Virginia Center *for* Transportation
INNOVATION & RESEARCH

We bring innovation to transportation.

VDOT Evaluation of WiFi Matching Technology

Michael D. Fontaine, P.E., Ph.D., VCTIR
Noah Goodall, P.E., Ph.D., VCTIR

Overview

- Bluetooth MAC address matching is a commonly used method for generating travel time data

Overview

- While Bluetooth matching is very useful, sample sizes must be large enough to create stable estimates of mean speed/travel time.
- Devices must be in discoverable mode, which limits samples
- Typical probe sampling rates are in the 2-6 percent range, which can create data availability problems for real time applications

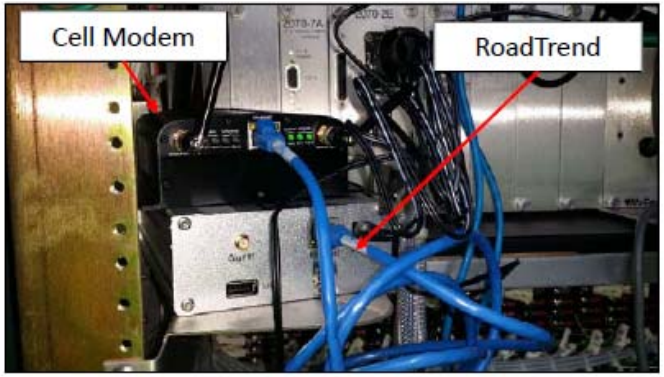
WiFi Matching

- Several vendors are offering similar systems that rely on matching WiFi MAC addresses rather than Bluetooth
- Has the potential to significantly increase sample size over Bluetooth
- Potential areas of application and biases are still unclear

VDOT WiFi Evaluation

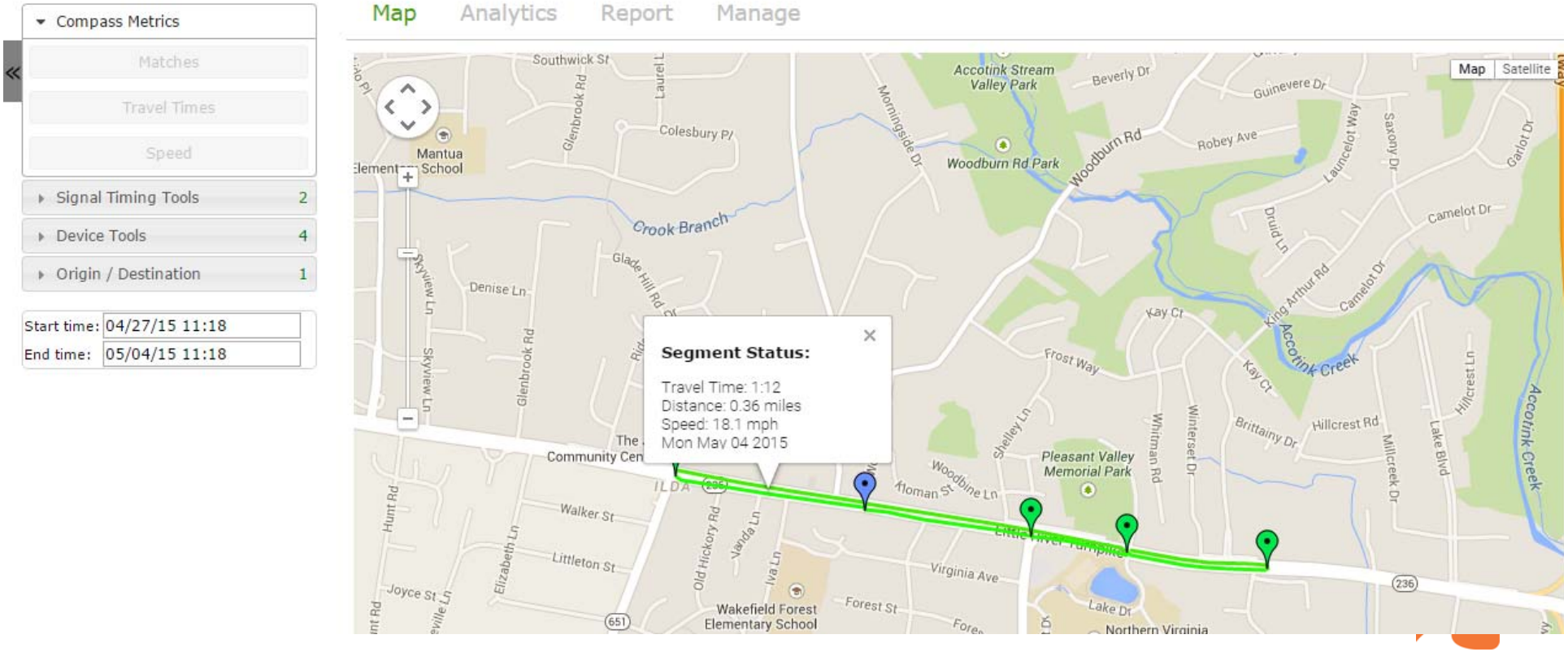
- Acyclica offered their RoadTrend WiFi system to VDOT for a pilot test
- Two phases of testing:
  - Bench testing to determine performance characteristics
  - Field deployment along SR 236 (Little River Turnpike)

Acyclica RoadTrend Equipment



Acyclica RoadTrend Web Interface

- Web interface with analytics and data archive



WiFi Bench Testing

- Bluetooth signals ping approximately every second
- Smart phones search less often for WiFi
  - Typically transmit MAC addresses in short bursts
  - Between 20 sec and several minutes between bursts
- Need to know behavior to determine how it impacts traffic monitoring

