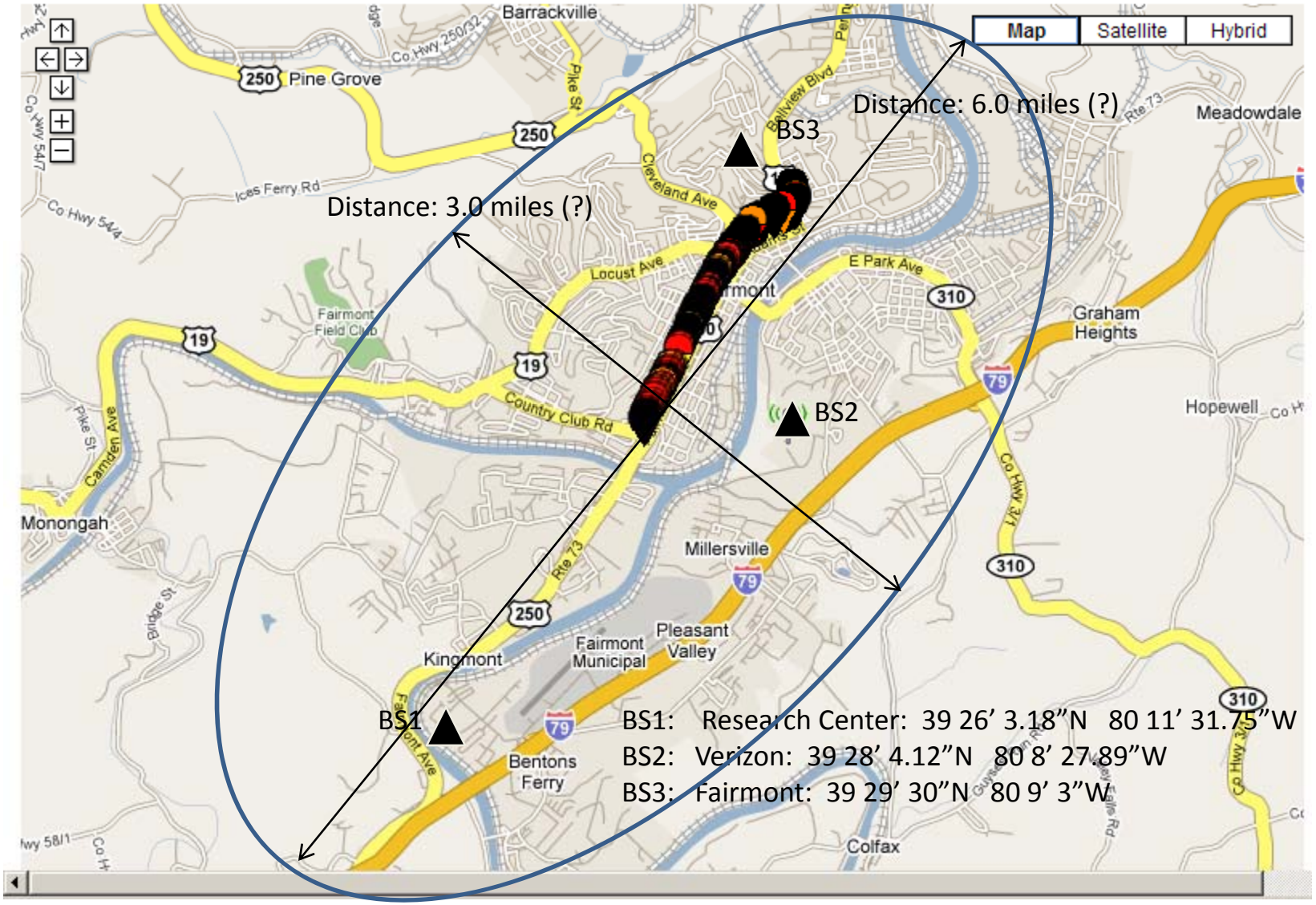
Evaluation of West Virginia High Technology Consortium Foundation's 4.9 GHz WiMAX Network July 9, 2008 (Draft)

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Points of view in this document are those of the author and do not necessarily represent the official position or policies of the US Department of Justice.



Overview of WiMAX System at the West Virginia

Deployment Details

- BS1:
  - Elevation:
  - Two sectors (EIRP: 40)
- BS2
  - Elevation:
  - Three sectors (EIRP: 40)
- BS3
  - Elevation:
  - Three sectors (EIRP: 40)

Methodology

- Fixed the radio to a single channel (to avoid issues caused by handoffs)
- TCP Throughput tests
  - fixed location (client located in a stationary car)
  - Client radio an Airspan EasyST
- Coverage tests
  - Nomadic operation
  - Client test tool operated in a vehicle
  - Client radio an M/A-COM high power model (with a 6 dB mag mount antenna)

