

***Bluetooth*[™] Versus Wi-Fi for MAC Address Data Collection**

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OVERVIEW

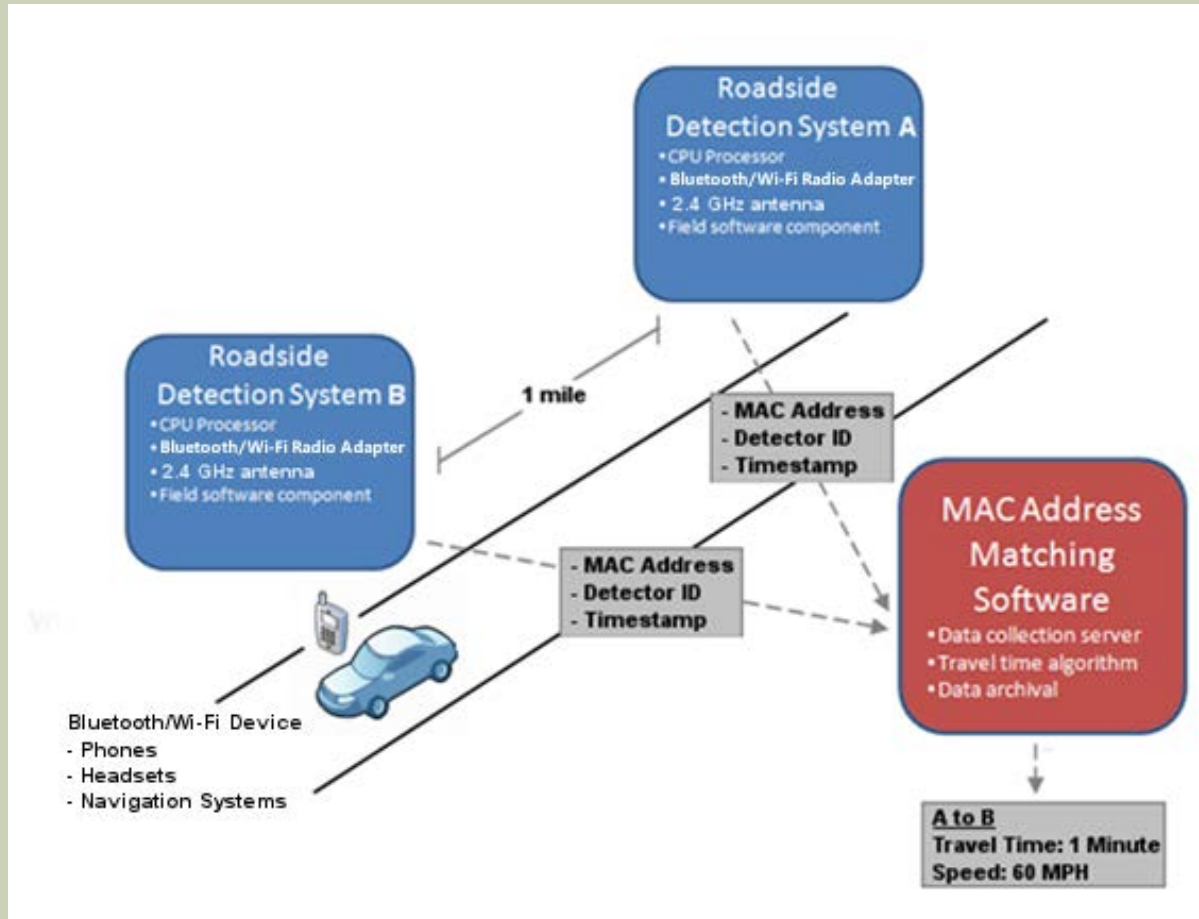
- Background
- Concept
- Field Testing Results
- Challenges
- Application
- Concluding Thoughts

PRESENTERS (TTI) BACKGROUND

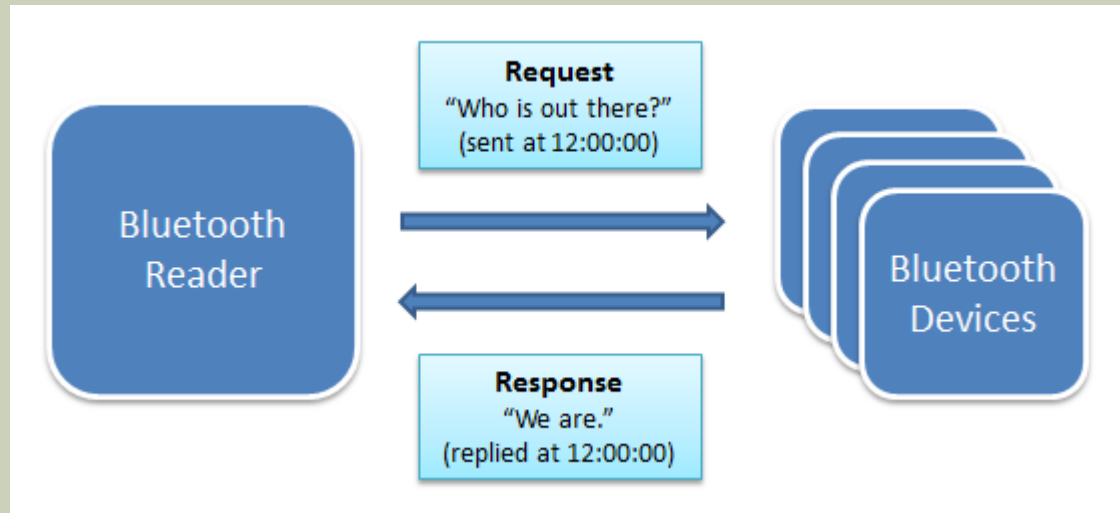
- Assisted and participated in over 3,000 deployments of field readers.
- Deployed in multiple geographic locations, State DOT's, local municipalities, several states and foreign countries.
- Extensive demonstrations of address matching technologies (Toll tag, ALPR, *Bluetooth™*, Wi-Fi).
- Analyzed and documented applications beyond just travel times - Origin-Destination, Intersection/Corridor Delay, Border/Ferry Wait Times, etc..