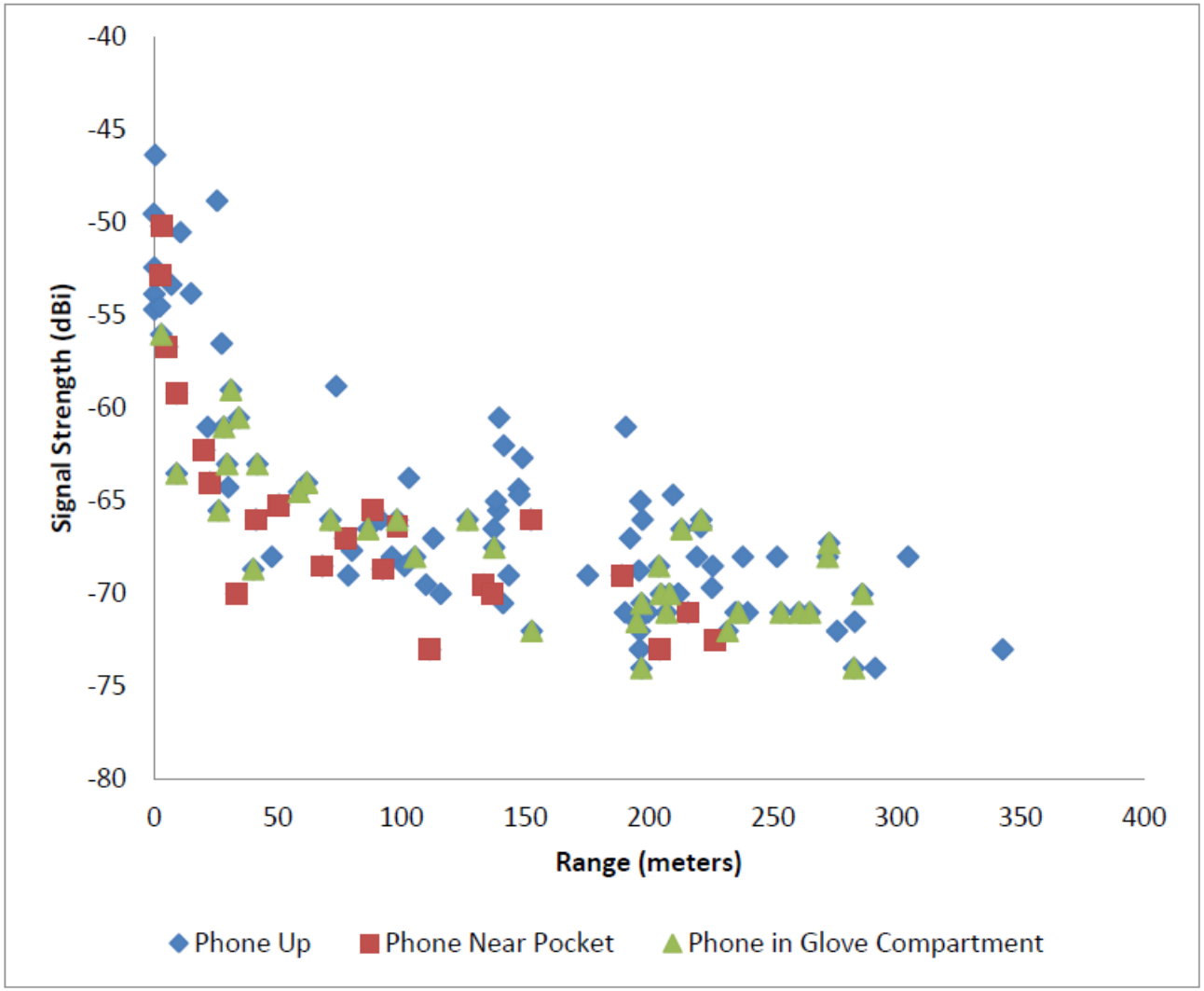
Bench Testing – Time Between WiFi Samples

Condition	Phone	Mean	Avg. of Longest 5 Readings
Battery	MotoX 2ndGen	67.3	134.8
	DROID MAXX	53.3	130.3
	iPhone 4s	19.3	45.3
Charging	DROID MAXX	21.3	38.9
	iPhone 4s	43.1	90.6
Charging and running software	iPhone 4s, Waze	32.1	54.3
	iPhone 4s, Pandora	38.5	76.8

Bench Testing - Range

- Bluetooth is a short range communications protocol (100 meter max)
- WiFi signals can extend much longer distances
- Tested RoadTrends ability to detect an iPhone 4s traveling in a vehicle at low speeds

WiFi Signal Strength vs. Distance



Detection Rates vs. Speed

- Compared number of MAC addressed logged at:
  - Rural 4-way stop control intersection
  - 45 mph arterial

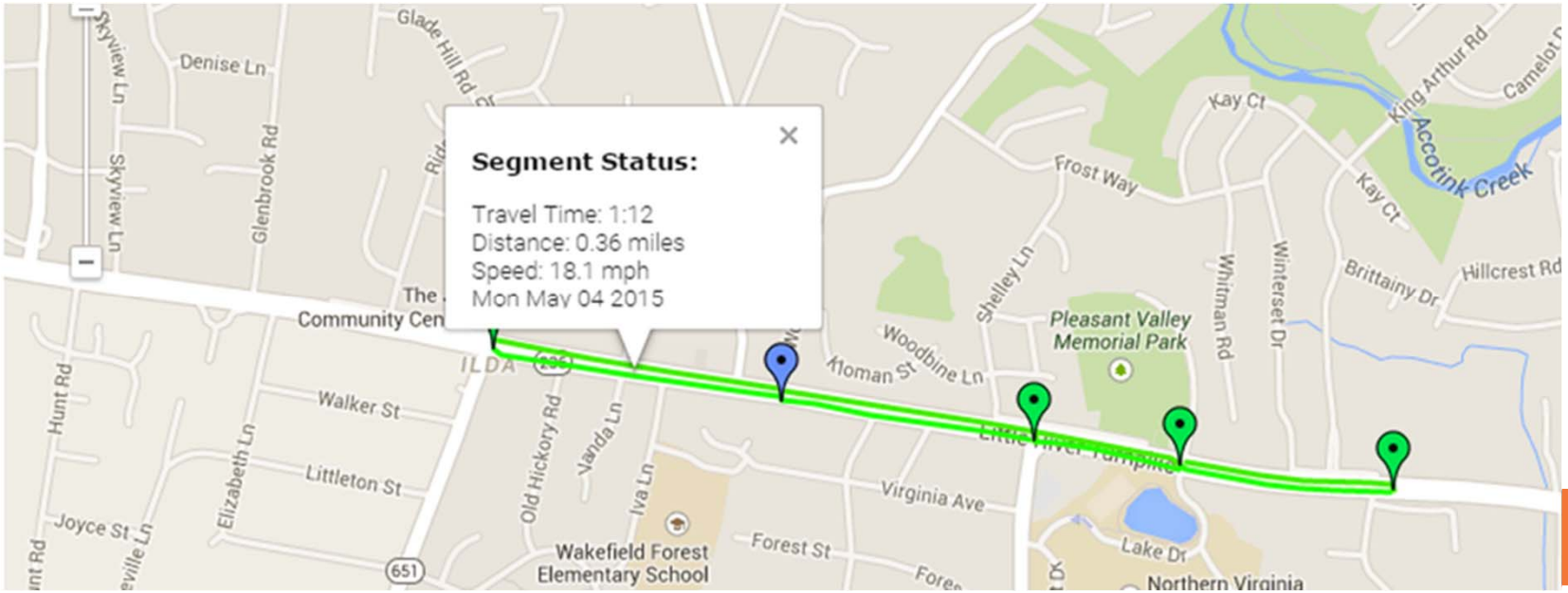
Site	MAC address per 100 vehicles
Rural 4-way stop	44
45 mph suburban arterial	29

Bench Test Summary

- Since phones search for WiFi more infrequently than Bluetooth, they may perform worse on higher speed roads
- Number of detections at a single device is high – between 29 and 44 MAC IDs per 100 vehicles.

