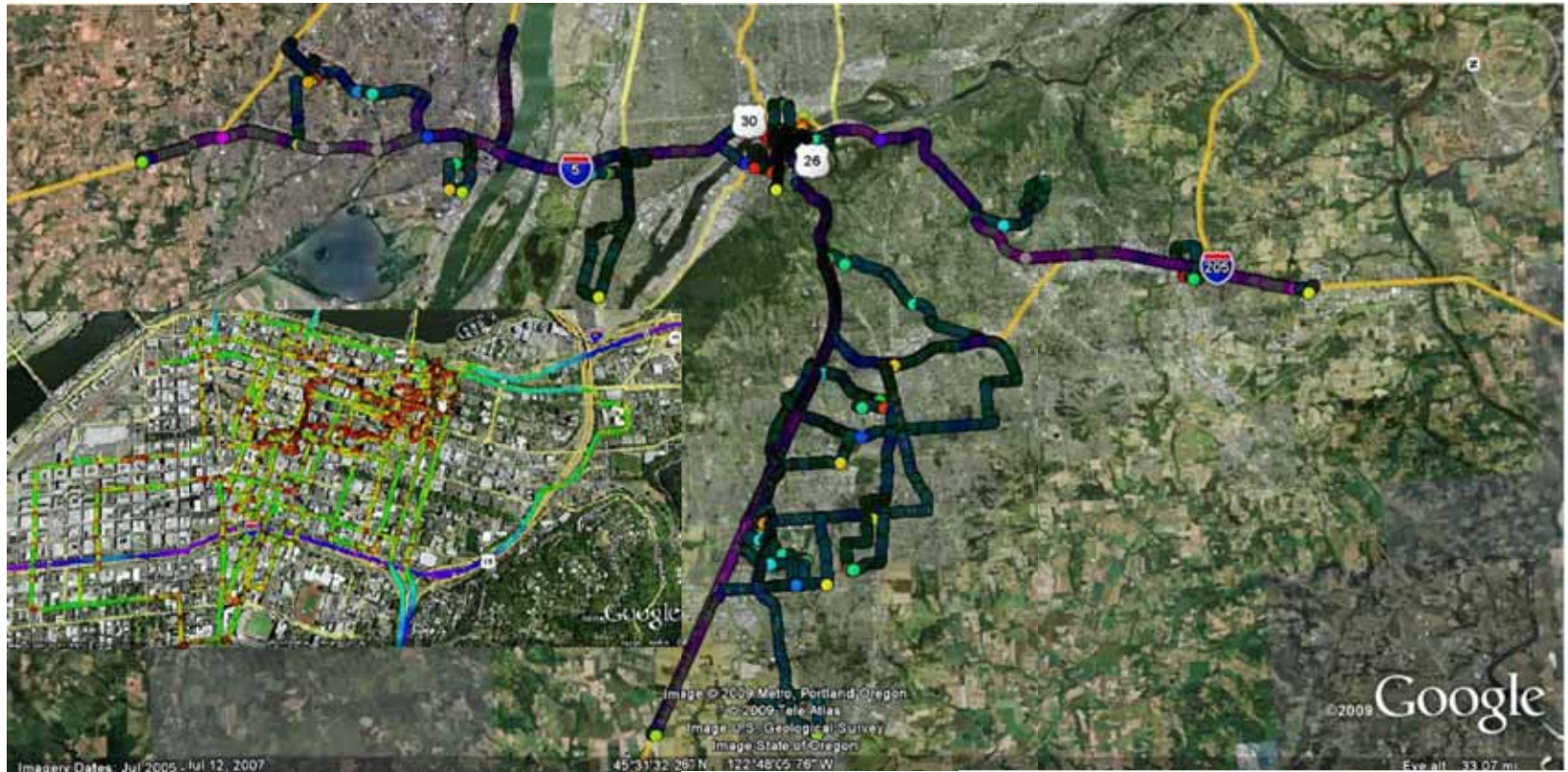
Manufacturer	Model	Form Factor	Chipset	Status	Features
Motorola	USBw 100	USB dongle	Beceem BCS200	non-commercial firmware	MIMO A/B; 2.3GHz/2.5GHz
Ubee	N.A.	USB dongle	Beceem BCS250	non-commercial hardware	UL transmit diversity; MIMO A/B; 2.3GHz/2.5GHz
Franklin	U300	USB dongle	Beceem BCS200	non-commercial firmware	EV-DO; MIMO A/B 2.3GHz/2.5GHz
Fujitsu-Siemens	Lifebok P8020	Notebook (embedded)	Next Generation embedded Intel WiMAX	non-commercial hardware	MIMO A/B; 2.3GHz/2.5GHz/3.5GHz
2go Convertible	Classmate	Netbook (embedded)	Intel Echo Peak	commercial	MIMO A/B; 2.3GHz/2.5GHz

Source: Signals Research Group, LLC

Mobile WiMAX Drive Test Methodology (cont'd)

"Oh the places we did go!"