ADDRESS MATCHING CONCEPT

(Same for *Bluetooth™* and Wi-Fi)



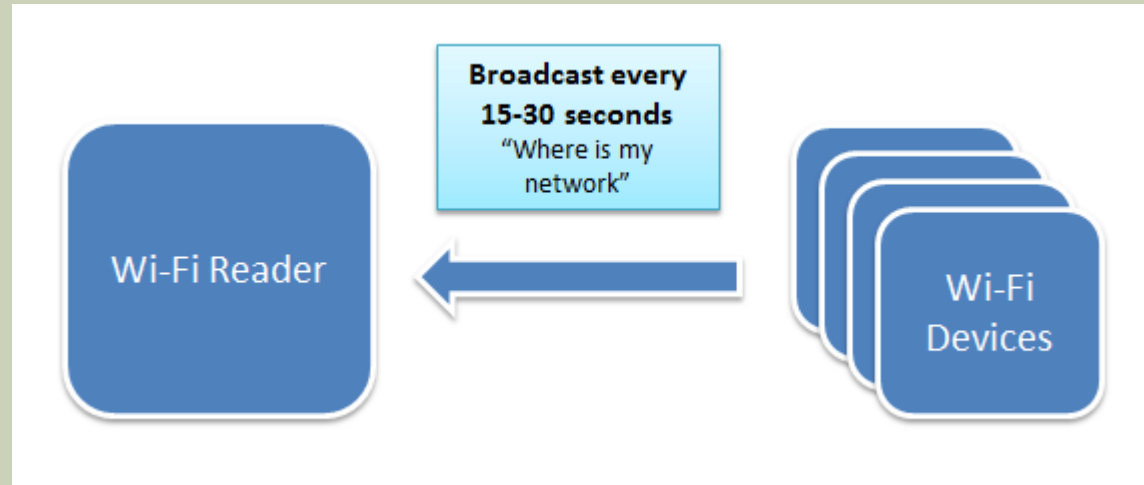
BLUETOOTH™ MAC ADDRESS DETECTION



Characteristics (TTI methodology)

- Two-way request/response.
- Reader initiates response from Bluetooth devices.
- Devices in range respond immediately (differs from standard *Bluetooth™* inquiry process).
- Regardless of speed, devices have > 90% chance of being detected.

WI-FI MAC ADDRESS DETECTION



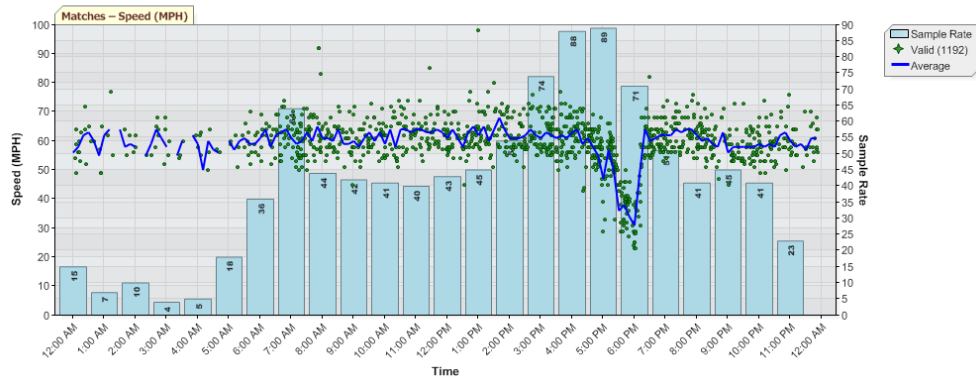
Characteristics

- Wi-Fi device sends request. Wi-Fi reader only listens.
- Wi-Fi devices send network inquiries approximately every **15-30 seconds** (depending on device type and activity).
- Detection probability is highly dependent on speed.

