

Analysis of Bluetooth and Wi-Fi Technology to Measure Wait Times of Personal Vehicles at Arizona-Mexico Ports of Entry

July 26, 2016

**ENTERPRISE Webinar: Data Collection and
Uses at International Border Crossings**

Presented by Yung Koprowski, PE, PTOE



Acknowledgements



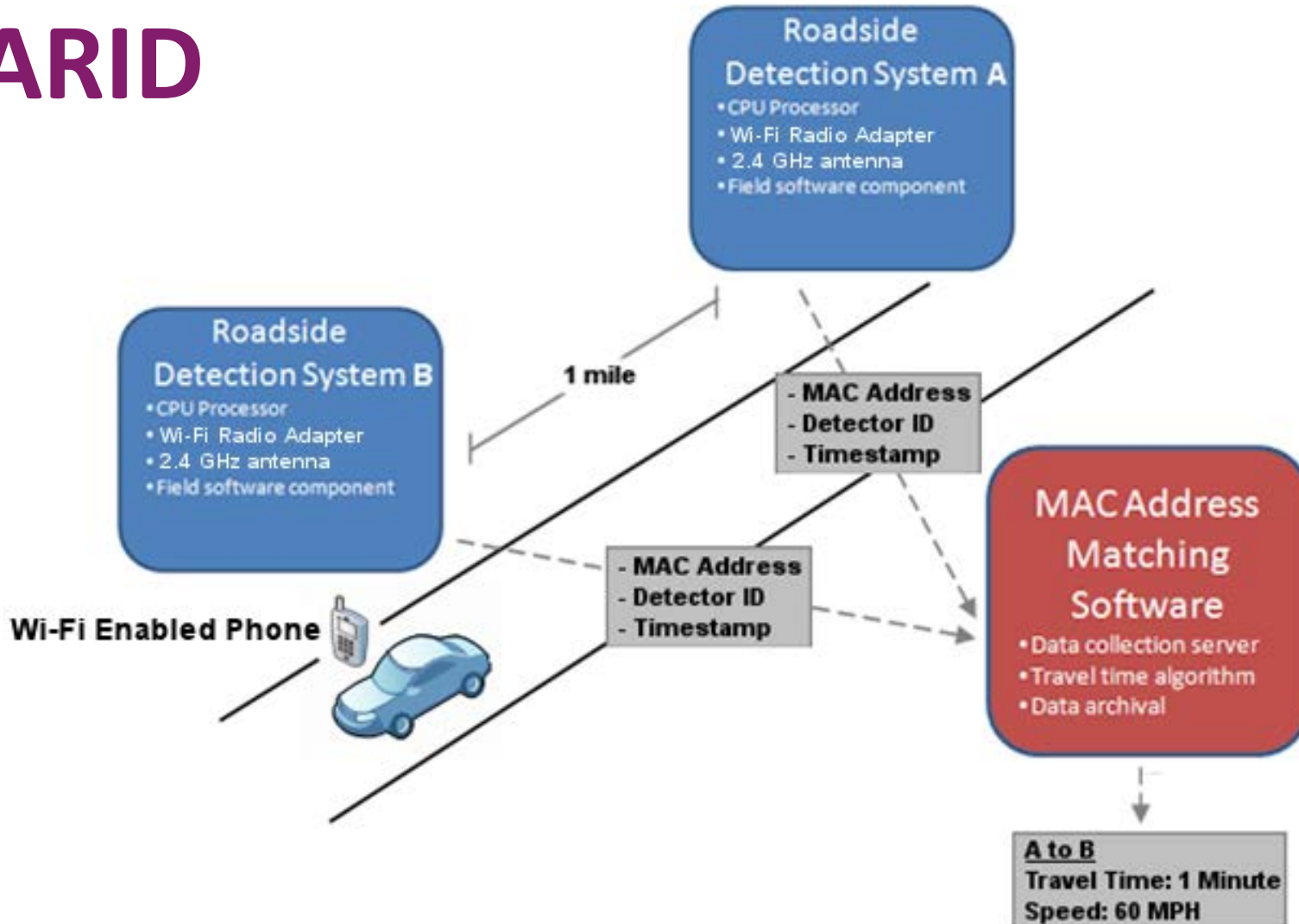
- ▶ **Gail Lewis**, Director, Office of P3 Initiatives and International Affairs
- ▶ **Rudy Perez**, Project Manager
- ▶ **Reza Karimvand**, Assistant State Engineer, Transportation Technology Group Manager