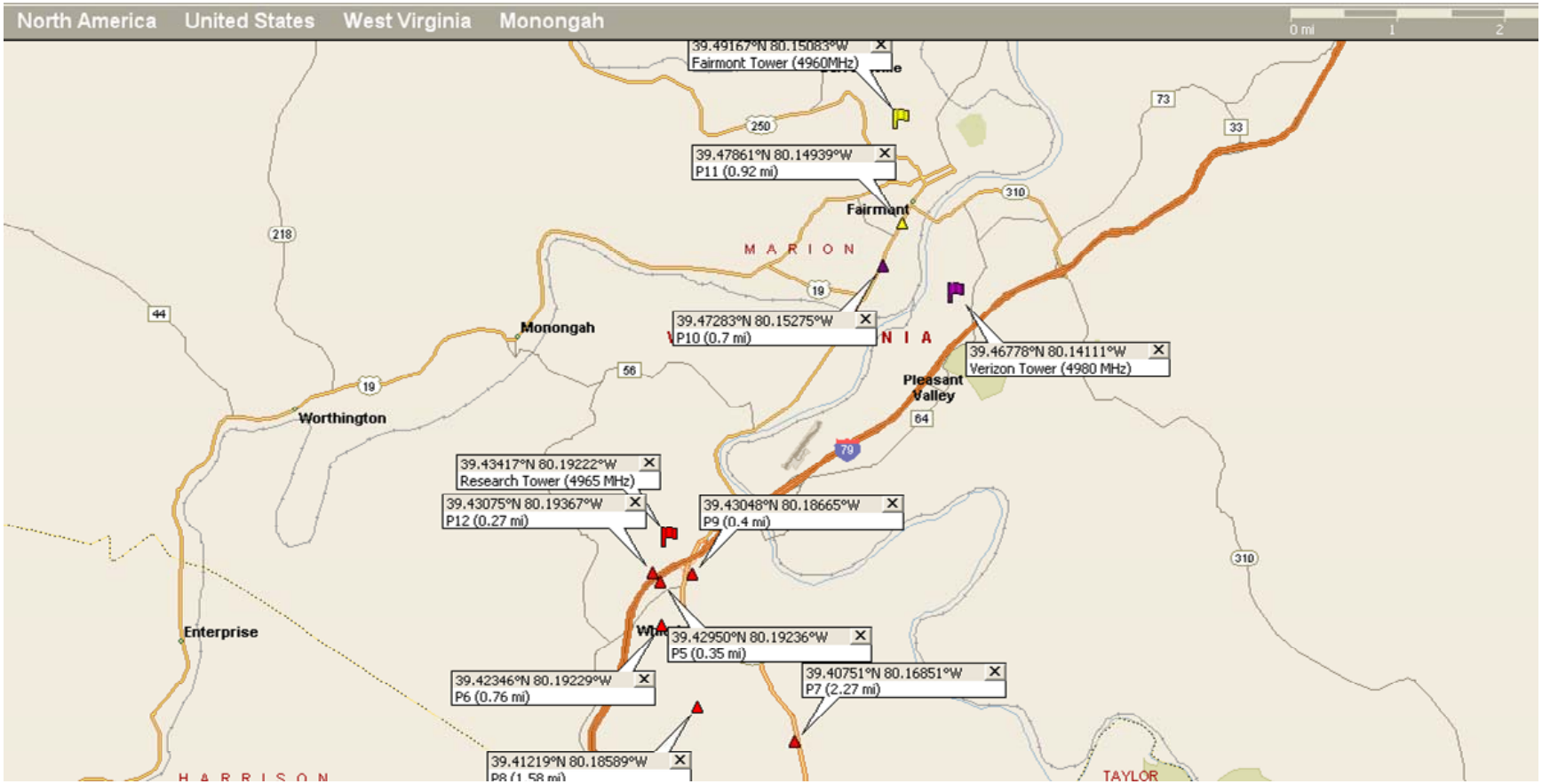
TCP Throughput Results

Results Summary

Location No.	GPS	Avg US TCP Throughput (Mbits/sec)	Avg DS TCP Throughput (Mbits/sec)	RSSI (dBm)	SNR (dB)	DS Modulation	US Modulation	RTT (msec)
5	39.42950 N 80.19236 W	2.712	NA	-70.6	29.4	64QAM3/4	16QAM1/2	NA
6	39.42346 N 80.19229 W	5.489	NA	-62.1	34.8	64QAM3/4	64QAM2/3	NA
7	39.40751 N 80.16851 W	1.414	6.596	-78.6	25.2	64QAM2/3	QPSK1/2	NA
8	39.41219 N 80.18589 W	2.773	7.42	-63.4	32.0	64QAM3/4	16QAM1/2	NA
9	39.43048 N 80.18665 W	4.044	7.45	-66.9	34.8	64QAM3/4	16QAM3/4	43.6
10	39.47283 N 80.15275 W	2.350	822 Kbits/sec	-76.3	27.3	64QAM3/4	BPSK1/2	76.3
11	39.47861 N 80.14939 W	2.148	6.806	-62.6	34.0	64QAM3/4	64QAM2/3	69.3
12	39.43075 N 80.19367 W	4.581	7.45	-65.5	34.8	64QAM3/4	16QAM3/4	43.8

*Note: Location numbers are showed on the following map.

TCP Throughput Results



Study Locations and WiMax Towers

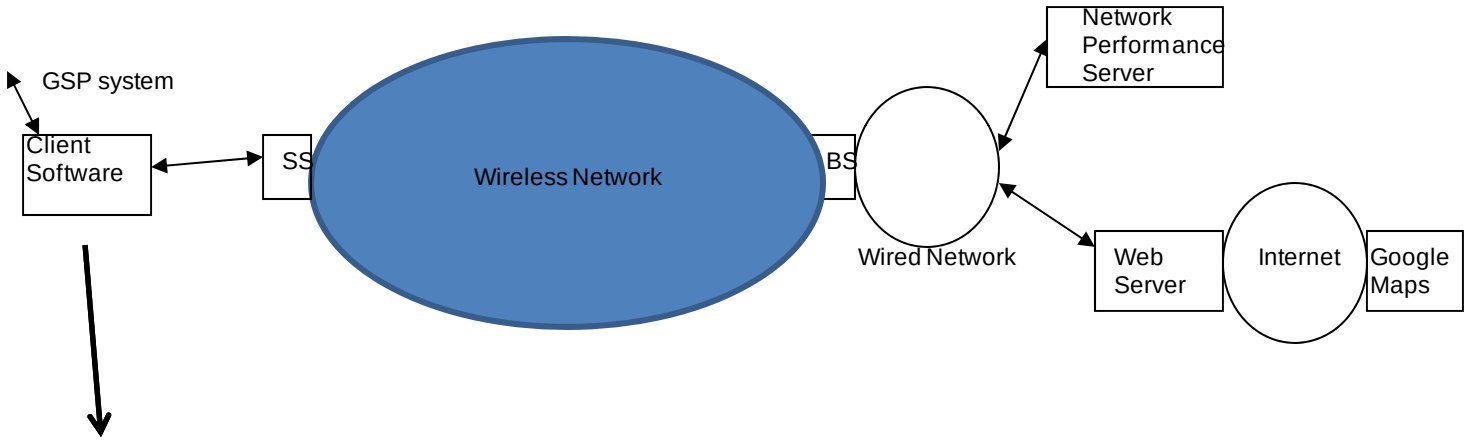
Researchers chose 7 locations in Fairmont, WV area to measure the WiMax communication performance by using iperf. Locations from No.5 to No.9, No.12 were covered by WiMax towers within WVHTC. No.10 was in the Verzion tower coverage area, while No. 11 was covered by Fairmont tower. This straight distance from each test place to the WiMax tower is showed in the map.