AWAM BLUETOOTH™-WI-FI PROFILES

SH-6 Northbound

From South Addicks Dam to North Addicks Dam (1.2 miles) - Matches - 7/11/2013

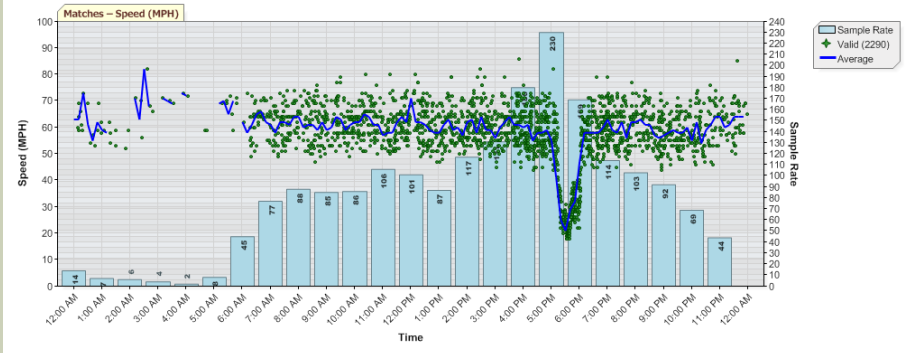


Bluetooth™

Wi-Fi

SH-6 Northbound

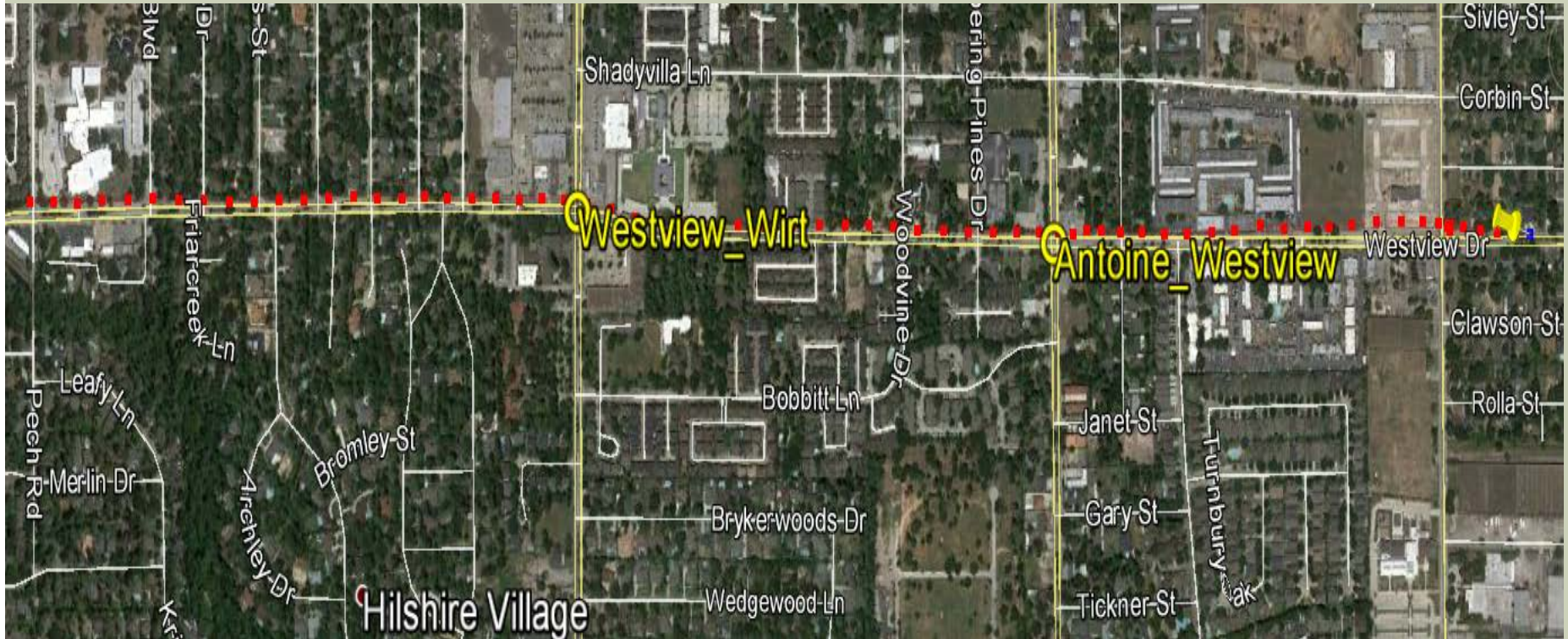
From South Addicks Dam to North Addicks Dam (1.2 miles) - Matches - 7/25/2013