Agenda

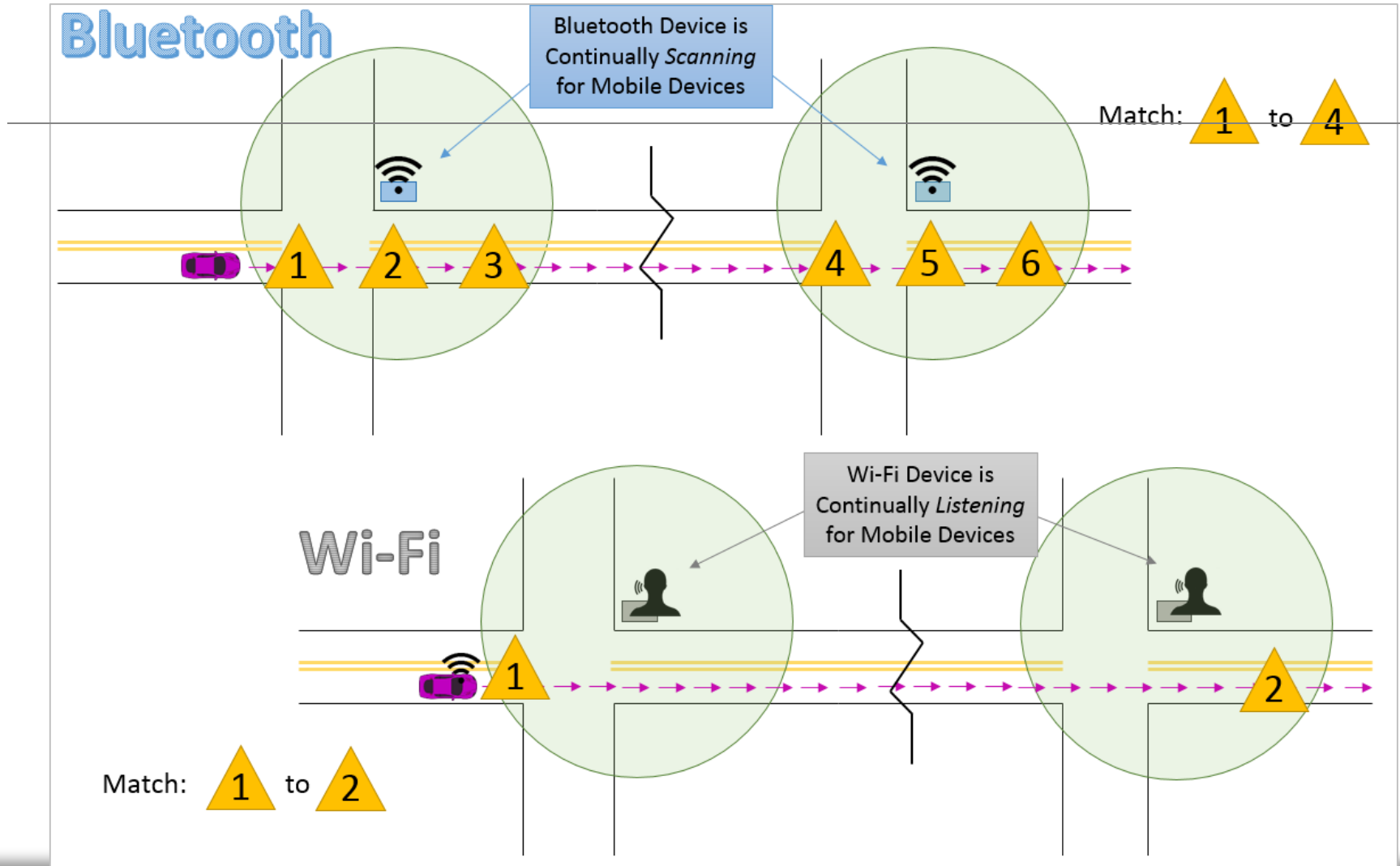


- ▶ **What is ARID?**
- ▶ **Bluetooth vs. Wi-Fi**
- ▶ **Project Overview & Purpose**
- ▶ **Data Collection**
- ▶ **Results**
- ▶ **Other Applications**

Anonymous Re-IDentification ARID



Bluetooth vs. Wi-Fi



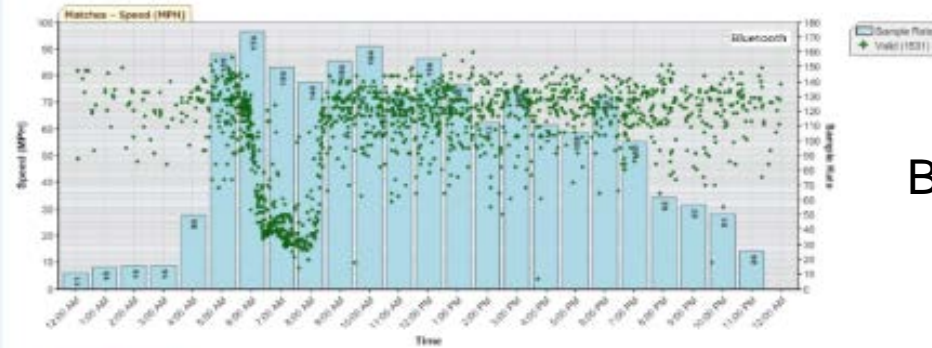
Comparison

Side-by-side comparison on I-45 (Texas) at same location

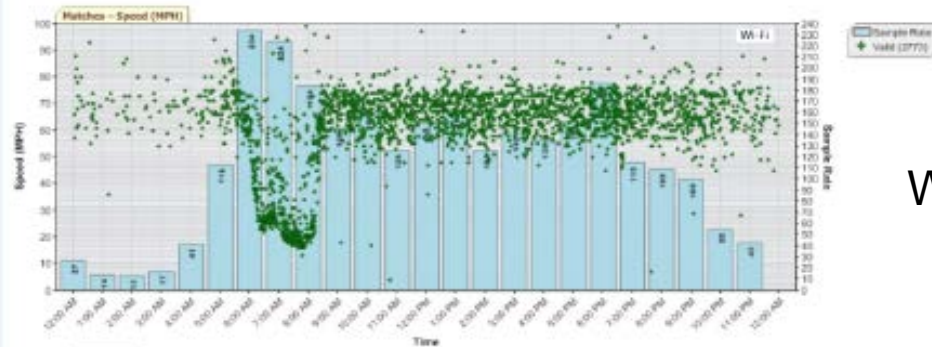
- Typical mid-week day
- Travel time patterns are virtually identical