TCP Throughput Results

Modulation	Upstream TCP Throughput	Downstream TCP Throughput
64 QAM ¾	*	7.55 Mbps
64 QAM 2/3	5.57 Mbps	6.74 Mbps
16 QAM ¾	4.2 Mbps	5.07 Mbps
QPSK ¾	2.15 Mbps	
QPSK ½	1.46 Mbps	1.64 Mbps
BPSK ½	.775 Mbps	

Additional TCP Throughput Data using the M/A-COM high power radio

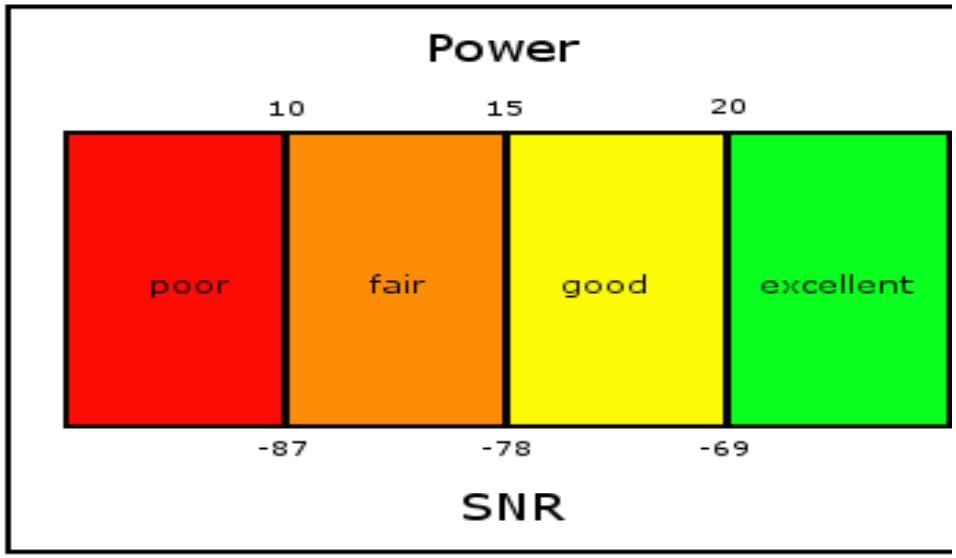
Wireless Network Coverage Tool

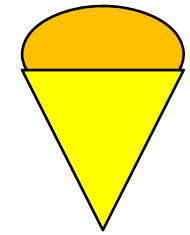


Results from client tool:

GPS lat/long	snr	rss	DS mod	UP mod	speed	elevation	date	UDP ping RTT
39.486940|-80.140598|	10.3|	-89.6|BPSK 1/2	|BPSK 1/2	|nan mph|1018.0 ft|06/20/08 11:28:34 |				63727.000000

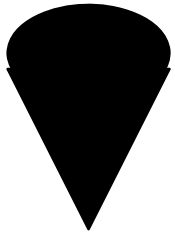
Coverage Map Visual Key





ICE CREAM: Power (received signal strength, RSS)

CONE: SNR



Link connectivity mode
black: no link,
green: link exists

Currently the tool provides two assessments:

- RF (see color code above)
- Connectivity (green) based on either:
  - SNR > 5
  - IP Ping Succeeds

Measurement data obtained 6/19-6/20 2008

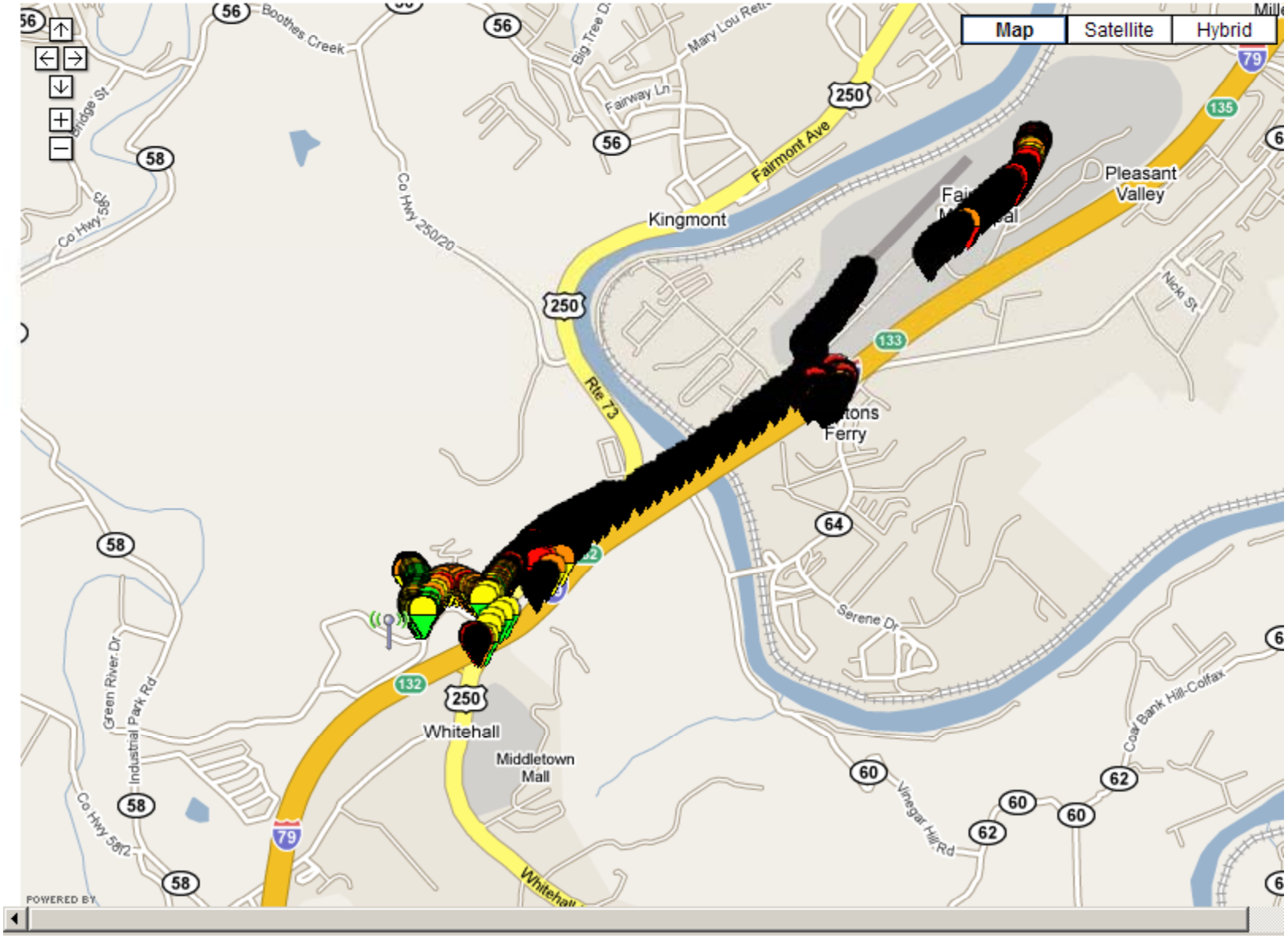
GPS coordinates of the three base stations:

Research Center: 39 26’ 3.18”N 80 11’ 31.75”W
Verizon: 39 28’ 4.12”N 80 8’ 27.89”W
Fairmont: 39 29’ 30”N 80 9’ 3”W

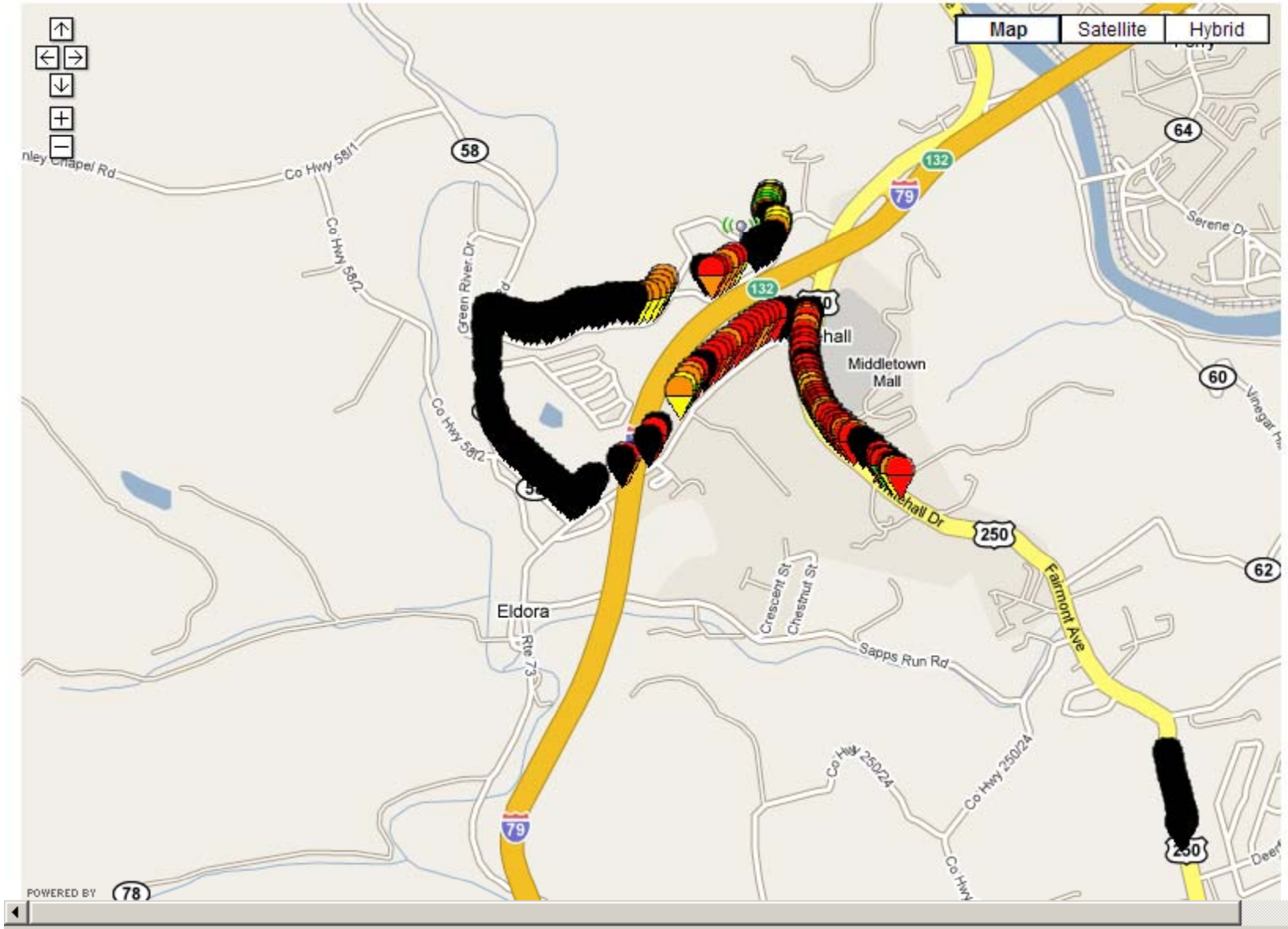
BS: tower 1 (Research Center, aka base)
WV1.dat: data run around tower 1
WV10.dat : mall parking lot with base setup (6 db mag mount antenna)
WV11.dat : mall parking lot with 9 inch 9db gain antenna
WV15.dat : mall parking lot with my setup EXCEPT used an Airspan EasyST
WV12.dat : measurement run using second sector at base
WV16.dat : did 2 loops in front of the BS with tcp going and using tcpdump. trace is WV3.trc (WV1.trc is US/DS tcp at bpsk and qpsk,
WV17.dat : going from base to the hotel

BS: verizon
WV4.dat : Verizon tower - from base to fairmont
WV7.dat : Verizon tower - from fairmont to base