Field Test – SR 236

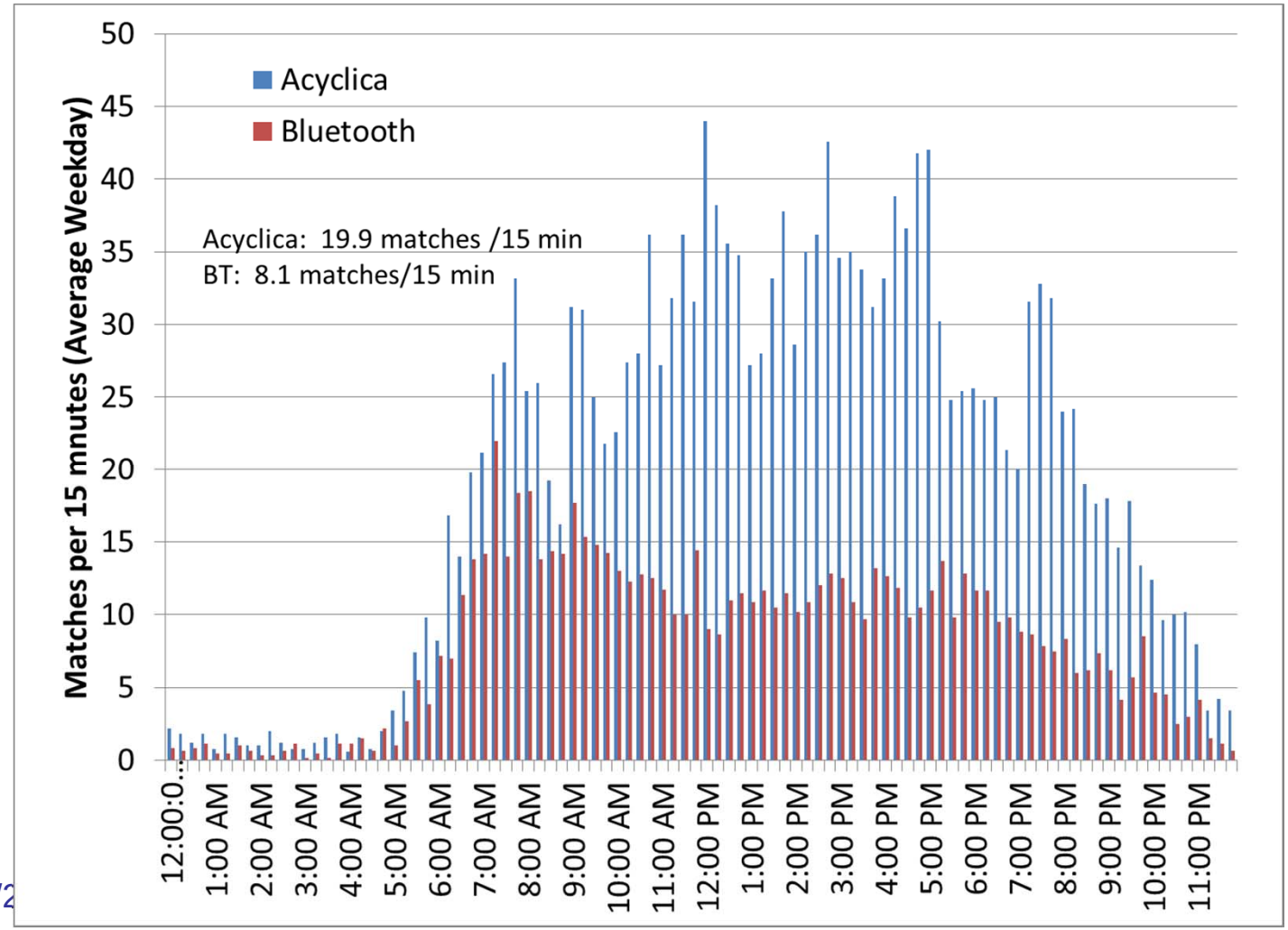
- RoadTrend was deployed in the controller cabinet at 5 intersections on SR 236 (Little River Turnpike) between Guinea and Duncan