Geo plot of all test routes with speed (mph)



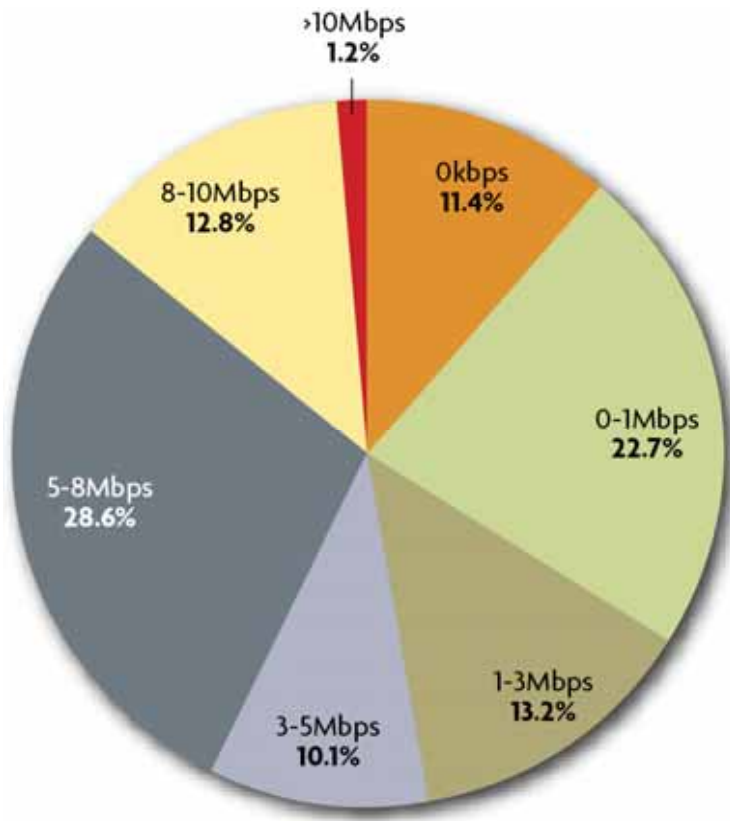
- During our tests we transferred ~46.3GB of data.
 - Mobile - 30.7GB; Pedestrian – 14.6GB
- We drove 420 miles over the course of a 4 day period.