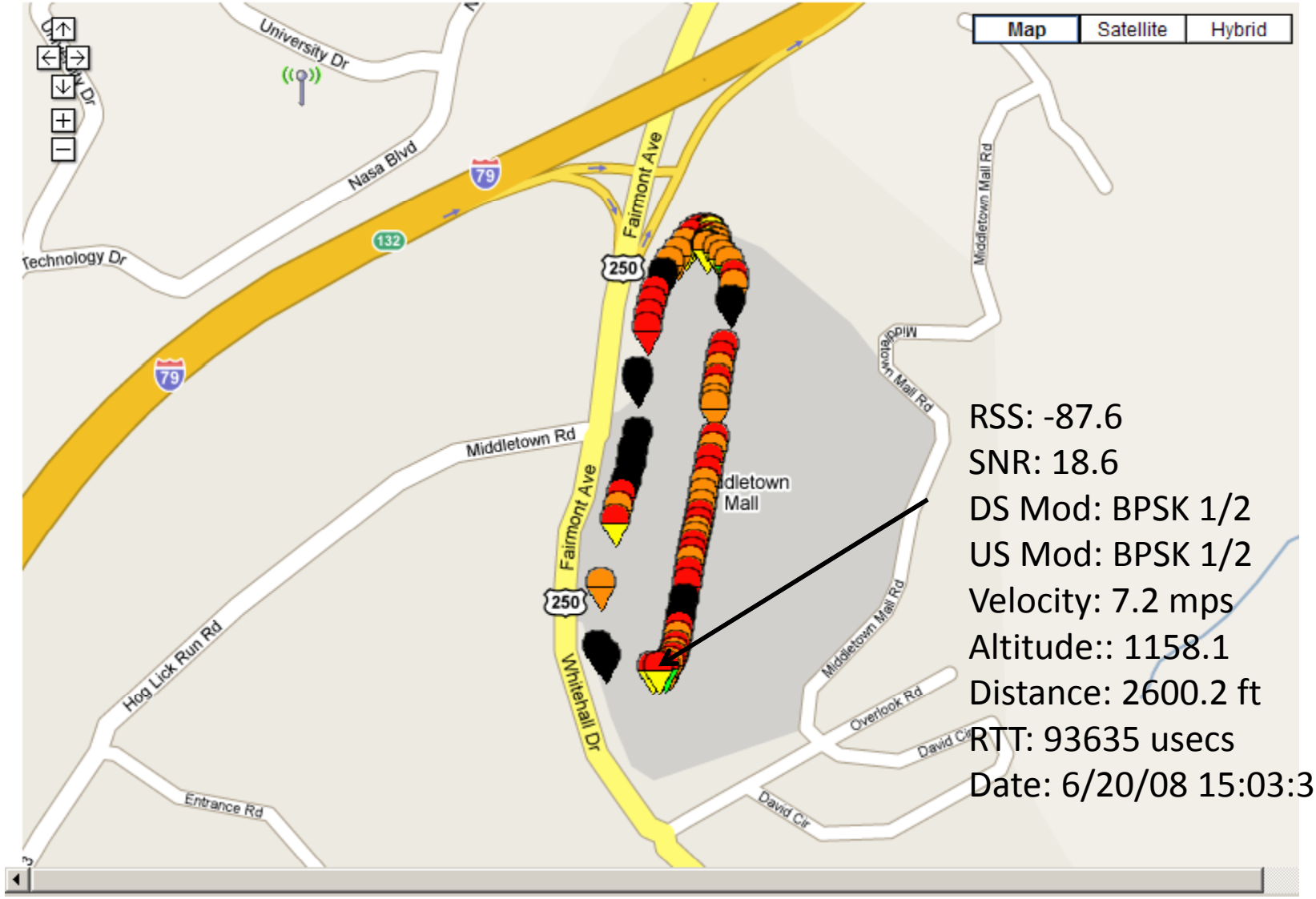
BS: fairmont
WV5.dat : In fairmont
WV6.dat : From fairmont police dept. to Subway. Ran iperf - see WViperf1.dat



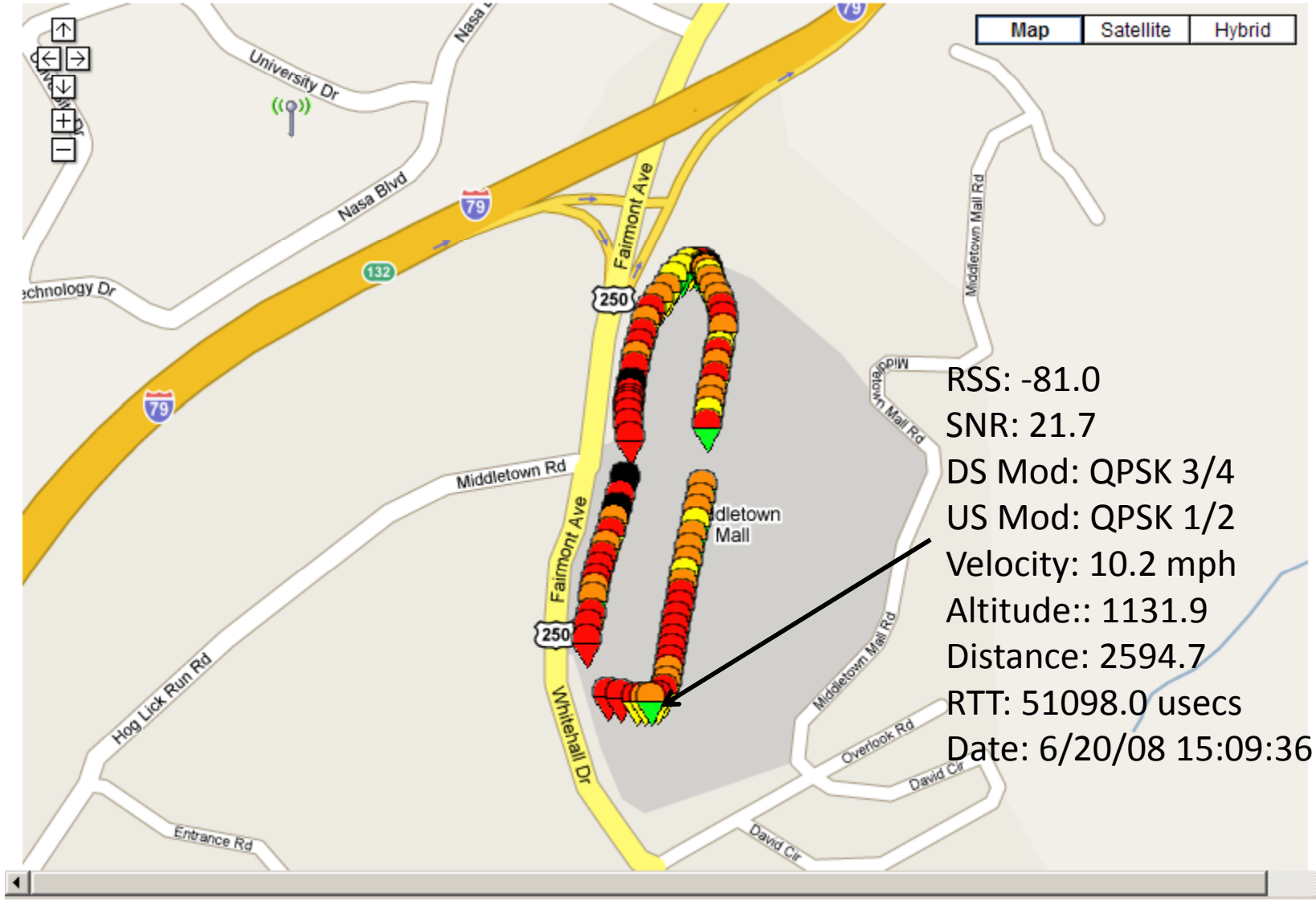
WV1.dat: main sector at the research tower