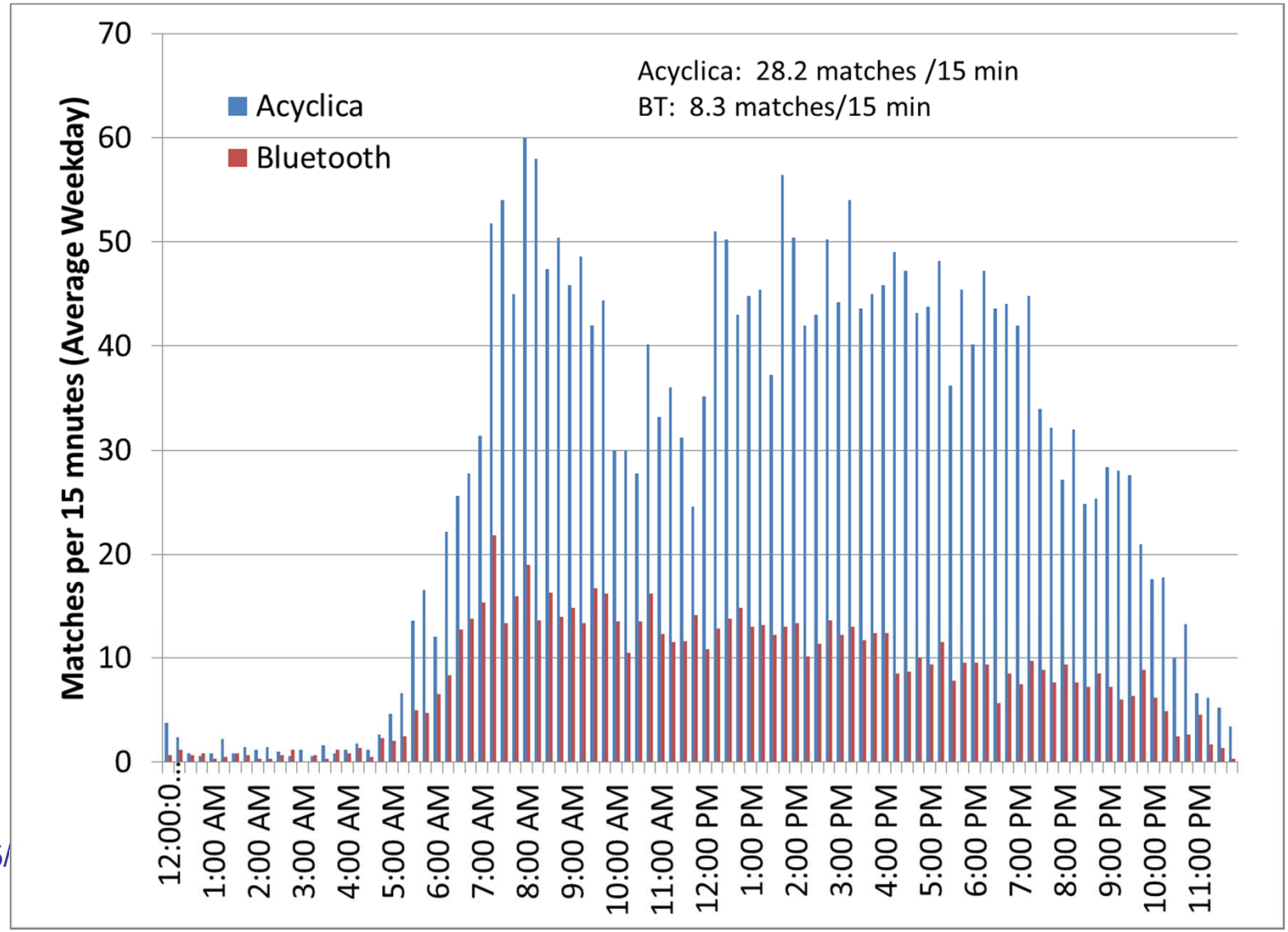
Field Test

- RoadTrend was compared to performance of portable Bluetooth readers
  - # of re-identifications (following screening using IQR algorithm)
  - Degree of consistency between Bluetooth and WiFi

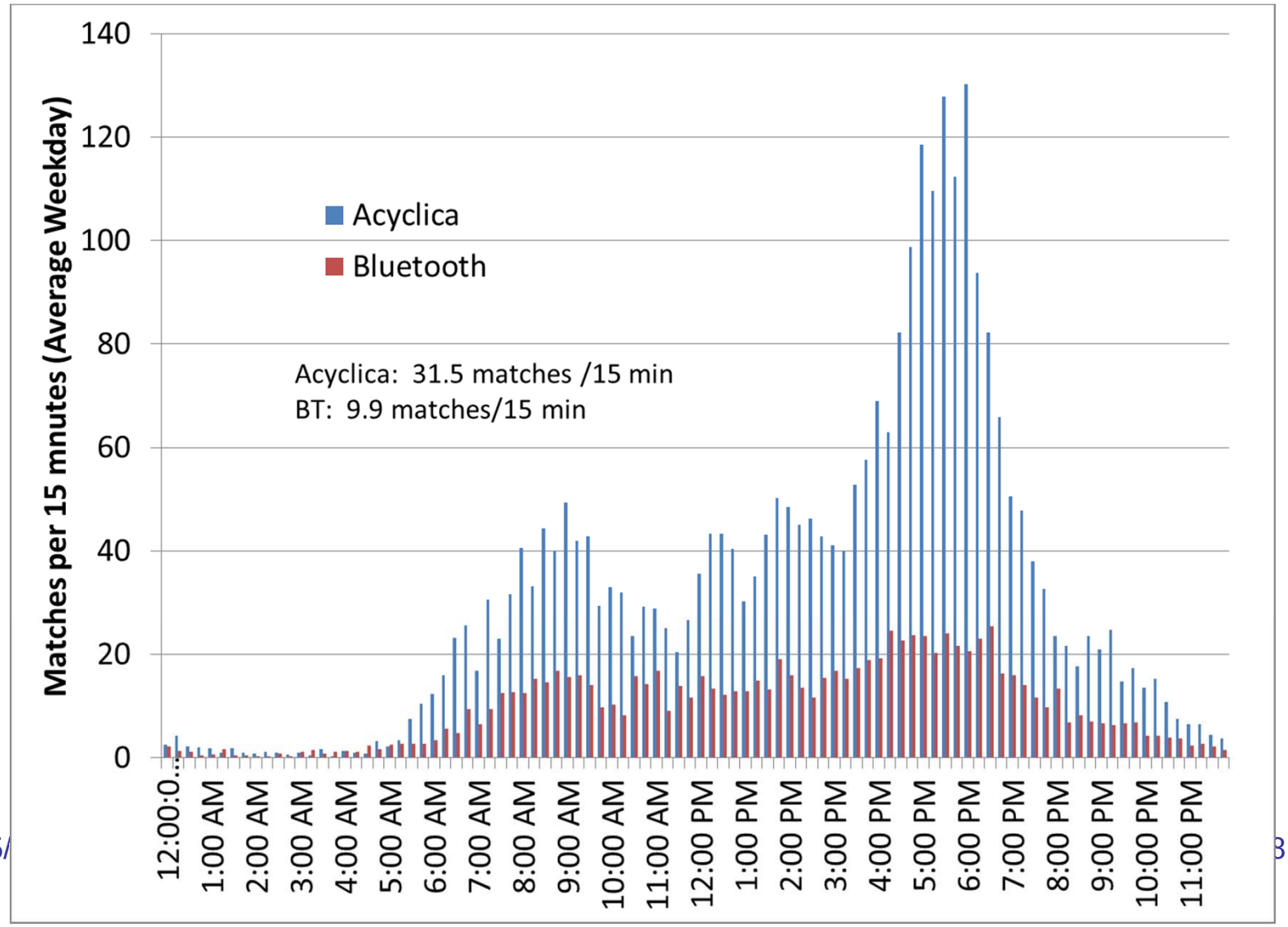
Number of Matches (EB, Prosperity/Woodburn to Wakefield Chapel, 0.3 mi)