Mobile WiMAX Drive Test – downtown Portland mid afternoon

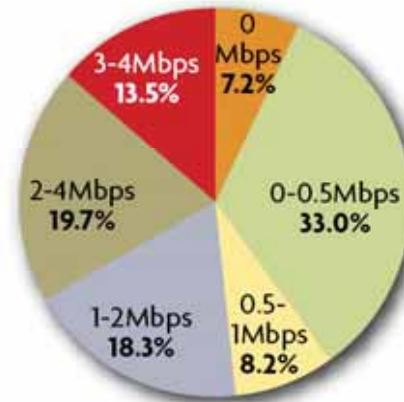
Test Scenario 21 KPIs

Distribution of DL/UL Data Rates and MIMO Matrix A/B

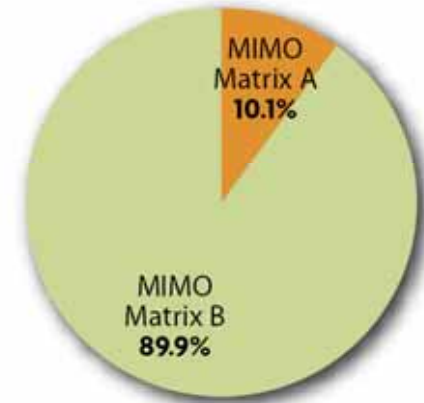


Total Transfer = 995.4MB
 Avg Speed = 6.8Mph
 Adj Avg DL = 4.4Mbps

Adj Avg UL = 1.4Mbps
 Max DL = 10.8Mbps
 Max UL = 3.9Mbps



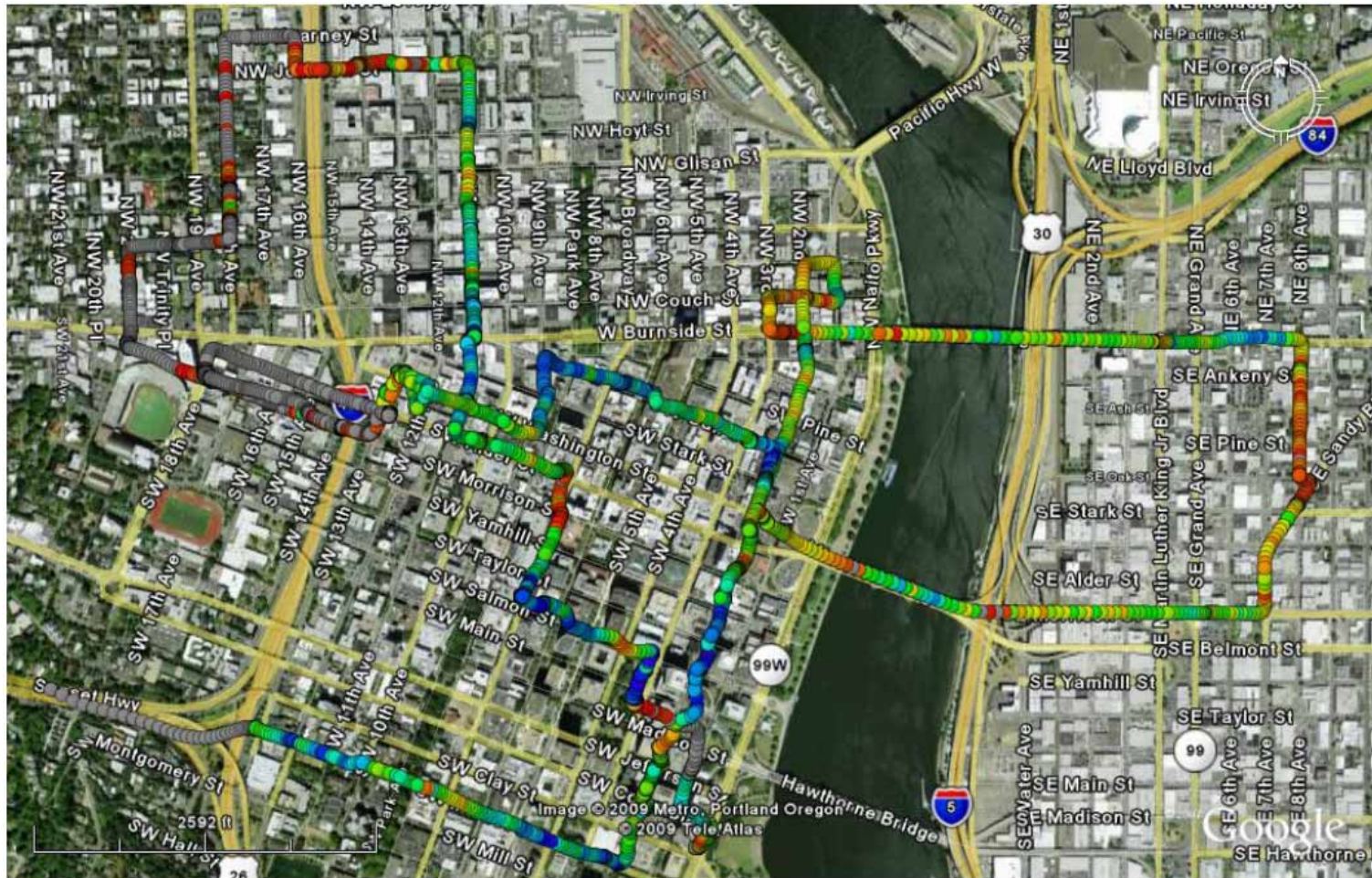
UL Throughput



Source: Signals Research Group, LLC

Mobile WiMAX Drive Test – downtown Portland mid afternoon

Portland Vehicular Mode
Geo plot of DL Data Rates (Test Scenario 21)



DL Throughput (Mbps)

12,000	9,500	7,000	4,500	2,000
11,500	9,000	6,500	4,000	1,500
11,000	8,500	6,000	3,500	1,000
10,500	8,000	5,500	3,000	500
10,000	7,500	5,000	2,500	

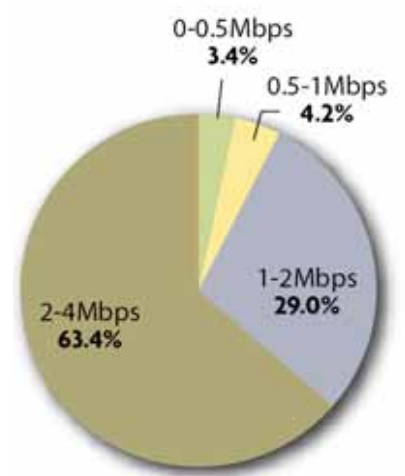
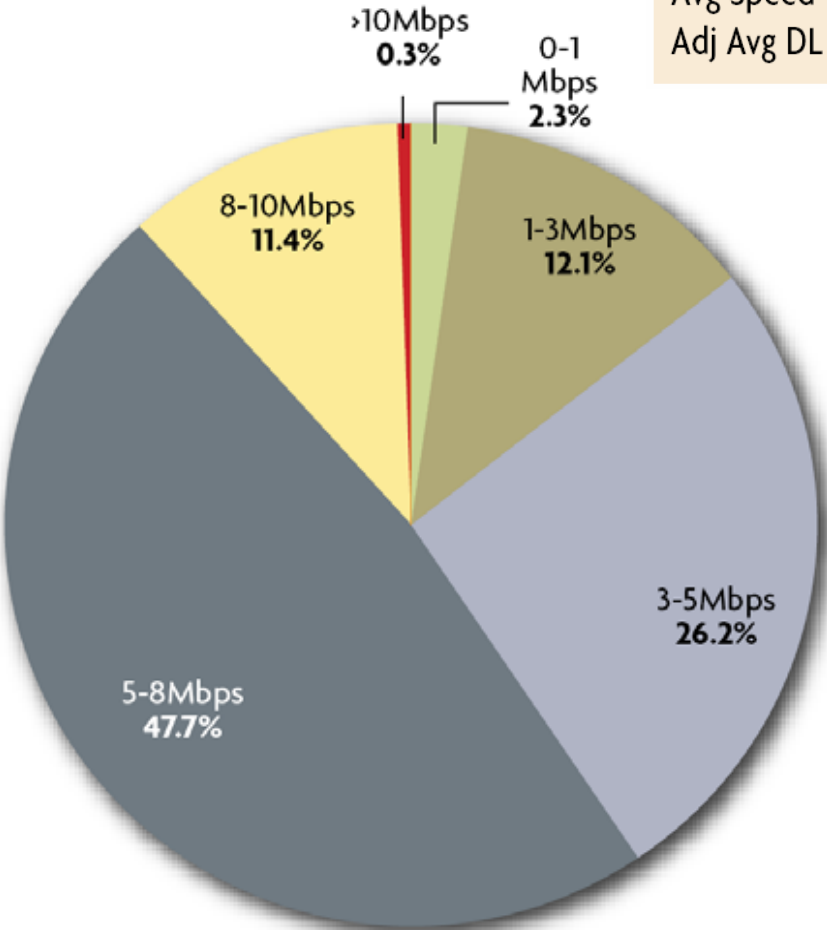
Source: Signals Research Group, LLC