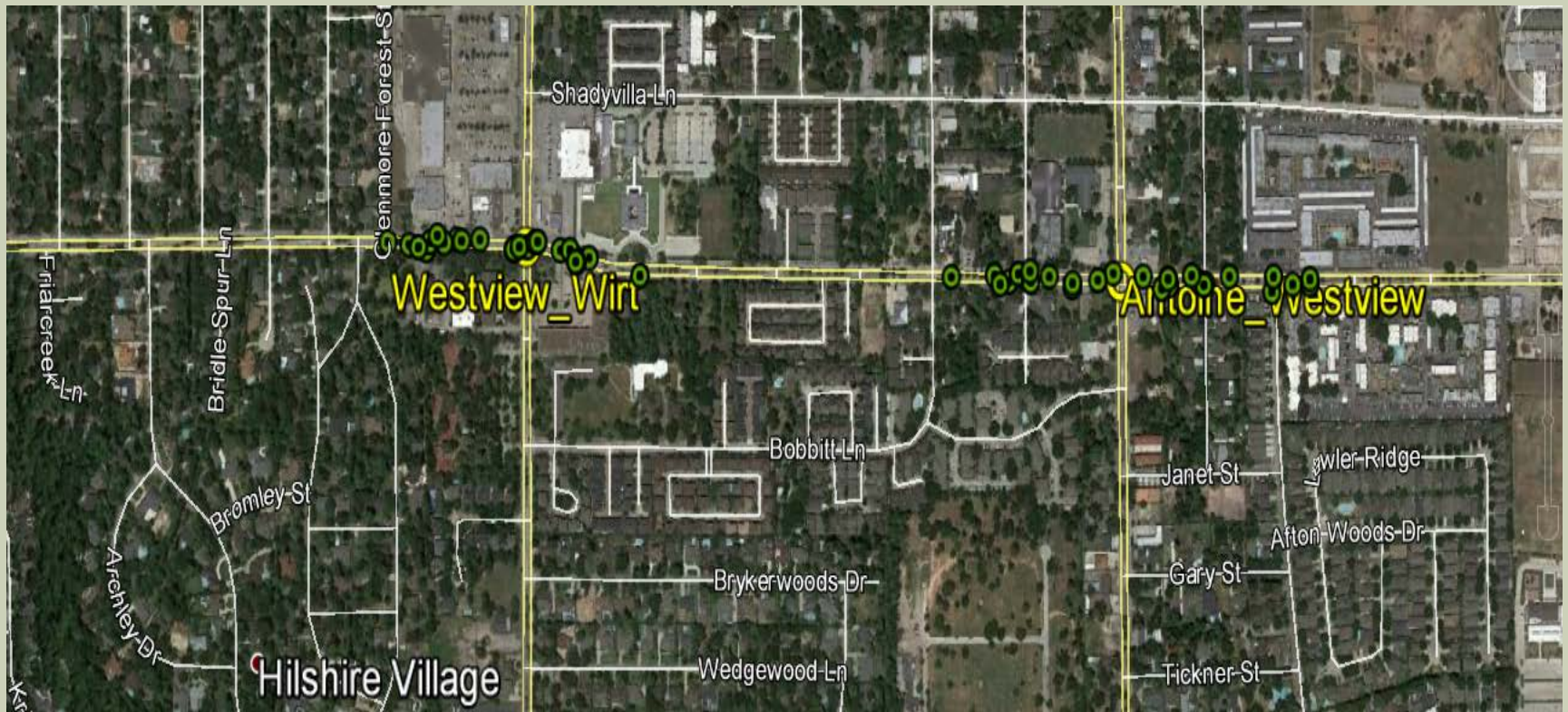
STUDY LOCATION

0.6 miles – 10,000 ADT

(red dots are study trip route - ~ 1/2 mile before and after)



REPRESENTATIVE READ LOCATIONS WITH GPS AND SIGNAL STRENGTH



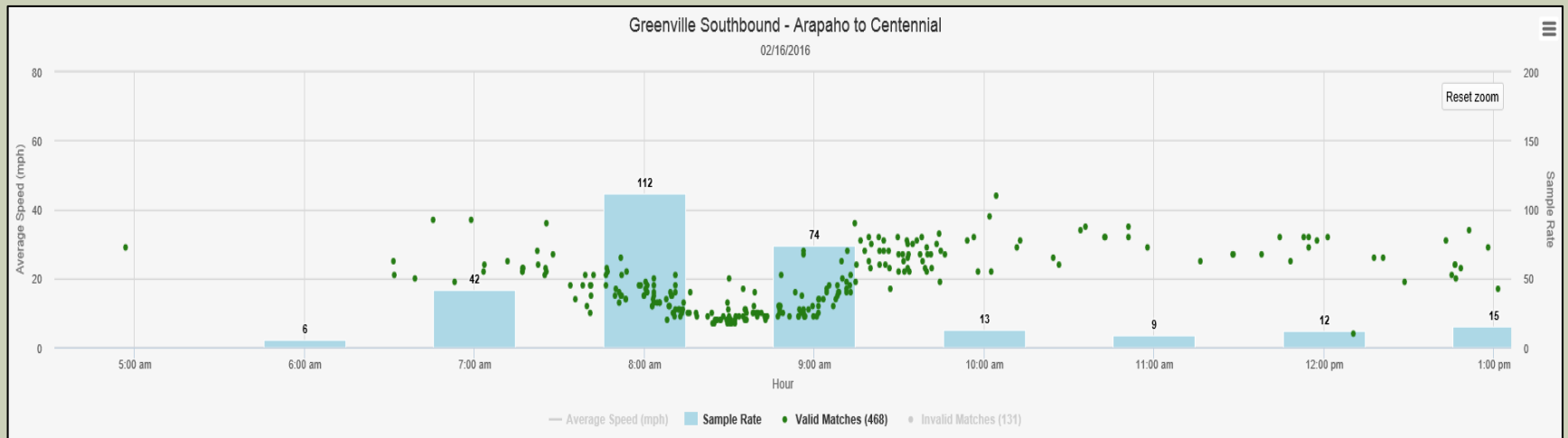
● Read Location

WI-FI DETECTION PROBABILITY

Condition	Detection Probability
Traveling past the reader at 60 MPH (97 KPH)	Less than 10%
Traveling past the reader at 35 MPH (56 KPH)	Less than 20%
Stopped at a reader for 10 seconds	Less than 70%
Stopped at a reader for more than 15 seconds	Almost 100%