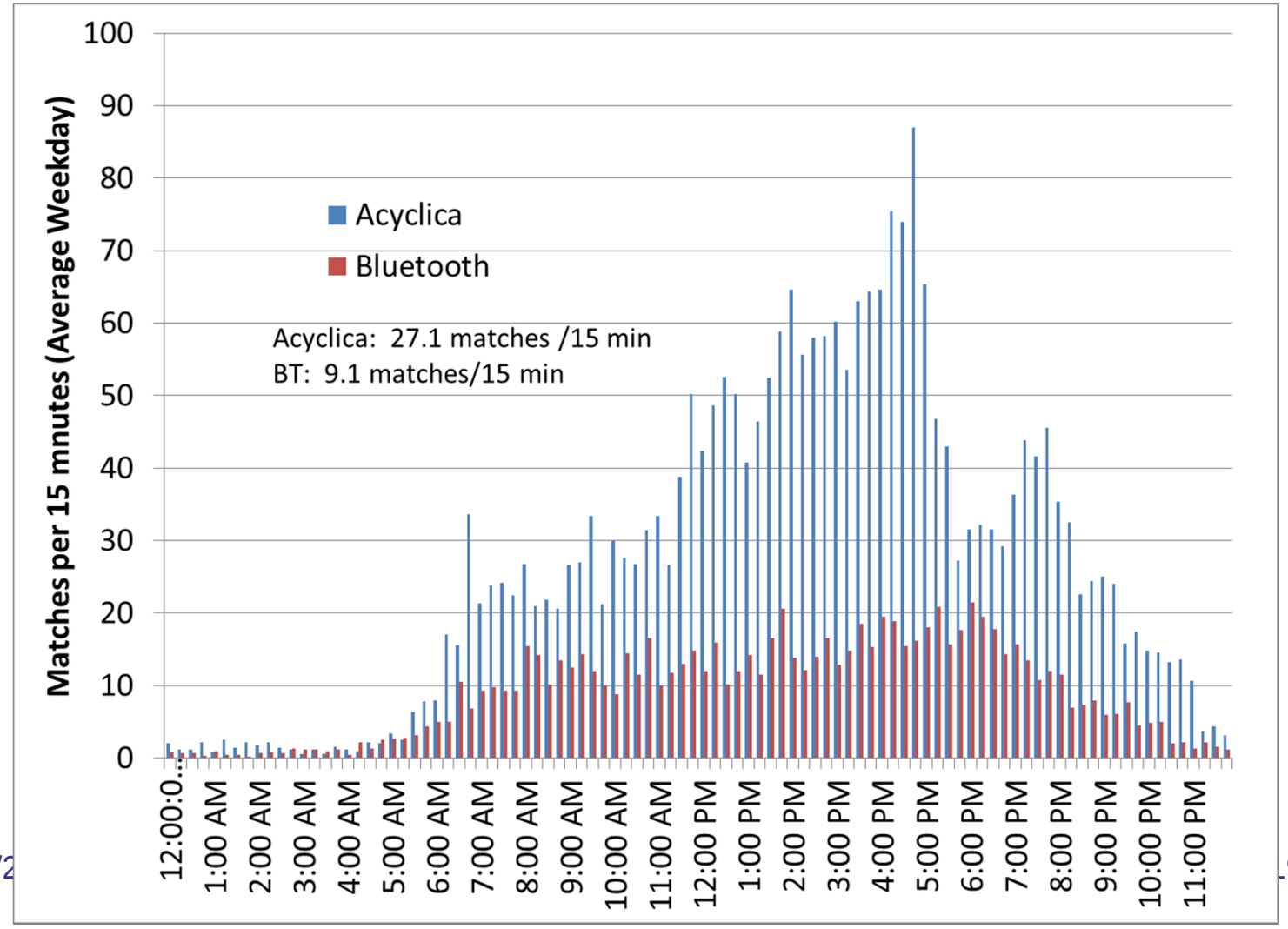
Number of Matches
(EB, Wakefield Chapel to Lake, 0.2 mi)



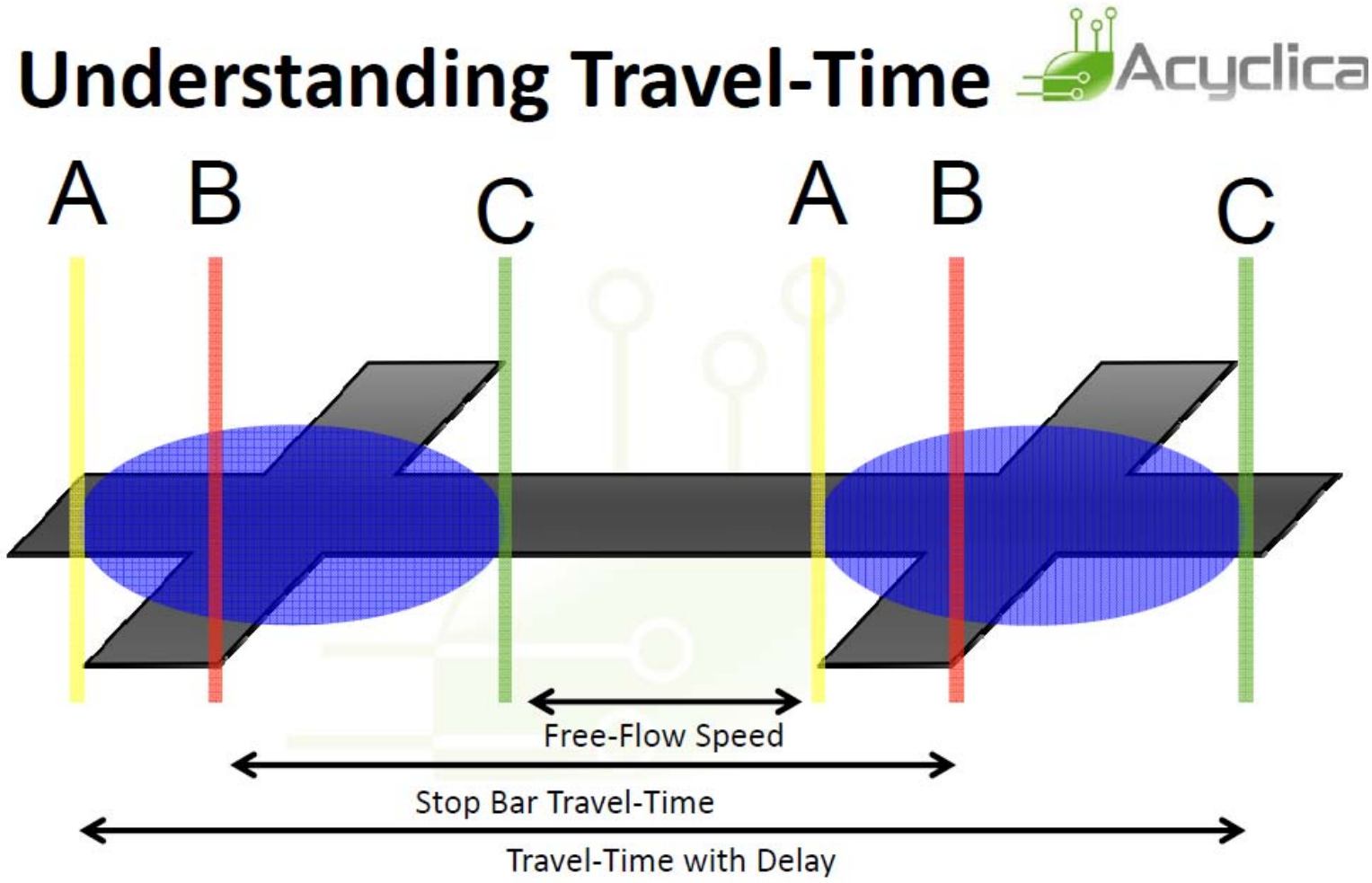
Number of Matches
(WB, Lake to Wakefield Chapel, 0.2 mi)