Mobile WiMAX Pedestrian Test – downtown Portland early evening

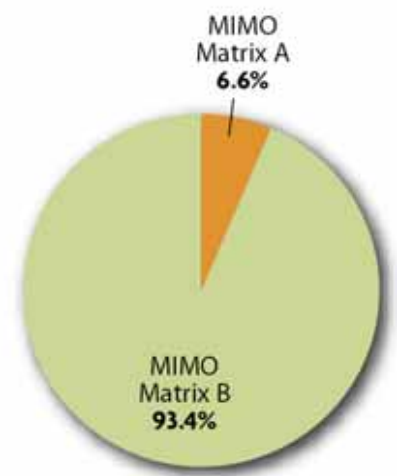
Test Scenarios 14-15 KPIs

Distribution of DL/UL Data Rates and MIMO Matrix A/B

Total Transfer = 1,728.5MB	Adj Avg UL = 2.4Mbps
Avg Speed = 2.8Mph	Max DL = 10.2Mbps
Adj Avg DL = 5.4Mbps	Max UL = 2.4Mbps



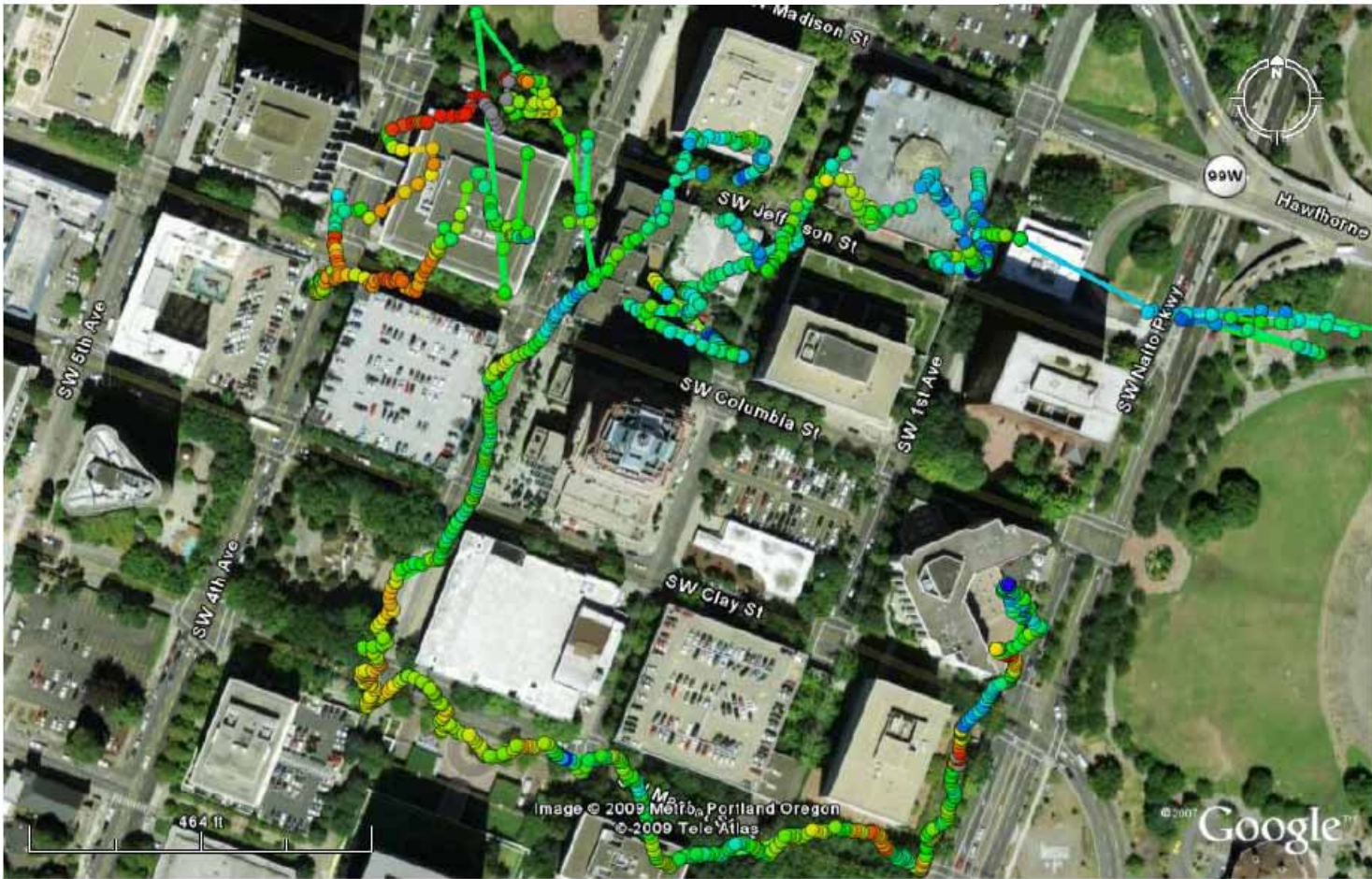
UL Throughput



Source: Signals Research Group, LLC

Mobile WiMAX Pedestrian Test – downtown Portland early evening

Downtown Portland Pedestrian Mode