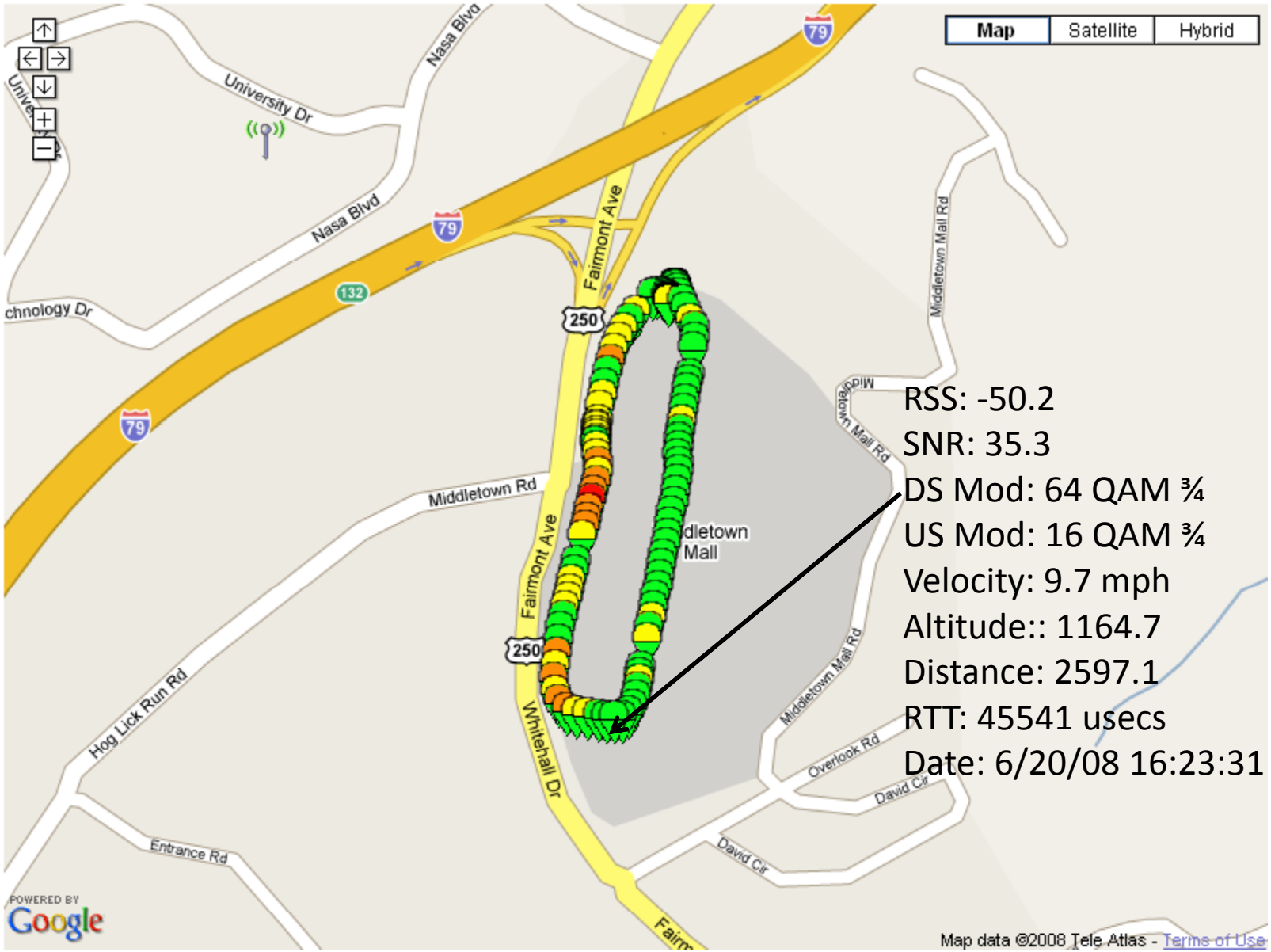
WV12.dat: second sector at the research tower