Number of Matches (WB, Prosperity/Woodburn to Guinea, 0.7 mi)

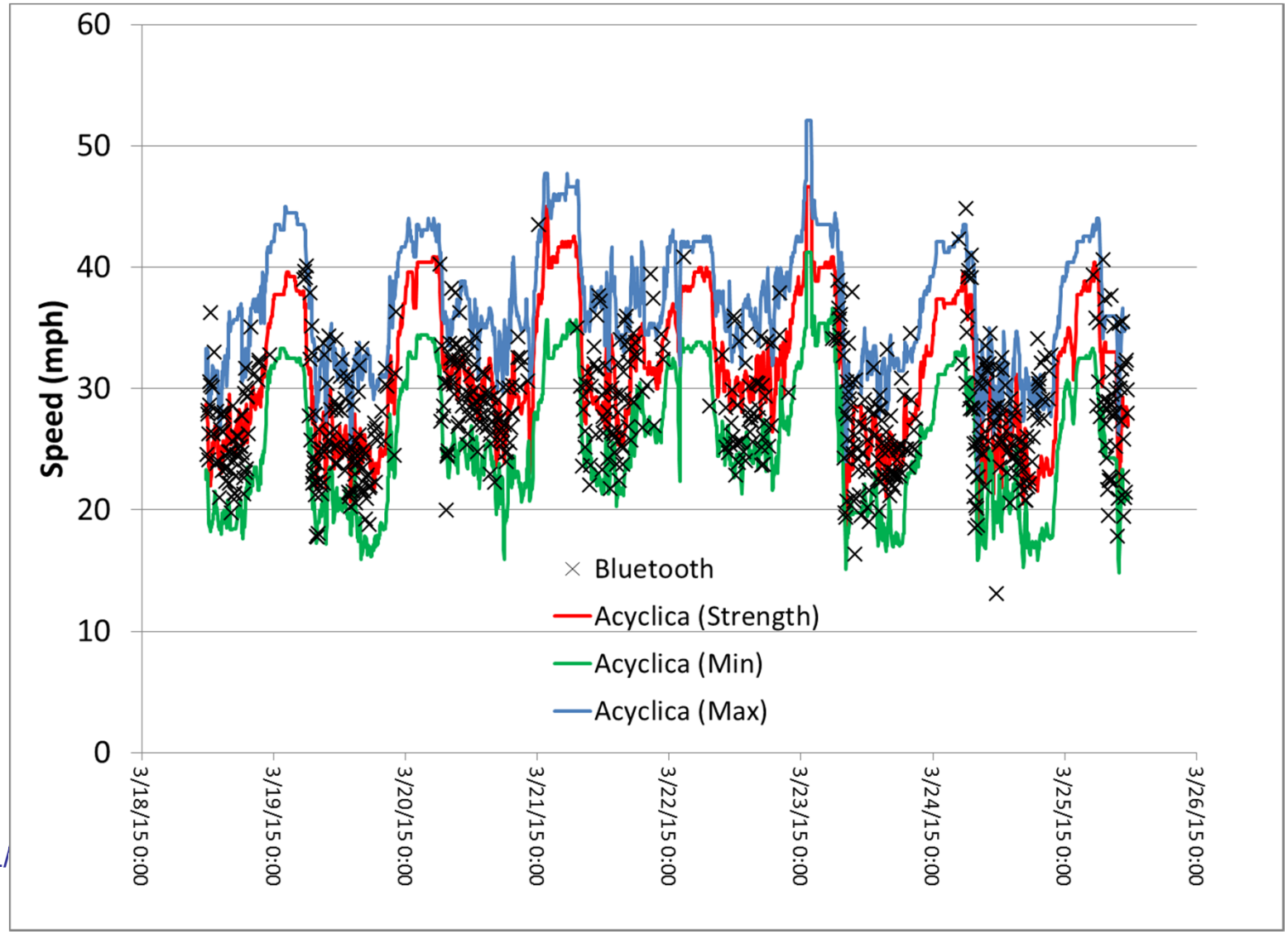


Acyclica Travel Times

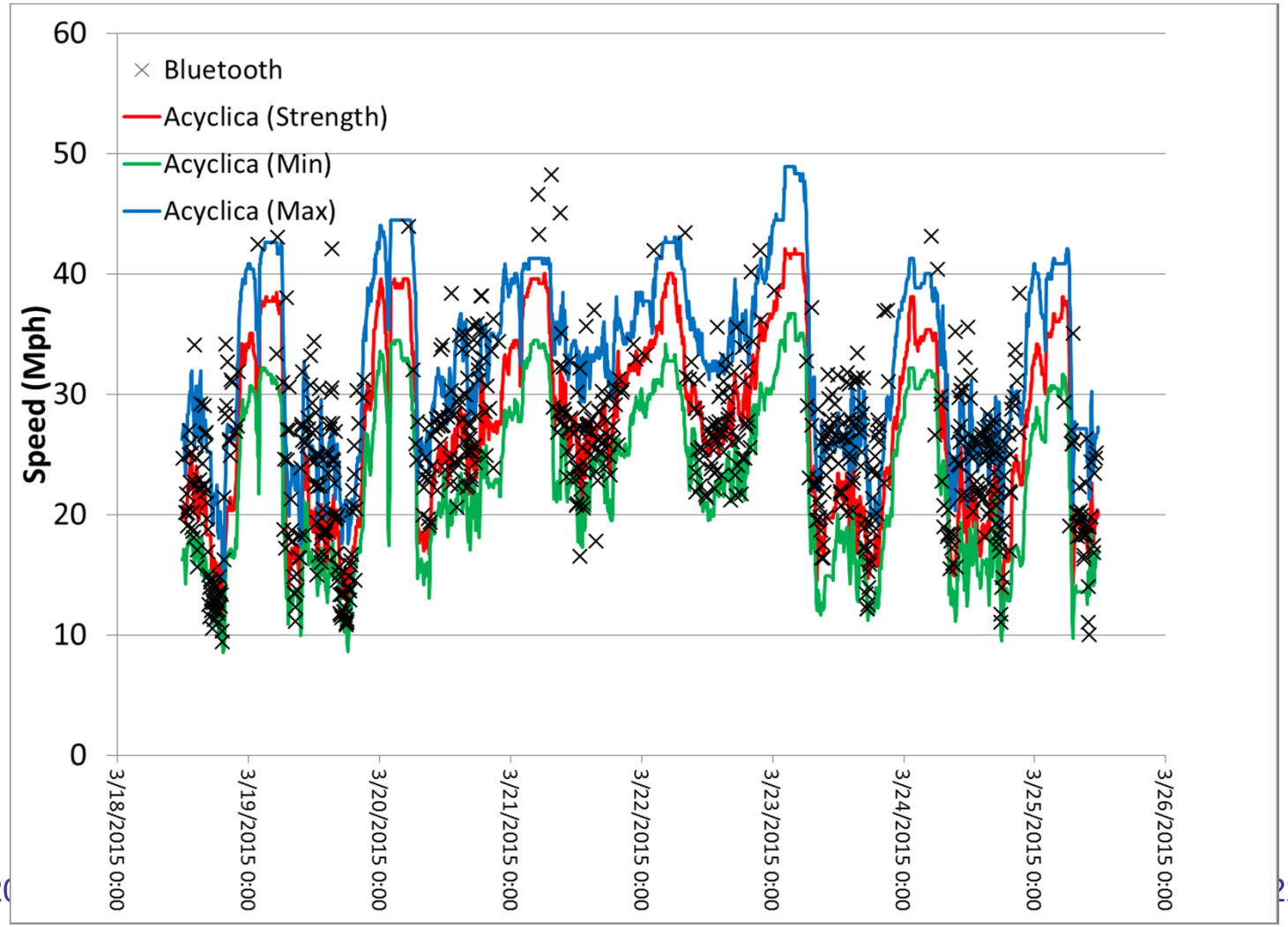


Note: ("Strength" = B to B) ("First" = A to A) ("Last"= C to C) ("Min"= C to A) ("Max"= A to C)

Bluetooth vs. Acyclica (EB, Guinea to Duncan)



Bluetooth vs. Acyclica (WB, Duncan to Guinea)