 Geo plot of DL Data Rates (Test Scenario 14-15)



Source: Signals Research Group, LLC

DL Throughput (Mbps)				
12,000	9,500	7,000	4,500	2,000
11,500	9,000	6,500	4,000	1,500
11,000	8,500	6,000	3,500	1,000
10,500	8,000	5,500	3,000	500
10,000	7,500	5,000	2,500	

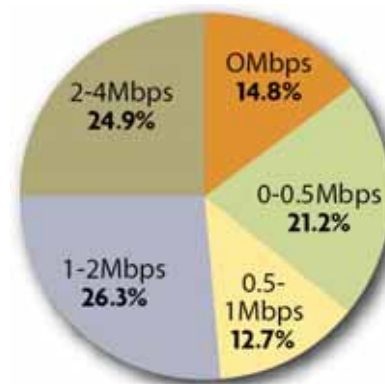
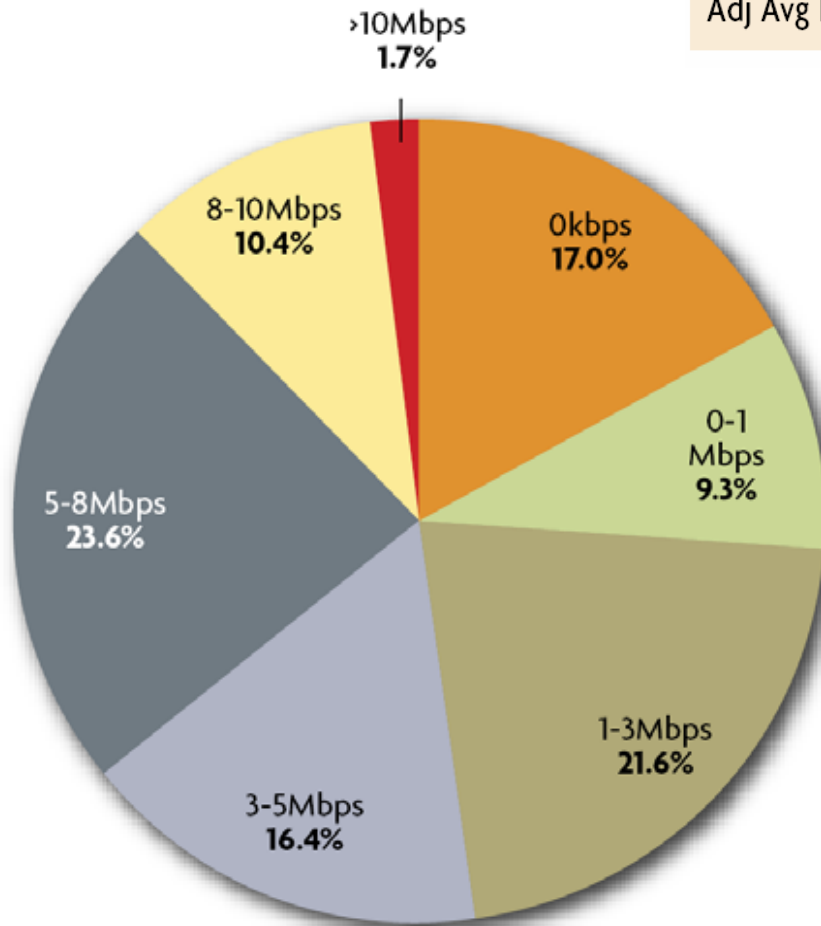
Mobile WiMAX Drive Test – Hillsboro mid afternoon

Test Scenario 18 KPIs

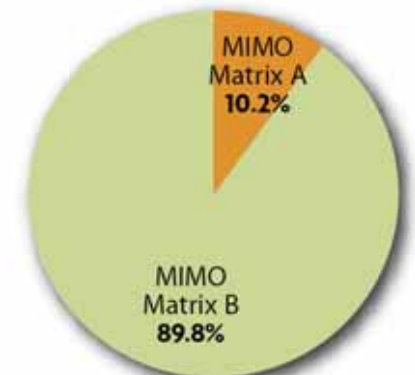
Distribution of DL/UL Data Rates and MIMO Matrix A/B