* Assumes a detection radius of 1000 feet (305 meters)

WI-FI DETECTION PROBABILITY

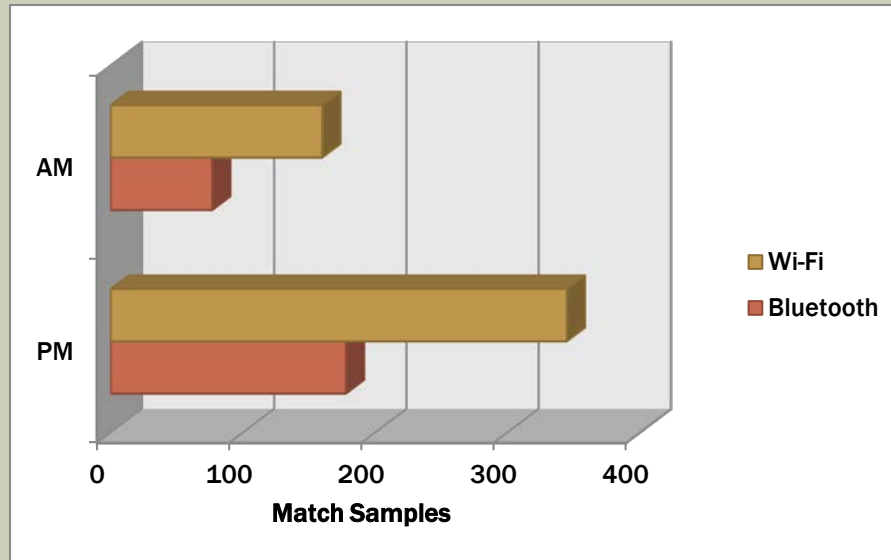


Sample Rate increases 3 to 4 times during peak period due to the lengthened time that vehicles are spending in the detection zone of the Wi-Fi readers.

Volume has not increased at the same rate.

WI-FI/BLUETOOTH™ COMPARISONS

In cabinet readers were equipped with a device capable of both Bluetooth and Wi-Fi and accomplishing 20 directional trips for each both types of observations.



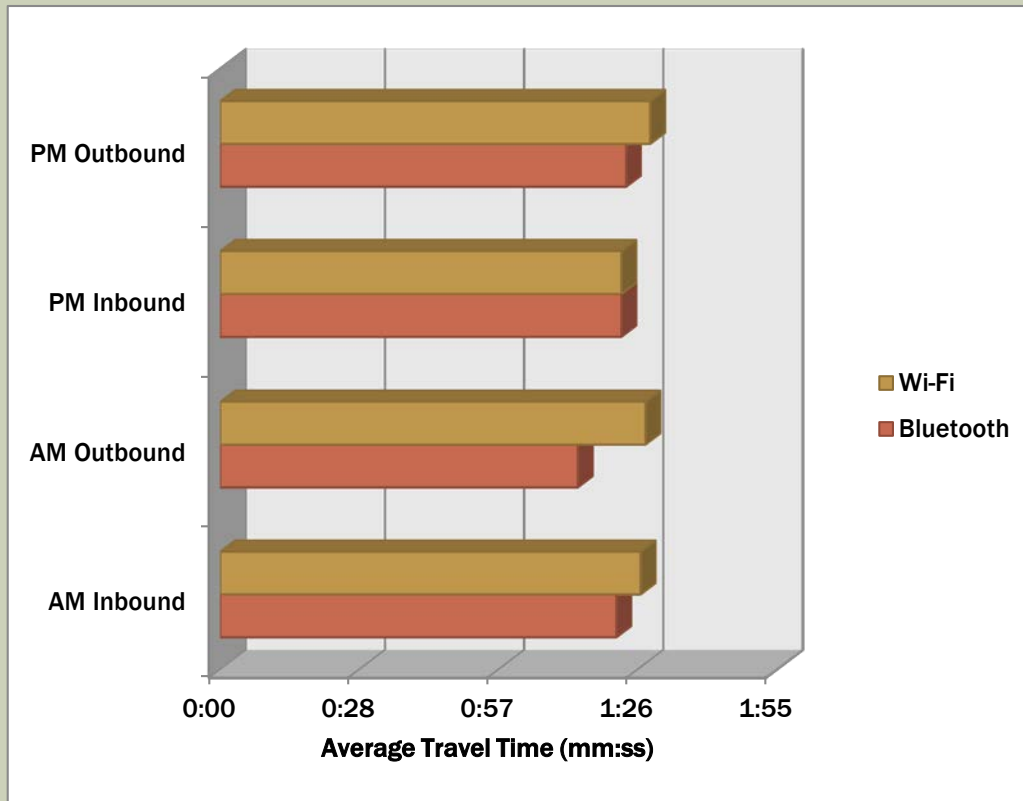
Sample Sizes

- Wi-Fi generated around 2 times as many valid matches as *Bluetooth™*.