IH-45 Gulf Northbound

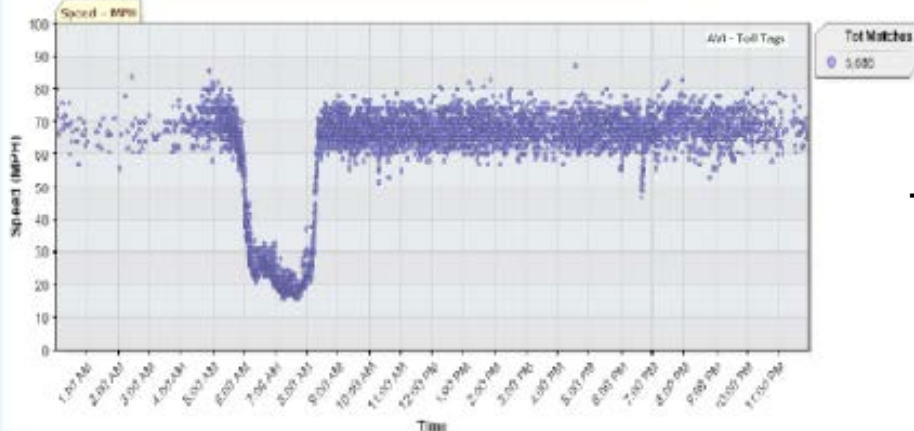
From Edgewood to Monroe (1.9 miles) - Matches - 842814



Bluetooth



Wi-Fi



Toll Tag

Project Overview & Purpose



- ▶ Will ARID devices collect sufficient sample size to confidently estimate wait time of US and Mexico bound personal vehicles?
- ▶ Should ARID devices be installed permanently?
- ▶ In what priority order should they be installed?

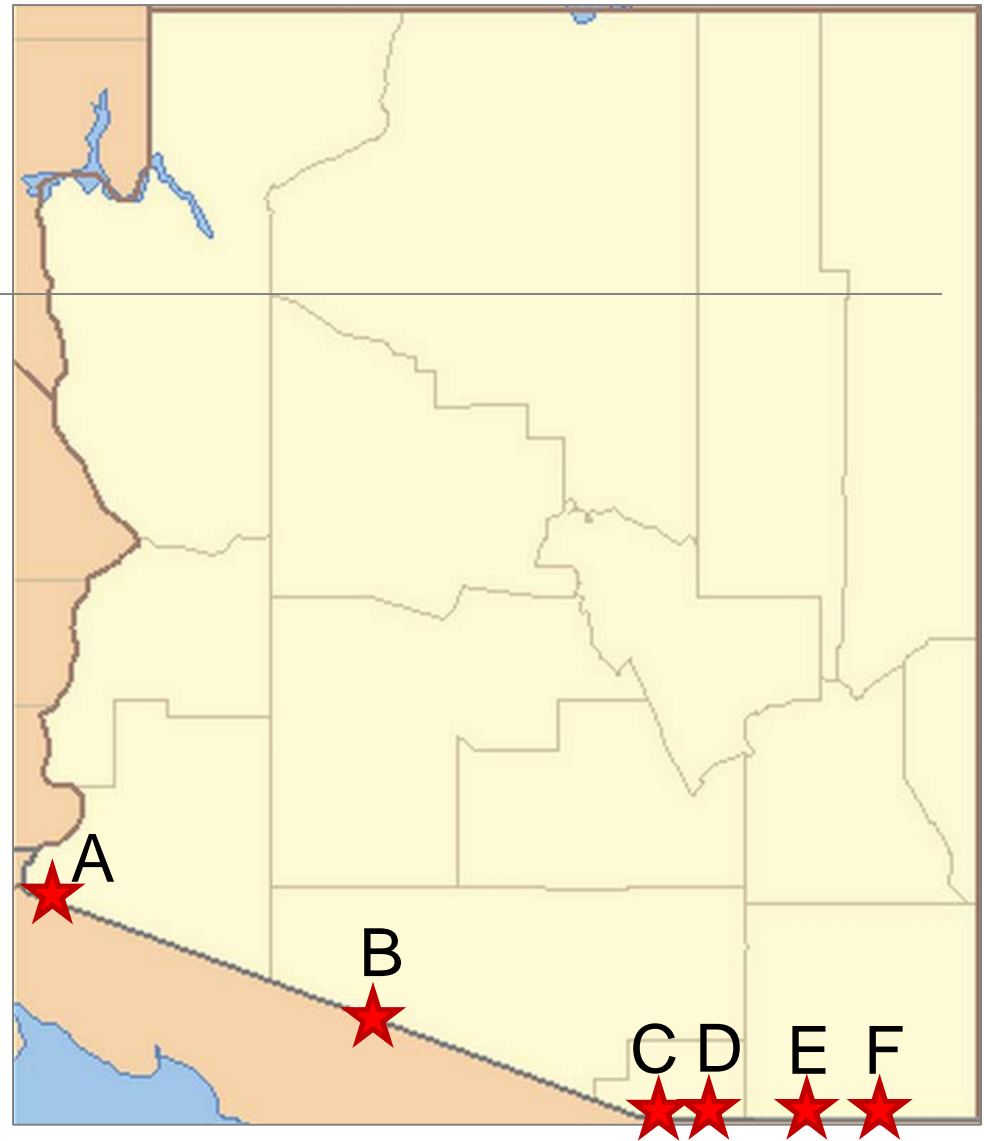
Anonymous Re-**ID**entification

ARID



Port of Entry Locations

- ▶ **A: San Luis**
- ▶ **B: Lukeville**
- ▶ **C: Mariposa**
- ▶ **D: DeConcini**
- ▶ **E: Naco**
- ▶ **F: Douglas**



Workplan

Tasks

1. **Technical Memorandum No. 1 – Refine the Work Plan and Project Kickoff Meeting**
2. **Working Paper 1 – Data Collection Plan**
3. **Perform Field Data Collection**
4. **Analyze Field Data**
5. **Present Study Results**
6. **Draft Final Report**
7. **Executive Summary and Final Report**



Data Collection

Temporary ARID Deployment



Data Collection

Temporary ARID Deployment

- ▶ Collected the weeks of June 15th and June 29th
- ▶ 2 Days at each POE
- ▶ Volumes also obtained