Total Transfer = 1,851.5MB
Avg Speed = 19.7Mph
Adj Avg DL = 4.5Mbps

Adj Avg UL = 1.4Mbps
Max DL = 11.1Mbps
Max UL = 3.9Mbps



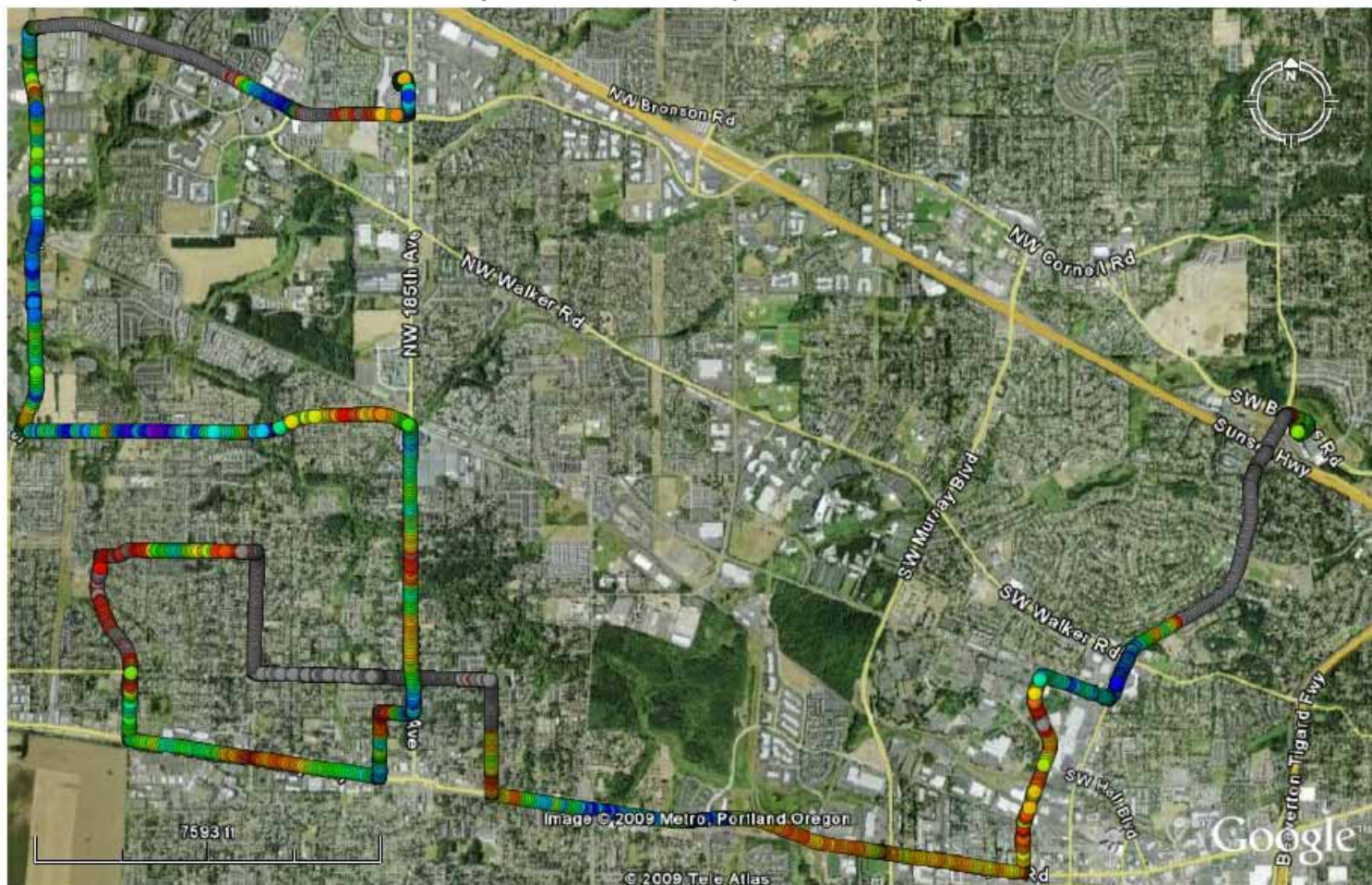
UL Throughput



Source: Signals Research Group, LLC

Mobile WiMAX Drive Test – Hillsboro mid afternoon

Hillsboro Vehicular Mode
Geo plot of DL Data Rates (Test Scenario 18)