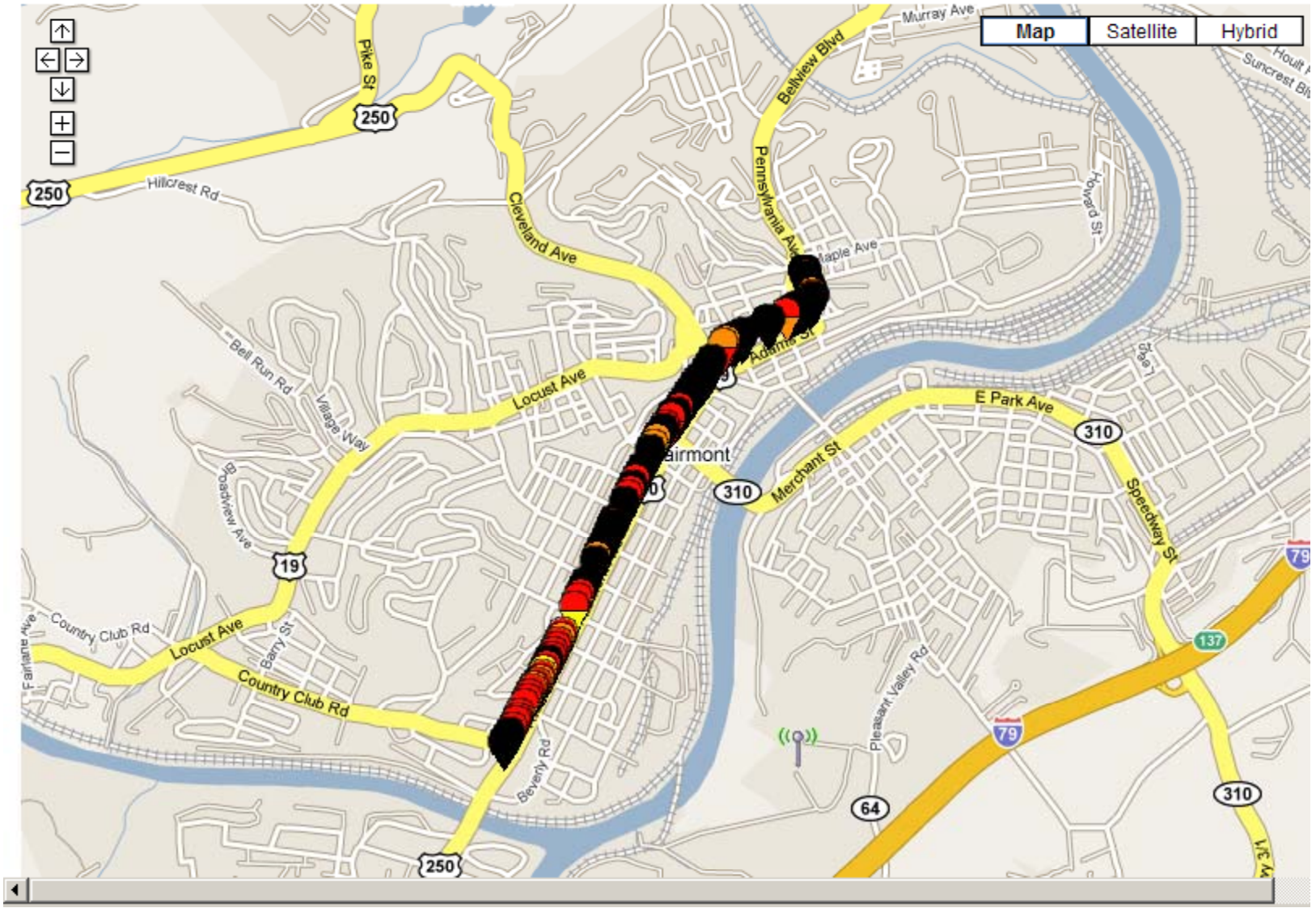
WV10.dat: baseline setup in parking lot



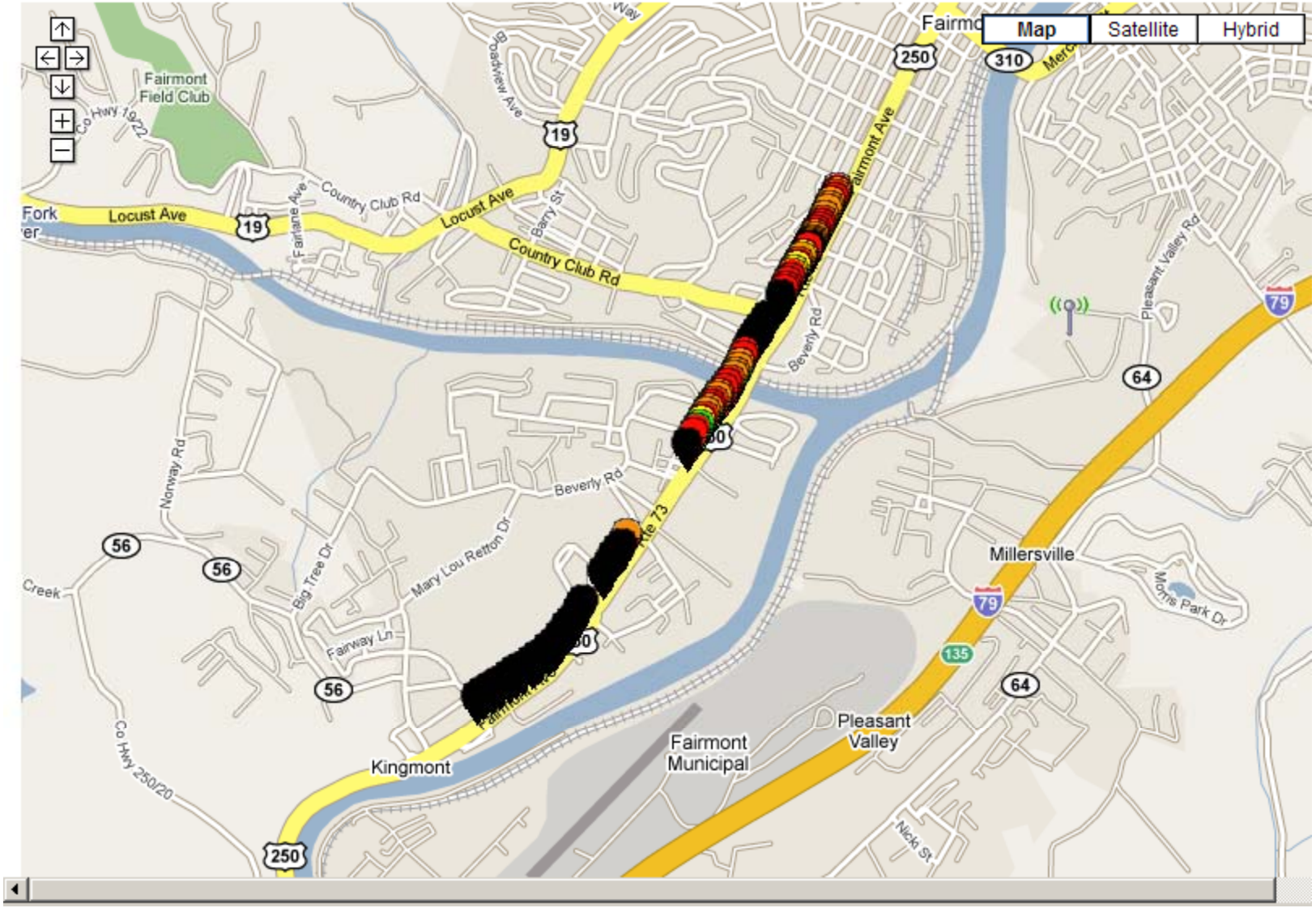
WV11.dat: baseline with 9 db antenna setup in parking lot



