

TASK ASSIGNMENT IA-001
ANALYSIS OF BLUETOOTH AND WI-FI TECHNOLOGY
TO MEASURE WAIT TIMES OF PERSONAL VEHICLES
AT ARIZONA-MEXICO PORTS OF ENTRY

NOVEMBER 24, 2015



PREPARED FOR
OFFICE OF P3 INITIATIVES AND INTERNATIONAL AFFAIRS

PREPARED BY



EXECUTIVE SUMMARY

The Arizona Department of Transportation (ADOT), Office of P3 Initiatives and International Affairs selected Lee Engineering to analyze the penetration rate of Anonymous Re-Identification (ARID) technology to measure wait time of U.S. and Mexico bound personal vehicles at 6 (six) United States-Mexico Ports of Entry (POEs) in Arizona. The purpose of this study is for ADOT and stakeholders to have an understanding of ARID data collection technology, validity of measuring wait time at POEs, and recommendations on which POEs to install permanent ARID technology, in priority order.

Lee Engineering and Crossborder Group collected travel time and traffic volumes in June and July of 2015. A pilot field study was conducted to analyze ARID Bluetooth and Wi-Fi technologies, and it was determined that the Wi-Fi technology was more successful in match identification for this application. ARID Wi-Fi devices developed by Post Oak Traffic Systems were used in this analysis and data was collected for at least two operational days at each Port of Entry.

Statistical analysis was completed to determine the minimum required sample size of valid ARID matches at each port of entry. The minimum sample size required is a result of the level of variability in the ARID data. Higher minimum required sample sizes mean that there are more vehicles needed in order to estimate travel time. The values shown in the table were determined based on a 95% confidence level. If this sample size is not met, the confidence level in the results is reduced. The table below shows that the ARID data at all POEs met the minimum required sample size, with the exception of the Mariposa POE in the northbound direction.



Port-of-Entry	Travel Direction	Time of Day Data Used	Sample Size Required		Observed Vehicles (Wi-Fi)		Observation Vehicles Sufficient?
			3-Hr Period	1-Hr Period	3-Hr Period	1-Hr Period	
Douglas	NB	12 pm - 3 pm	127	43	325	134	YES
Douglas	SB	12 pm - 3 pm	4	2	217	82	YES
Mariposa	NB	12 pm - 3 pm	88	30	28	14	NO
Mariposa	SB	12 pm - 3 pm	1	1	9	6	YES
Naco	NB	12 pm - 3 pm	8	3	43	18	YES
Naco	SB	4 pm - 7 pm	1	1	71	30	YES
DeConcini	NB	12 pm - 3 pm	140	47	333	130	YES
DeConcini	SB	12 pm - 3 pm	90	30	239	99	YES
Lukeville	NB	12 pm - 3 pm	42	14	312	127	YES
Lukeville	SB	12 pm - 3 pm	9	3	75	33	YES
San Luis	NB	6 am - 9 am	117	39	229	85	YES
San Luis	SB	12 pm - 3 pm	6	2	448	167	YES

An analysis of penetration rate and vehicle delay was also conducted. The penetration rate is the proportion of unique ARID matches to the total number of passenger vehicles. The average vehicle delay is based on the ARID crossing time data and estimated free-flow speed. The average vehicle delay per vehicle ranged from 0.28 minutes to 5.46 minutes for the data collected as part of this study. These values were extrapolated based on the total number of vehicles in order to determine the average daily vehicle delay. The results of the delay analysis and the calculated penetration rates are provided in the table below.

	Port of Entry	Penetration Rate (%)	Average Delay Per Vehicle (Minutes)	Average Daily Vehicle Delay (Veh-Hours)
San Luis	Exiting U.S.	21.0	0.77	128.6
DeConcini	Entering U.S.	30.6	2.89	303.0
	Exiting U.S.	24.5	0.78	70.4
Mariposa*	Entering U.S.	5.7	5.46	238.2
	Exiting U.S.	2.4	0.96	42.0
Douglas	Entering U.S.	25.8	2.39	209.1
	Exiting U.S.	32.0	1.76	197.7
Lukeville**	Exiting U.S.	64.5	0.53	3.9
Naco**	Entering U.S.	53.5	0.72	4.9
	Exiting U.S.	27.8	0.28	3.8

* The results of the Mariposa POE should be interpreted with caution due to the low ARID penetration rate.

** The results of the Lukeville and Naco POEs should be interpreted with caution due to the low motor vehicle volumes at these POEs.

PRINCIPAL FINDINGS

This study evaluated the capabilities and limitations of using ARID technology to estimate wait times of U.S. and Mexico bound personal vehicles. The analysis concluded the following:

- The ARID technology was successful in identifying unique vehicle matches between two locations across the border, which allowed for crossing time data collection and wait time, delay, and average speed analysis.
- The pilot study of ARID travel time data collection using Wi-Fi technology resulted in higher penetration rates for this Port of Entry study application than using Bluetooth technology.
- ARID travel time data collection using Wi-Fi technology resulted in higher penetration rates for this Port of Entry study application than other Arizona deployments on freeways and urban arterial roadways within the past year.
- Of the four POEs with data both entering and exiting the U.S., three had higher ARID penetration rates of passenger vehicles entering the U.S.
- ARID (Wi-Fi) technology collects enough valid data to estimate border crossing times with 95% confidence, with the exception of the Mariposa POE in the northbound direction. This is due to low penetration rates at the Mariposa POE, which may have been related to deployment location or technology interference.
- The highest average individual vehicle delay entering the U.S. was observed at the Mariposa POE (5.46 minutes).
- The DeConcini POE has the greatest estimated average daily vehicle delay (303 vehicle-hours).

RECOMMENDATIONS

The implementation of permanent ARID devices at the Arizona-Mexico border are recommended in the following order, based on the amount of delay experienced at each location, the total personal vehicle volume, and the success of the ARID Wi-Fi deployments:

Rank	Port of Entry	Disposition
1	DeConcini / Mariposa	Recommended for simultaneous ARID implementation, with further evaluation of sensor location at the Mariposa POE due to low penetration rates observed for this study
2	Raul Hector Castro	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

The implementation of the ARID devices, specifically at the DeConcini, Mariposa, Raul Hector Castro, and San Luis Ports of Entry are expected to have the greatest impact and allow for the greatest vehicle flow and corresponding delay to be monitored and reported. Although the implementation at the Lukeville and Naco POEs would also yield beneficial wait time information and analysis, the significantly lower vehicle volumes lessens their priority. The DeConcini and

Mariposa POEs are recommended to be implemented together with highest priority due to the observed vehicle delay, annual volumes, and close proximity in location allowing them to serve as alternate routes to each other. The DeConcini and Mariposa Ports of Entry are located approximately 1.4 miles (2.25 km) apart in Nogales, Arizona/Sonora, and have a combined annual vehicle volume of 3,286,532.

Permanent ARID implementation at each Port of Entry should undergo Project Scoping to define the design concept, schedule, and cost of the project. The planning level design and construction cost for a single, stand-alone permanent ARID device is approximately \$28,000. This cost is highly dependent on the cost to provide electrical service to the site. Deployment at sites with existing power and communications infrastructure will significantly reduce implementation costs.