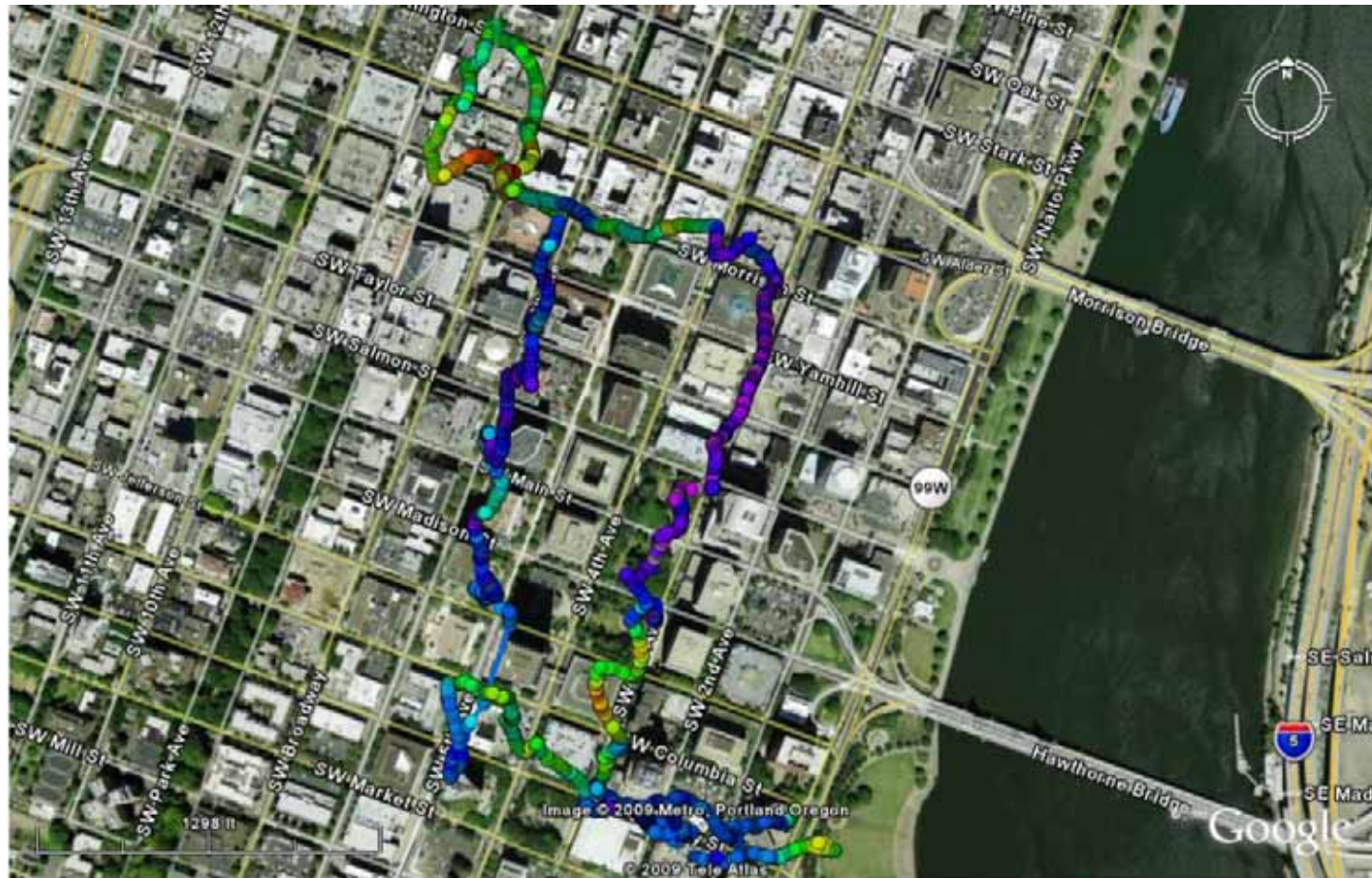


DL Throughput (Mbps)				
12,000	9,500	7,000	4,500	2,000
11,500	9,000	6,500	4,000	1,500
11,000	8,500	6,000	3,500	1,000
10,500	8,000	5,500	3,000	500
10,000	7,500	5,000	2,500	

Mobile WiMAX Pedestrian Test – downtown Portland morning (two devices)

Portland Pedestrian Mode

Geo plot of Total Throughput for 2 Devices (Test Scenario 37)