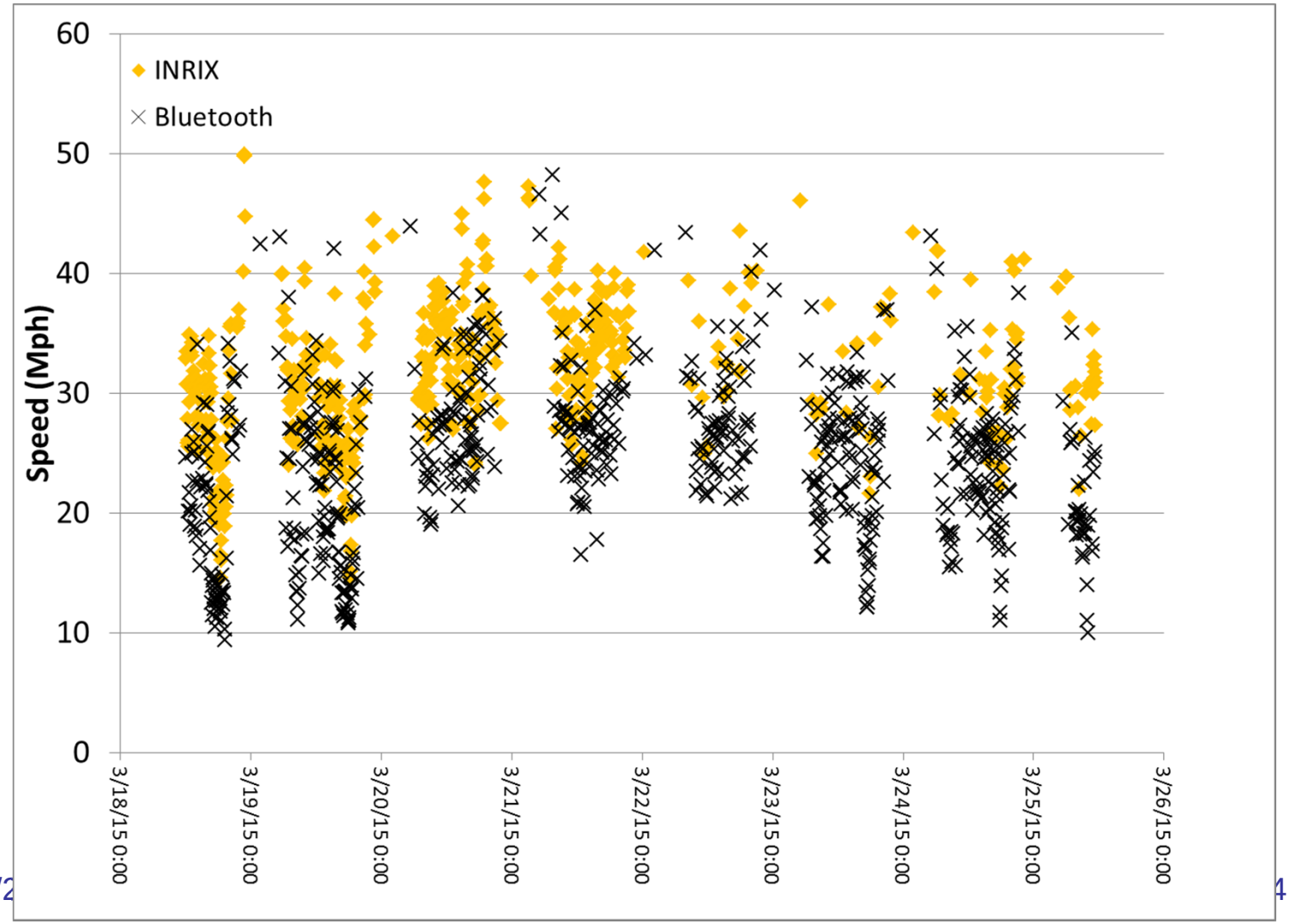


Comparison of BT vs. WiFi

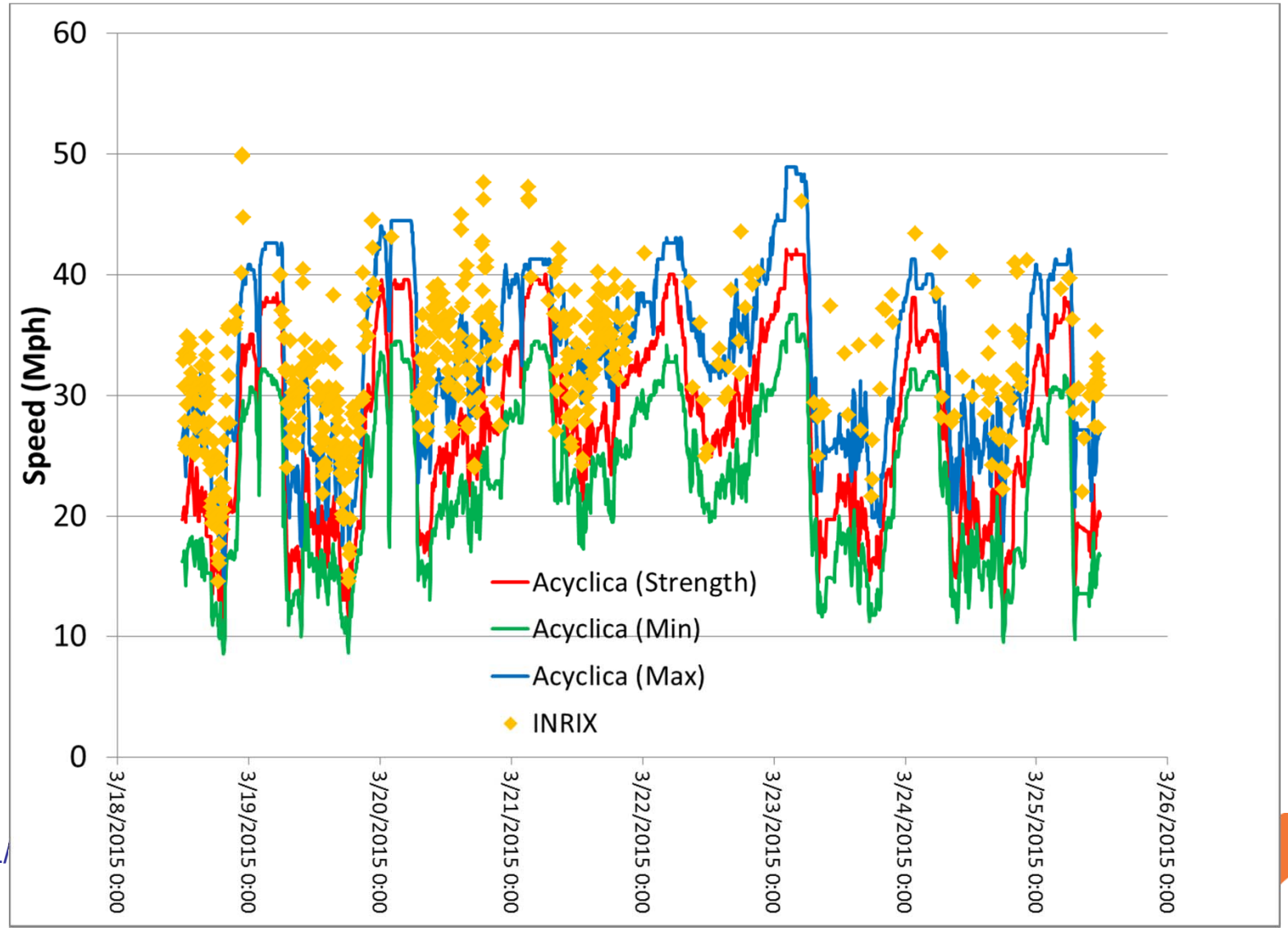
	Eastbound	Westbound
Average Bias (mph) (WiFi-BT)	-0.26	-2.38
Average Absolute Error	3.66	4.25
% of BT between Min and Max	82.5%	69.2%
% With 5 mph of BT	73.0%	66.3%
% within 10 mph of BT	96.6%	92.8%

- Bias increased when Bluetooth speeds > 35 mph
  - -5.25 mph EB and -10.3 mph WB

INRIX vs. Bluetooth (WB)



INRIX vs. WiFi (WB)



INRIX vs. WiFi and BT
SR 236 WB

	Bluetooth	WiFi
Average Bias (mph) (INRIX – BT or WiFi)	7.21	11.00
Average Absolute Error (mph)	7.78	11.22
% With 5 mph of INRIX	28.7%	17.1%
% within 10 mph of INRIX	67.6%	43.3%
# of 5-min intervals compared	293	668

- So, choice of technology for “benchmark” could play an important role when evaluating 3rd party data sources

Summary and Conclusions

- Smartphone scanning behavior is fundamentally different for WiFi than Bluetooth
- Number of matched MAC addresses was significant higher with WiFi than Bluetooth (2 to 4 times as many matches)
- Generally good agreement at lower speeds (< 35 mph)

Summary and Conclusions

- WiFi matching seems to be a useful tool for lower speed roads
- Spacing of readers may need to be widened on higher speed facilities
- Additional verification and testing is needed to determine whether performance is acceptable at higher speeds

Questions?

- Mike Fontaine
  - Michael.Fontaine@VDOT.Virginia.Gov
- Noah Goodall
  - Noah.Goodall@VDOT.Virginia.Gov