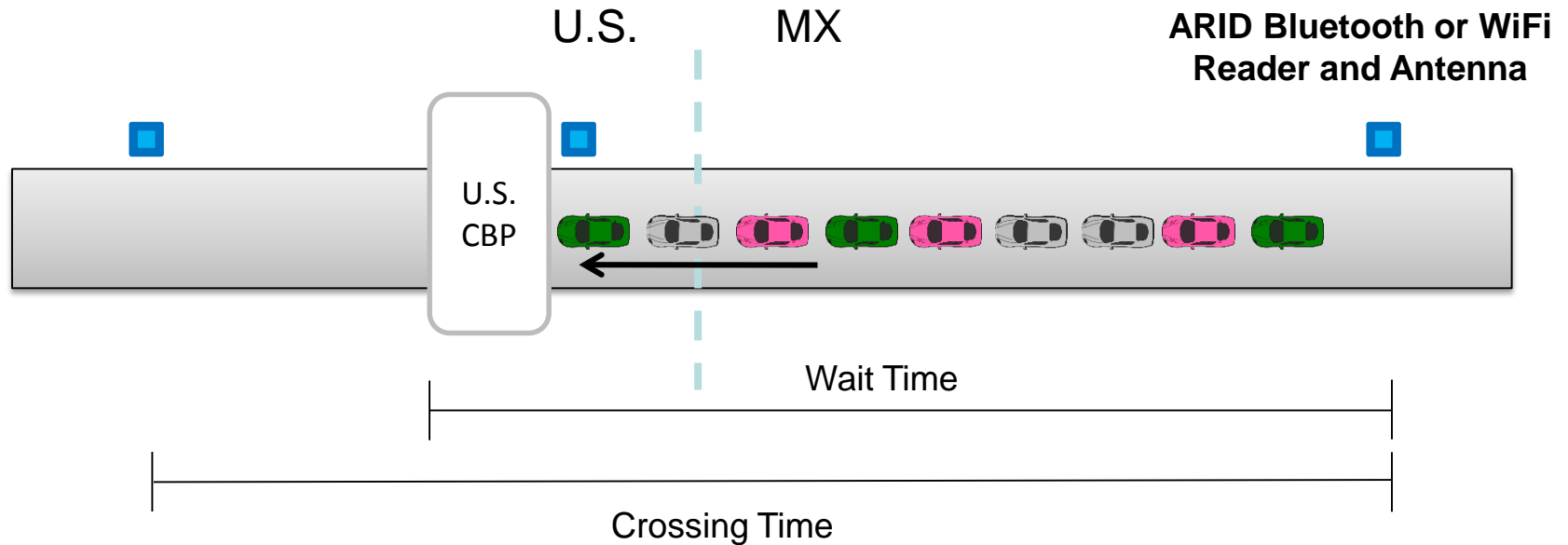


Data Collection

Considerations/Challenges

- ▶ **ADOT District right-of-way permits**
- ▶ **Moving equipment legally into Mexico**
- ▶ **Security of field technicians**
- ▶ **Deployment at Customs & Border Protection (CBP) sites**

Wait and Crossing Time Definitions



Wait Time (seconds) = Crossing Time (seconds) - time required at free flow condition from check point to downstream ARID device (seconds)

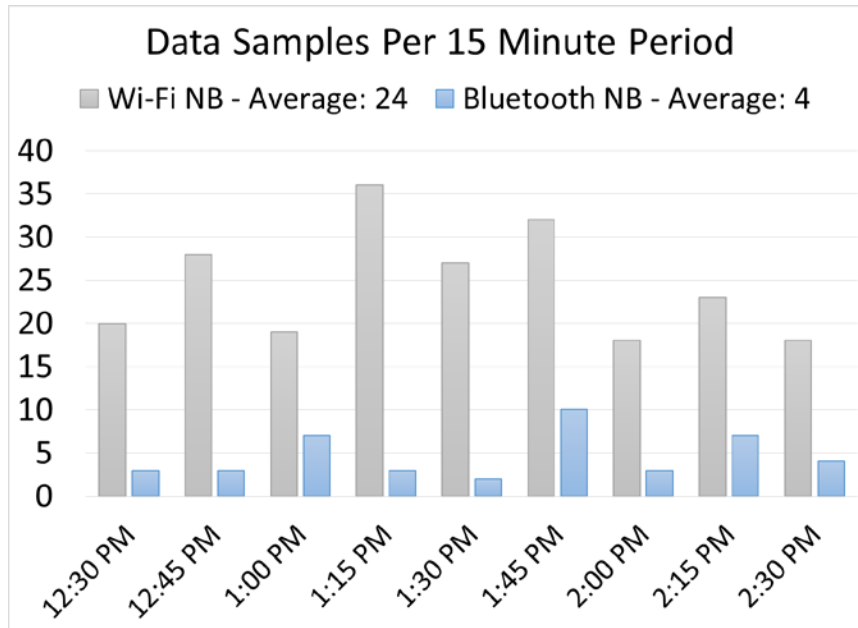
Delay (hours) = Wait Time (hours) – time required at free flow condition (hours)

Vehicle Delay (cars-hours) = Delay (hours) X Number of vehicles (cars)