Number of Valid Samples				
	AM Valid Samples Wi-Fi	AM Valid Samples Bluetooth	PM Valid Samples Wi-Fi	PM Valid Samples Bluetooth
Westview EB from Wirt to Antoine	79	37	164	87
Westview WB from Antoine to Wirt	81	40	181	91
Average	160	77	345	178

WI-FI/BLUETOOTH™ COMPARISONS

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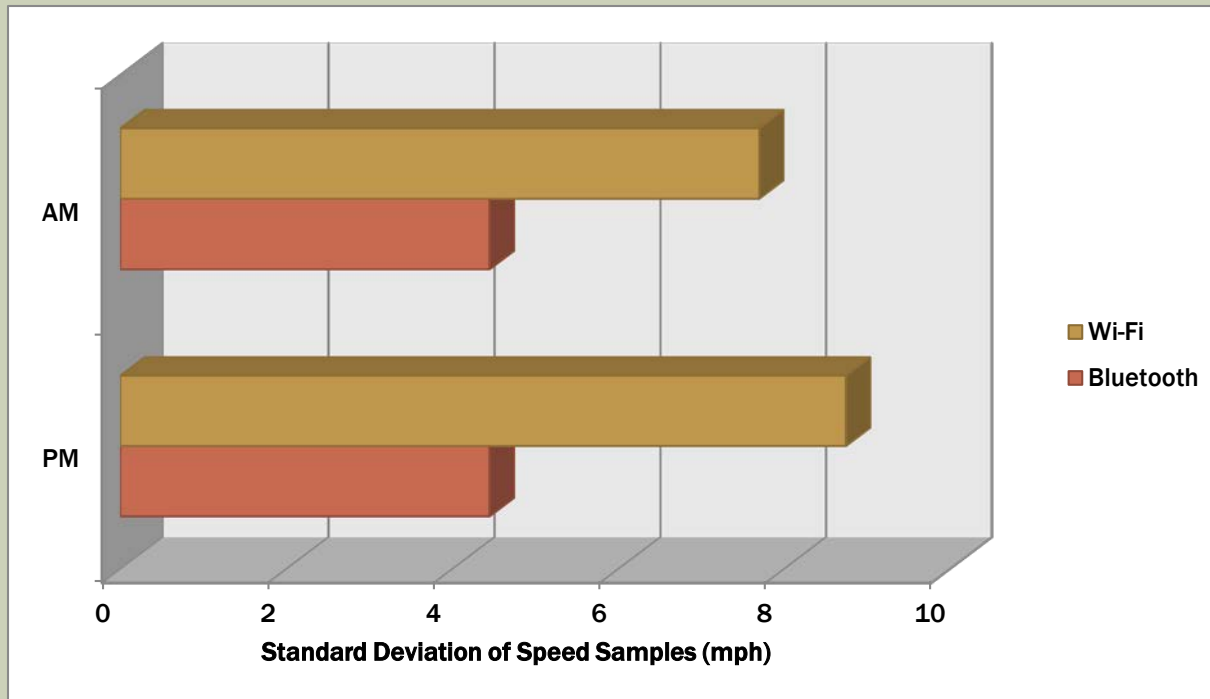


Travel Times

- Wi-Fi travel times always equaled or exceeded *Bluetooth™* travel times.
- Travel times averaged ~10% longer using Wi-Fi.

WI-FI/BLUETOOTH™ COMPARISONS

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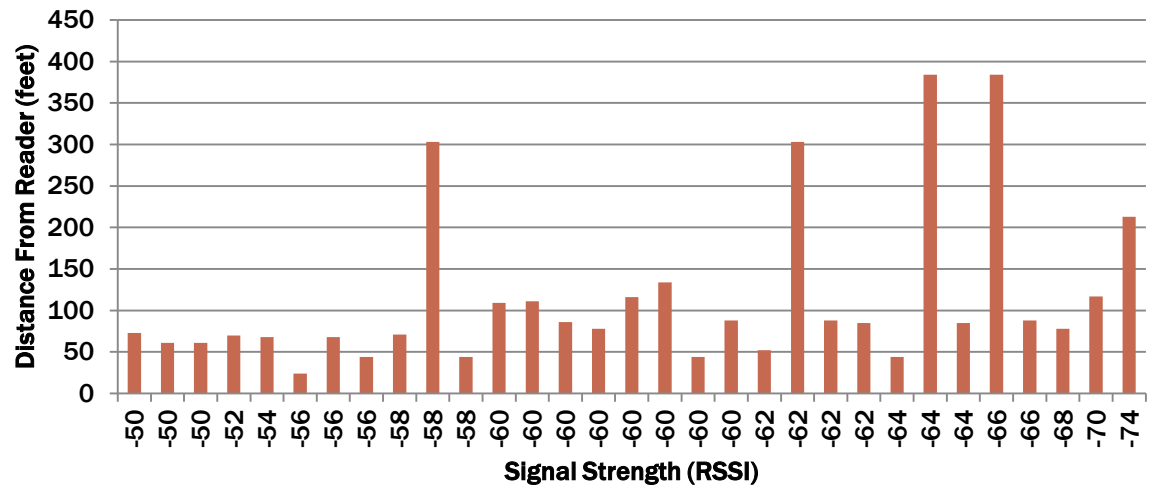
Variability

- Variance for Wi-Fi was nearly twice that of *Bluetooth™* due to the randomness of read locations within the “read zone”.