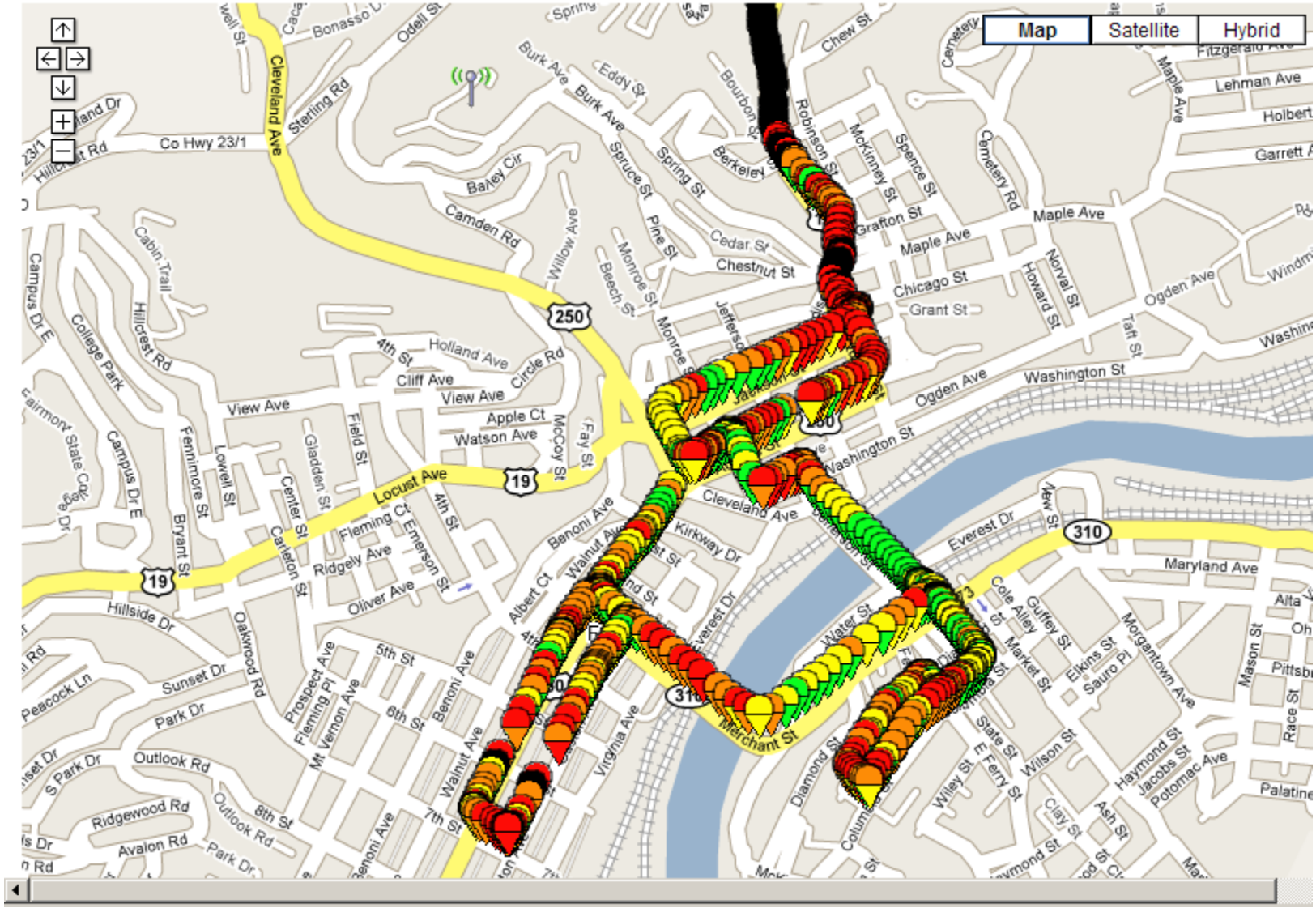
WV15.dat: baseline with Airspan EasyST in parking lot



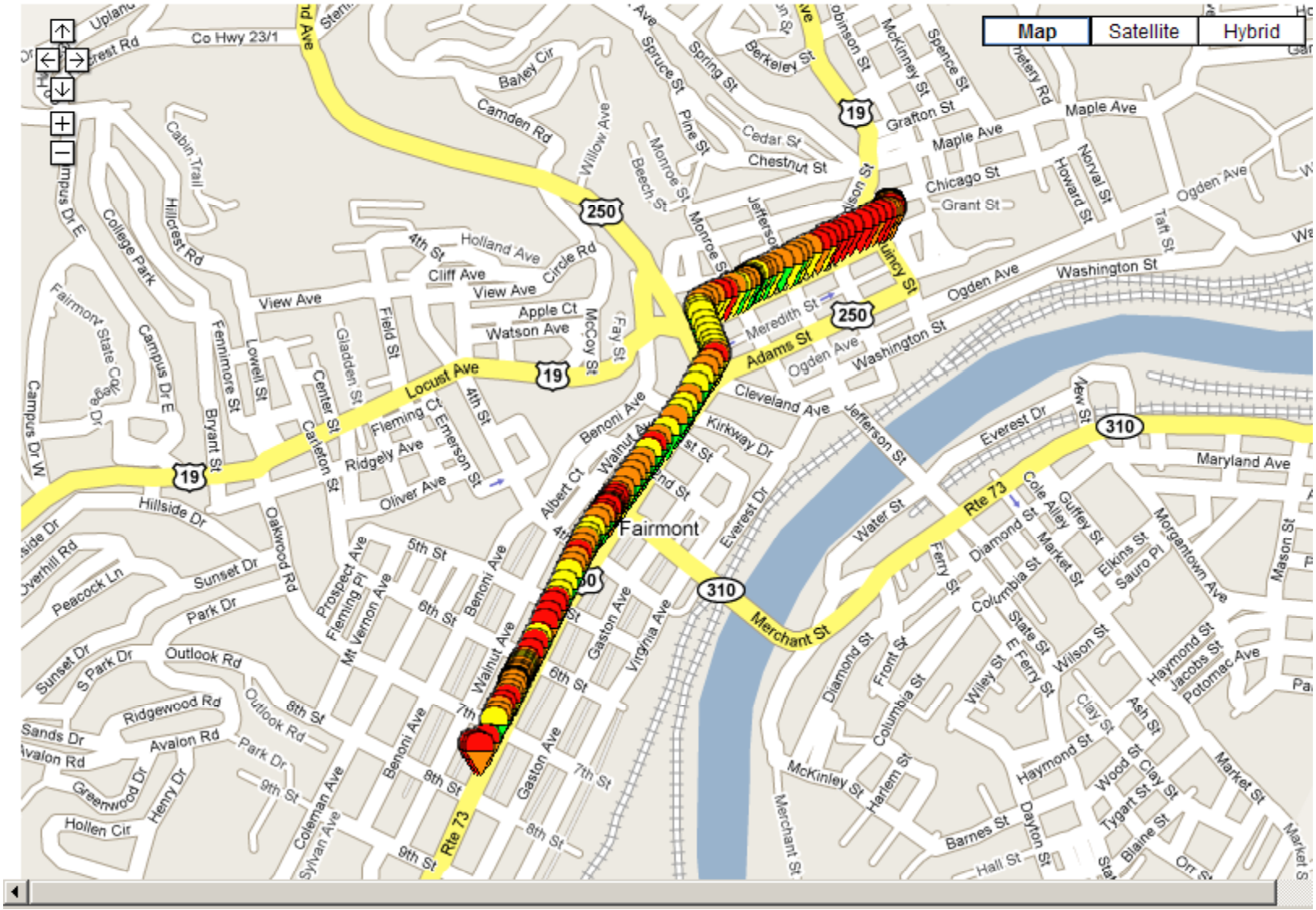
WV4.dat: From research to Fairmont



WV7.dat: from Fairmont to research



WV5.dat: In Fairmont



WV6.dat: From fairmont police dept. Ran iperf the entire time. Average US TCP throughput 1.24 Mbps (range 0 to 2.75 Mbps) (Data file WViperf1.dat)

Conclusions

- Great coverage for 4.9 GHz largely due to location of BSs and the use of sector antennas
- Tremendous difference observed between client radios (30 dB in one test!!)
- Future areas of study
  - Video to/from vehicles
  - Impacts of handoffs (with 802.16d)
  - Impacts of 802.16e (WV expects to upgrade in 2008)