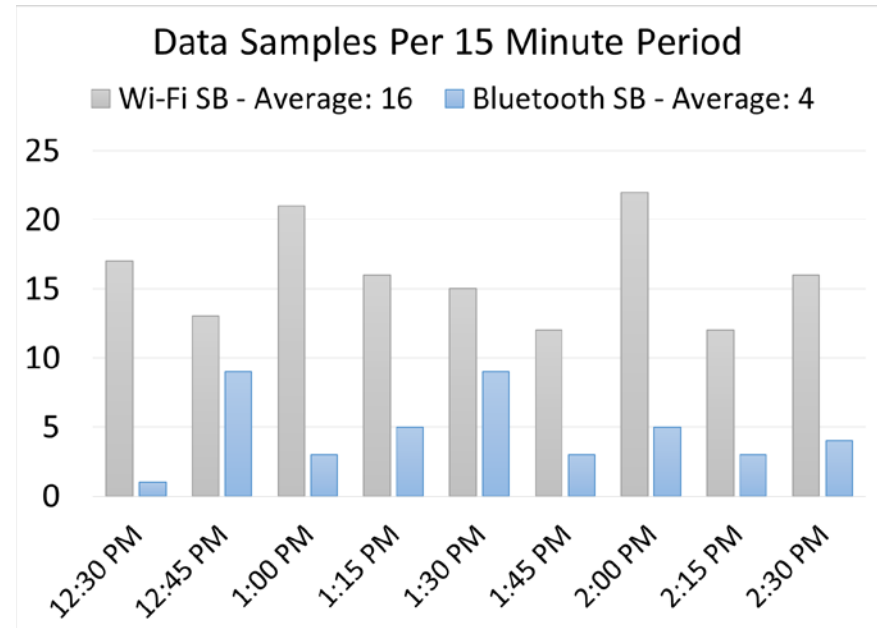
Data Collection

Wi-Fi vs. Bluetooth

Northbound



Southbound



Data Collection

Douglas Port of Entry



Data Analysis

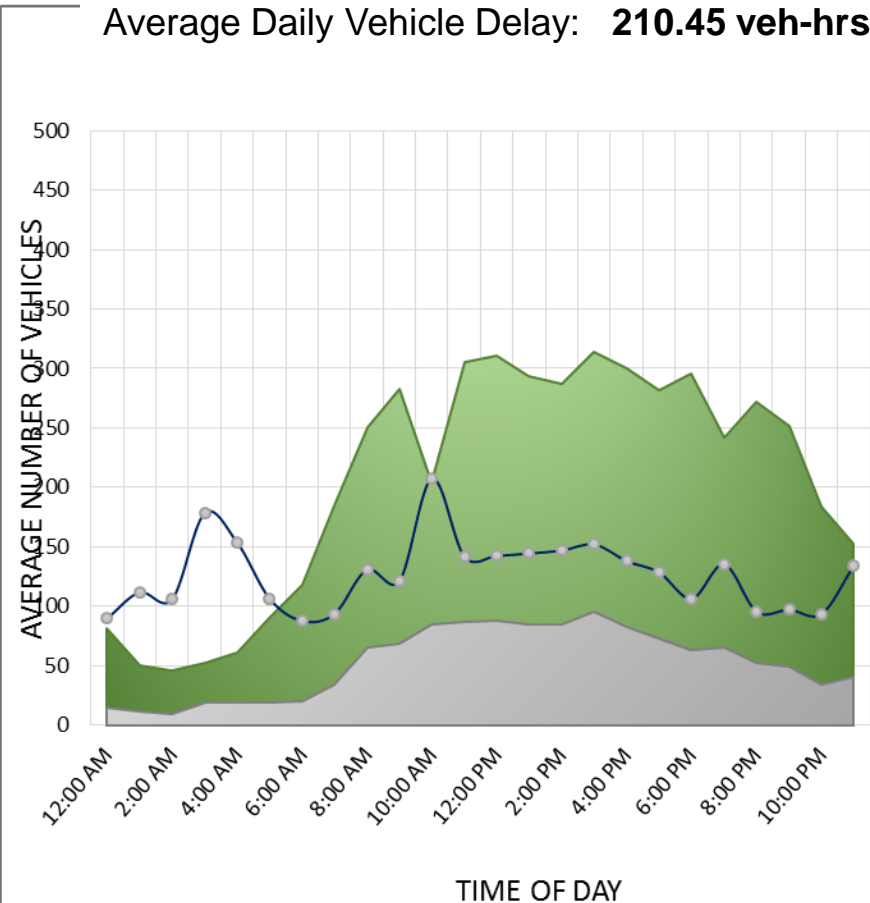
Douglas

NORTHBOUND

Penetration Rate: **25.8%**

Average Delay Per Vehicle: **2.39 minutes**

Average Daily Vehicle Delay: **210.45 veh-hrs**

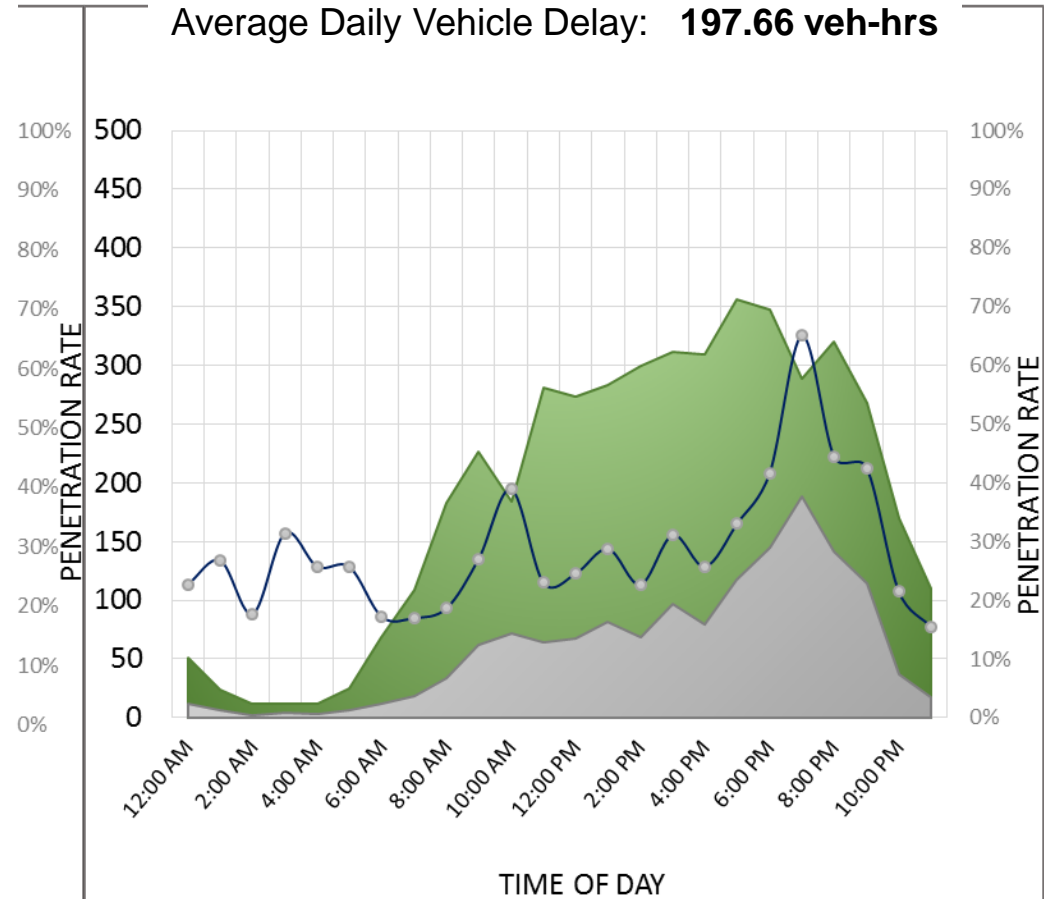