WI-FI SIGNAL STRENGTH TO DISTANCE

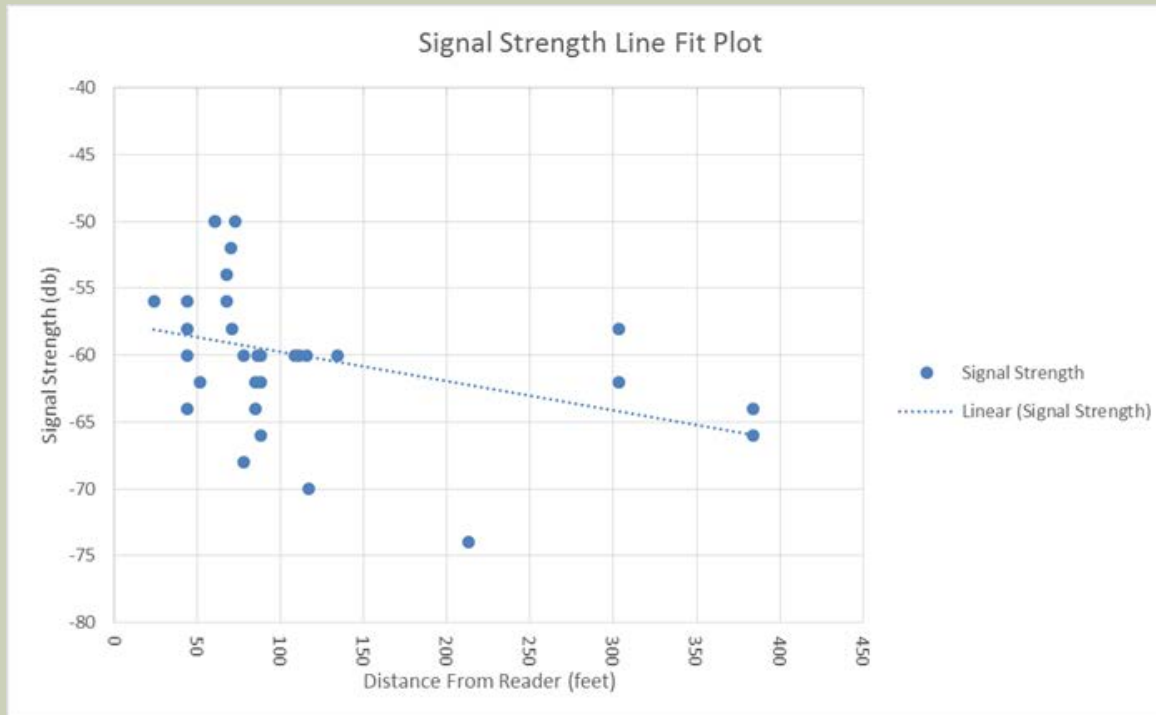
- Signal strengths varied by distance and don't show a consistent pattern.
- Likely influenced by occlusion from vehicles, landscaping, buildings, and RF interference.

Wi-Fi Readings By RSSI and Distance
Westview @ Wirt



Using Wi-Fi signal strength to determine distance from the reader is inconclusive.

WI-FI SIGNAL STRENGTH TO CLOSEST READ



- Signal strengths are highly variable when devices are less than 100ft away.

Using Wi-Fi signal strength to determine the “closest read” is inconclusive.

WI-FI CHALLENGES

- Oversamples slow or stopped vehicles creating a bias towards longer travel times.
- Variability of detection location in read zone causes more variation in travel times.
- Low re-identification rate between readers not good for collecting origin-destination data.

WI-FI ADVANTAGE AND SUGGESTED USE

High device penetration typically yields a higher match rate than *Bluetooth™* when readers are installed where traffic is slow or stopped.