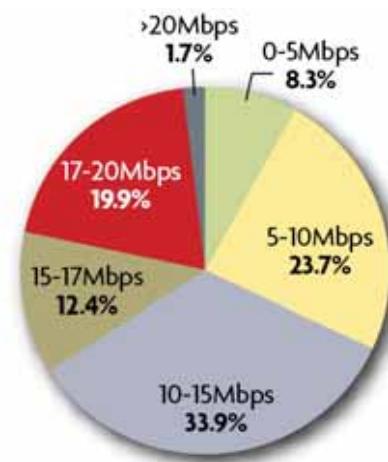
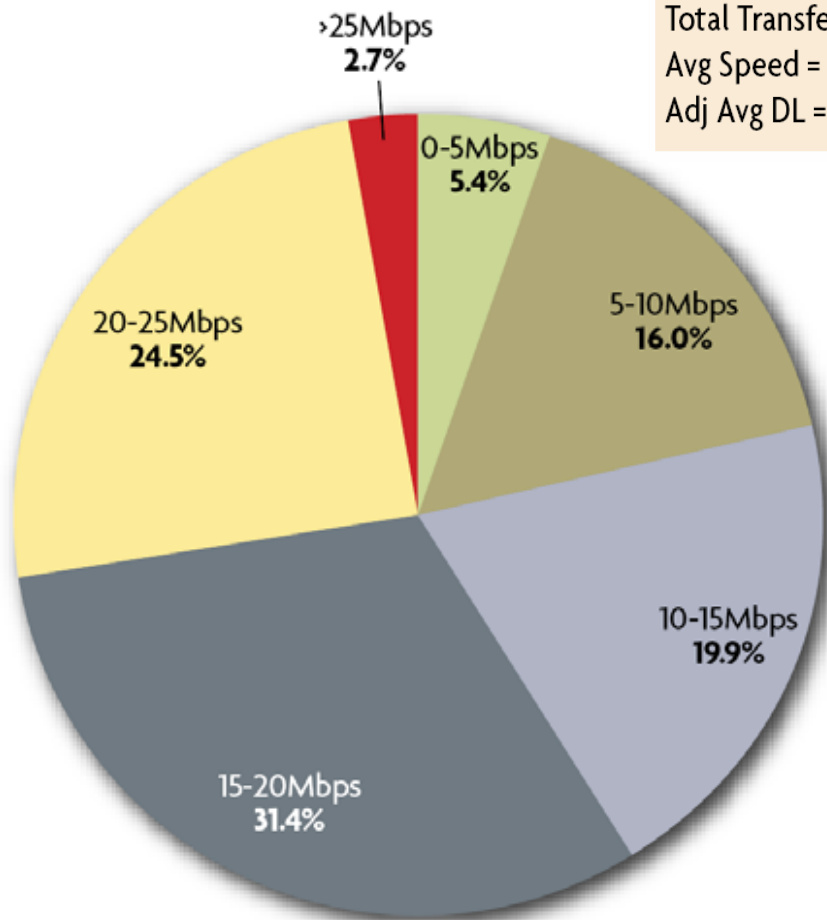


Source: Signals Research Group, LLC

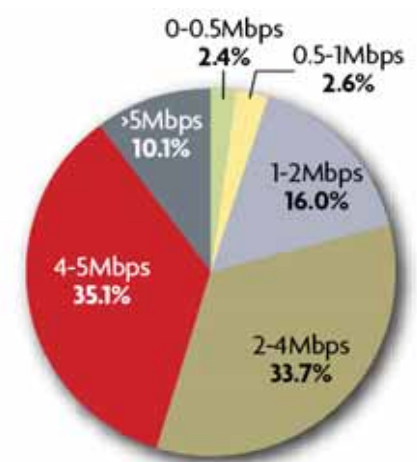
Mobile WiMAX Pedestrian Test – downtown Portland morning (two devices)

Distribution of Total Throughput and DL/UL Data Rates for Two Devices

Total Transfer = 4,421.9MB	Adj Avg UL = 3.5Mbps
Avg Speed = 2.4Mph	Max DL = 21.1Mbps
Adj Avg DL = 12.5Mbps	Max UL = 7.1Mbps



Total DL Throughput



Total UL Throughput

Source: Signals Research Group, LLC

Comparing the Incomparable

Dimensionality	HSPA+	Mobile WiMAX
Channel Bandwidth	10MHz (2x5MHz)	10MHz (1x10MHz) – 2/3 rd / 1/3 rd
Frequency	850MHz	2500MHz
Spectrum	10MHz – 2 carriers*	Urban - 60MHz; Non-Urban – 30MHz
Measured Data Rate	Physical layer – peak, normalized and average	Application layer – peak and average
Testing Procedure	Individual links	Concurrent downlink and uplink testing
Commercial Status	Commercial for several years	Commercial for several months

** Only one carrier was used; the presence of the 2nd carrier didn't necessarily improve our test results*

The Competitive Advantage

Criteria	Mobile WiMAX	HSPA+
Average DL/UL Data Rate	✓	✓
Peak DL Data Rate	✓	✓
Peak UL Data Rate	✓	
Coverage		✓
Higher Modulation Schemes	✓	
Latency	✓	✓
MIMO Availability	✓	
Spectrum Efficiency	?	?

Conclusions

- The performance of both networks, based on our user experience and the underlying metrics, exceeded our expectations.
- Barring spectrum considerations, it is unlikely that an HSPA operator would consider deploying Mobile WiMAX.
- 3G operators face a competitive challenge and they will need to respond.
 - EV-DO Rev A versus HSPA+/WiMAX
 - UMTS/HSPA versus HSPA+/LTE
- Operators may care about spectral efficiency, but consumers do not care.
- There are significant implications for the expected real-world performance of LTE.
 - Twice the bandwidth (2x10MHz versus 1x10MHz) = twice the data rate???
 - 700/1700MHz versus 2500MHz = better coverage
 - $N=1/\text{FFR}$ versus $N=3/N=6 = ???$

The logo for Signals Research Group features the word "SiGNALS" in a bold, black, sans-serif font. Above the letter "i" are four concentric, orange, semi-circular lines that resemble a signal or Wi-Fi icon. Below "SiGNALS" is the text "Research Group" in a smaller, orange, sans-serif font.

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