SOUTHBOUND

Penetration Rate: **32.0%**

Average Delay Per Vehicle: **1.75 minute**

Average Daily Vehicle Delay: **197.66 veh-hrs**

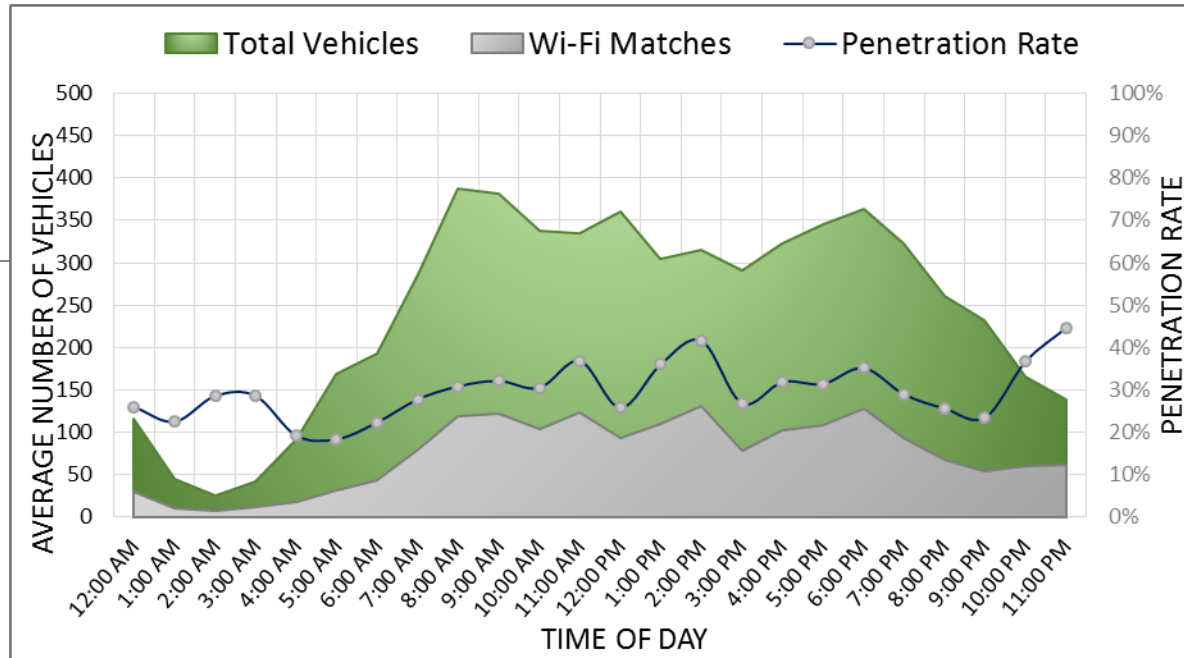


Data Analysis

DeConcini

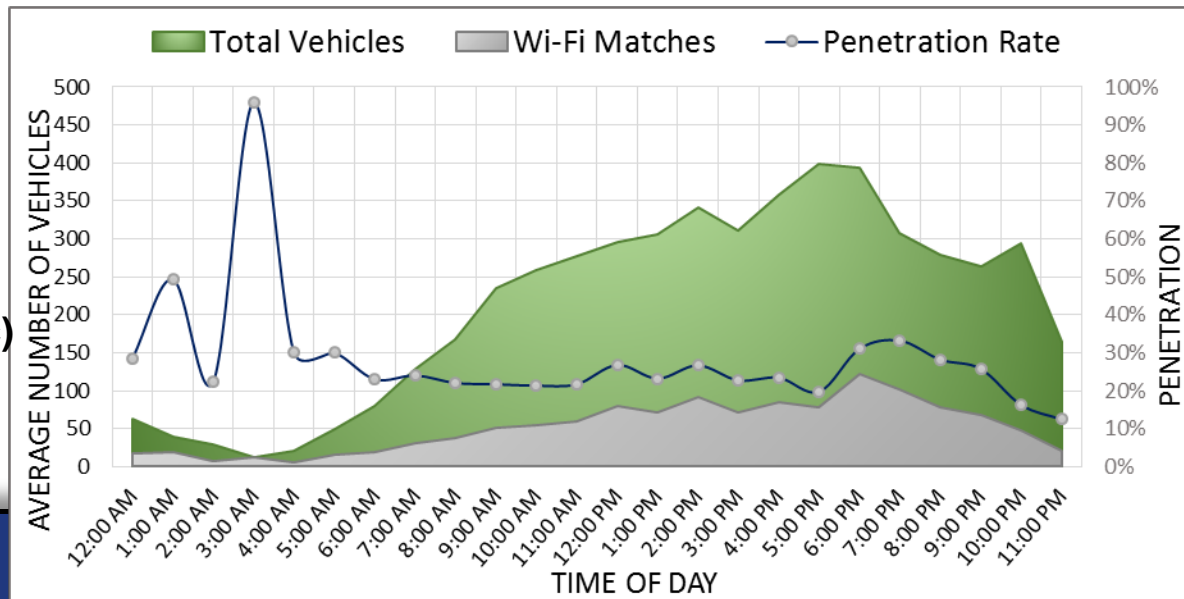
NORTHBOUND

Penetration Rate: **30.6%**
 Avg Delay Per Vehicle: **2.89 minutes**
 Avg Daily Vehicle Delay: **303 veh-hrs**