Usage Recommendations

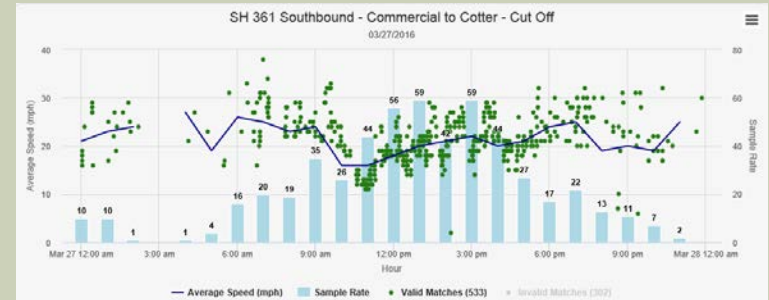
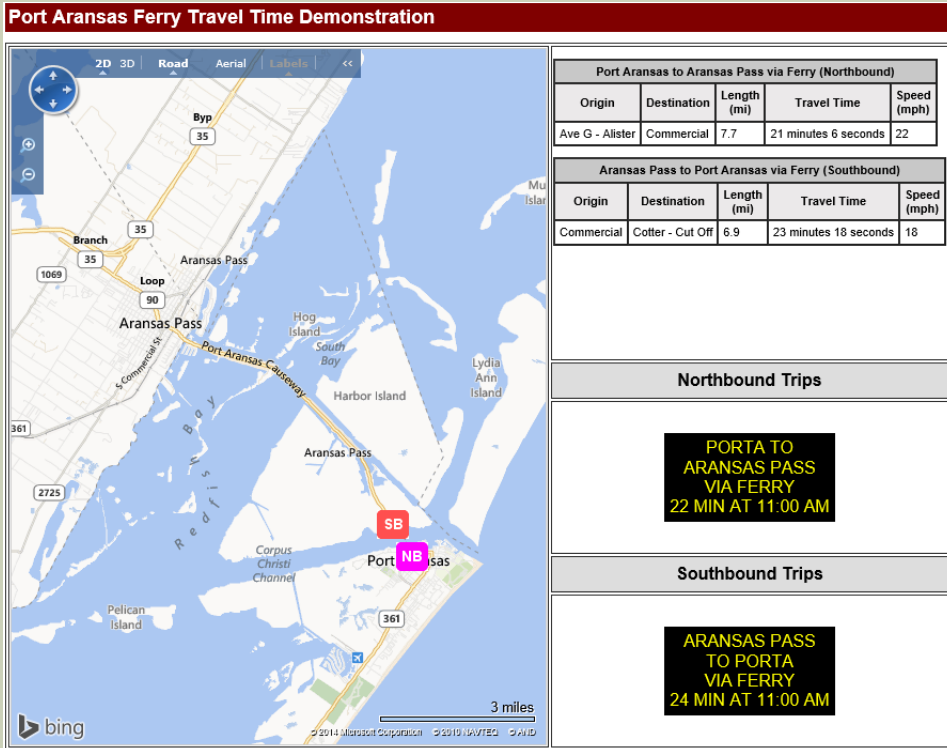
Lower volume roadways where Bluetooth sample sizes are inadequate (install Wi-Fi at signals).

Wait time applications where vehicles are queued for a significant amount of time.

1. Border crossings.
2. Ferry crossings.

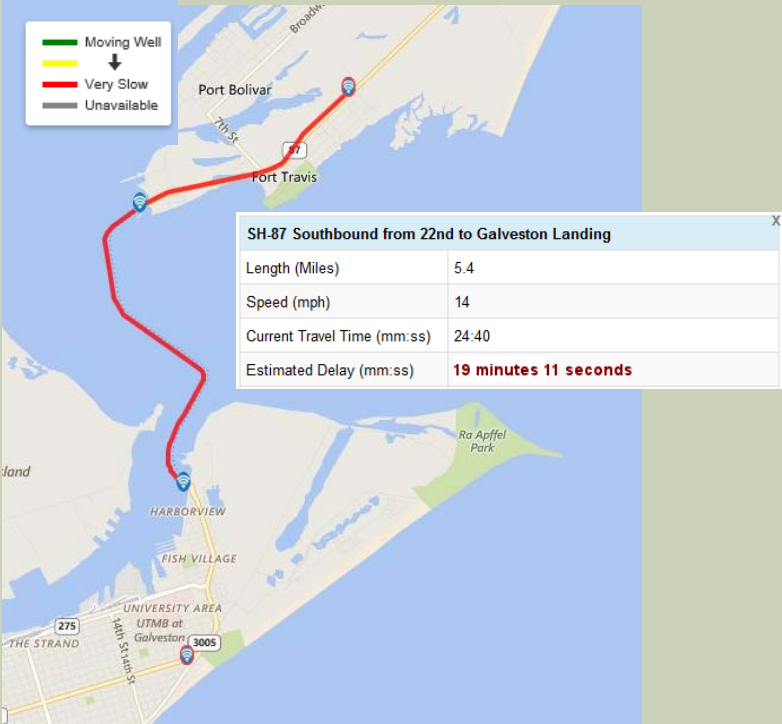
WI-FI APPLICATION

Ferry delay reporting, Port Aransas, Texas



WI-FI APPLICATION

Ferry delay reporting, Galveston, Texas



CONCLUDING THOUGHTS

- Despite the low re-id rate, the sheer volume of Wi-Fi devices provides generally adequate sample sizes.
- Wi-Fi typically offers more data however, not without some caveats--namely more variability and bias towards slower speeds. *More data is not necessarily better if results are biased.*
- Low re-id rate of Wi-Fi makes O-D data more challenging to collect.
- If the caveats are acceptable, Wi-Fi is an acceptable standalone or complementary tool to *Bluetooth™* address matching.

Wi-Fi is just another tool for the traffic data collection toolbox.

QUESTIONS?

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