SOUTHBOUND

Penetration Rate: **24.5%**
 Avg Delay Per Vehicle: **0.79 mins (47 sec)**
 Avg Daily Vehicle Delay: **70.4 veh-hrs**



Data Analysis

Penetration Rate Summary

	Port of Entry	Penetration Rate
San Luis	Exiting U.S.	21.0%
DeConcini	Entering U.S.	30.6%
	Exiting U.S.	24.5%
Mariposa	Entering U.S.	5.7%
	Exiting U.S.	2.4%
Douglas	Entering U.S.	25.8%
	Exiting U.S.	32.0%
Lukeville*	Exiting U.S.	64.5%
Naco*	Entering U.S.	53.5%
	Exiting U.S.	27.8%

*Low Volumes

$$\text{Penetration Rate (\% of traffic)} = \frac{\# \text{ of unique devices detected (devices per hour)}}{\text{traffic volume (cars per hour)}}$$

Data Analysis

Vehicle Delay Summary

	Port of Entry	Average Vehicle Waiting Time (seconds)	Segment Length (mi)	Average Speed (mph)	Average Delay Per Vehicle (Minutes)	Average Delay Per Vehicle (Hours)	Average Daily Vehicle Delay (Veh-Hours)
San Luis	Exiting U.S.	174	0.25	5.0	0.77	0.013	128.6
DeConcini	Entering U.S.	340	0.18	2.0	2.89	0.048	303.0
	Exiting U.S.	168	0.18	4.0	0.78	0.013	70.4
Mariposa	Entering U.S.	610	0.33	2.0	5.46	0.091	238.2
	Exiting U.S.	114	0.35	11.0	0.96	0.016	42.0
Raul Hector Castro	Entering U.S.	229	0.20	3.0	2.39	0.040	209.1
	Exiting U.S.	163	0.20	4.0	1.76	0.029	197.7
Lukeville	Exiting U.S.	60	0.14	8.0	0.53	0.009	3.9
Naco	Entering U.S.	82	0.17	7.0	0.72	0.012	4.9
	Exiting U.S.	61	0.17	10.0	0.28	0.005	3.8

Note: Data shown is representative of days sampled as part of this study only

Recommended Prioritization

Rank	Port of Entry	Disposition
1	DeConcini & Mariposa	Recommended for ARID implementation with further evaluation at Mariposa due to low penetration rate observed for this study
2	Douglas	Recommended for ARID implementation
3	San Luis	Recommended for ARID implementation
4	Lukeville	Not recommended due to low volumes, unless peak periods are a concern
5	Naco	Not recommended due to low volumes, unless peak periods are a concern

Estimated Cost

Item No.	Description	Unit	Est. Qty	Unit Price	Extended Price
7340103	CONTROL CABINET	EACH	1	\$4,000.00	\$4,000
7340304	CONTROL CABINET FOUNDATION (CABINET & TRANSFORMER)	EACH	1	\$1,000.00	\$1,000
7370480	PROVIDE ELECTRICAL SERVICE <i>(cost varies greatly)</i>	EACH	1	\$8,000.00	\$8,000
9240120	MISCELLANEOUS WORK (ETHERNET SWITCH)	EACH	1	\$800.00	\$800
9240133	MISCELLANEOUS WORK (Wireless Radio Assembly)	EACH	1	\$2,500.00	\$2,500
9240121	MISCELLANEOUS WORK (ARID Sensor)	EACH	1	\$2,500.00	\$2,500
<u>SUBTOTAL</u>					\$18,800
<u>TOTAL</u>					
<i>Including Design, traffic control, System integration, Contingency, Communications and other Miscellaneous (1.5*Subtotal)</i>					\$28,200

Permanent ARID implementation at each Port of Entry should undergo Project Scoping to define the design concept, schedule, and cost of the project.

Other Applications

Non-Project Related Example

- ▶ City-level Travel Time and Origin-Destination
- ▶ Freeways & Arterials

511 Driving Times SM ? Collapse ▾

Your trip: [Revise](#) [New](#) [Clear](#)

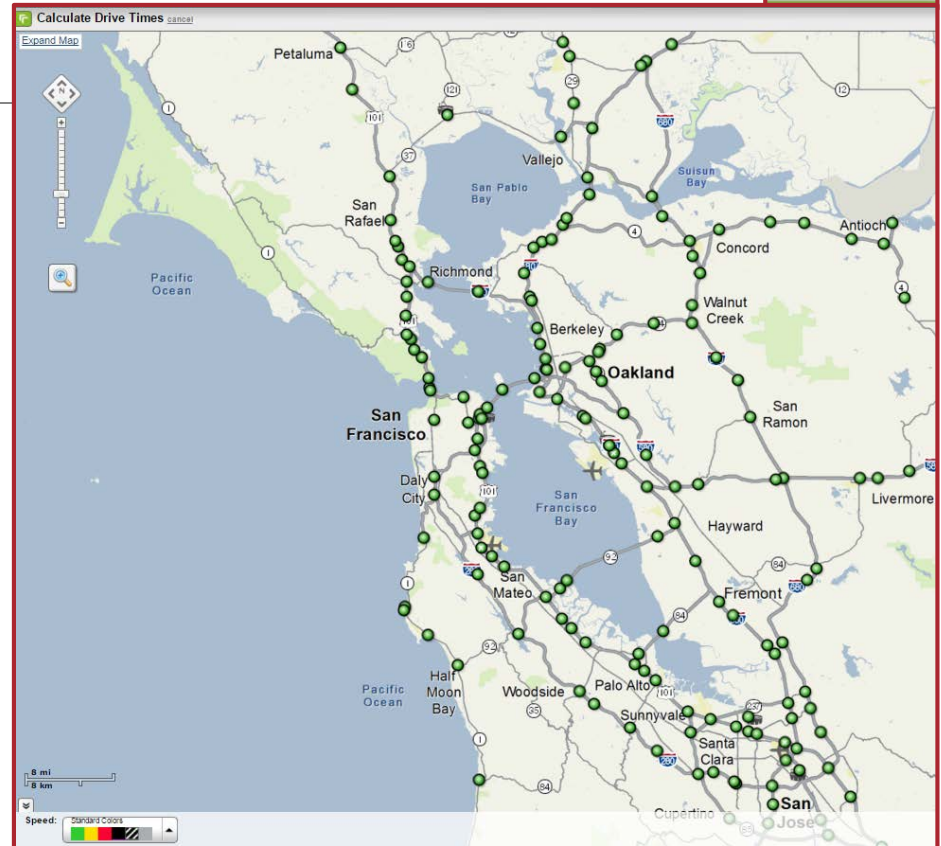
Now Specific Day and Time

A Start: Pleasant Hill I-680 & CHILPANCINGO PKY

B End: San Francisco I-280 N-King St Ramp & King St

Route	Current Time	Typical	Miles	Incidents
1	N/A *	34 min.	29.2	1
2	48 min.	44 min.	42.6	1
3	56 min.	53 min.	47.9	2
4	74 min.	50 min.	60.9	0
5	62 min.	58 min.	61.5	1

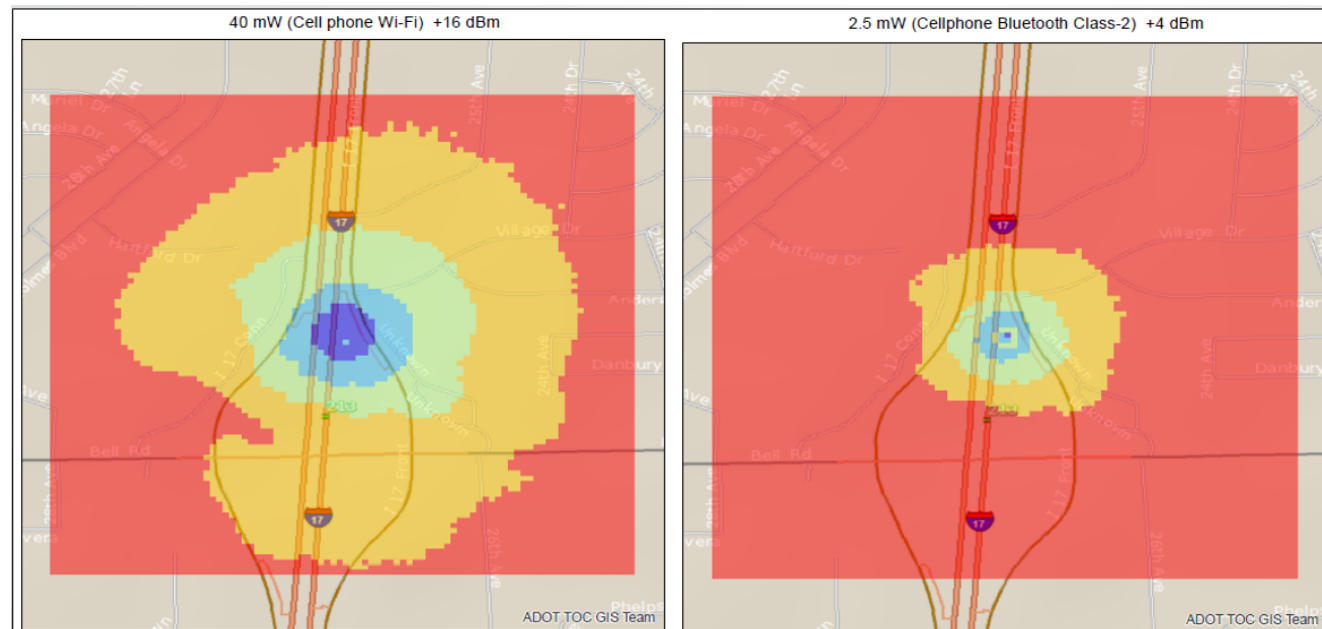
Example: San Francisco Bay 511



Other Applications

Results from a separate ADOT evaluation

- ▶ Use a higher gain antenna to cast a larger net for freeways
- ▶ RF modeling TAP software by SOFTWRIGHT



0 500 1,000 2,000 Feet

Legend

Received Power

Greater than -60 dBm	-80 to -70 dBm
-70 to -60 dBm	-90 to -80 dBm
Less than -90 dBm	

Other Applications

Results from a separate evaluation

- ▶ Turning Movement Percentages
- ▶ Inconsistent and highly variable - Not Recommended

Southern Avenue and Gilbert Road (Arterial- Arterial Intersection) Tuesday, April 7, 2015	Turning Movement Percentages		
	Eastbound Approach		
	Left	Thru	Right
Actual (Video)	22%	60%	17%
Wi-Fi Product A	48%	46%	6%
Wi-Fi Product B	27%	65%	7%



Thank You!

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