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A Comparison of Bicyclists' Performance Characteristics at Urban, Suburban, and Dedicated Path Intersections in Oregon

Kirk Paulsen
Portland State University

Christopher M. Monsere
Portland State University, monsere@pdx.edu

Sam R. Thompson
Portland State University

Miguel A. Figliozzi
Portland State University, figliozzi@pdx.edu

A Comparison of Bicyclists' Performance Characteristics at Urban, Suburban, and Dedicated Path Intersections in Oregon

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Presented by: Kirk Paulsen – Graduate Research Assistant

Research Team:
Sam R. Thompson – Graduate Research Assistant
Christopher Monsere – Associate Professor
Miguel Figliozzi – Associate Professor

Portland State UNIVERSITY
Department of Civil & Environmental Engineering

Introduction

When stopped at a red light, and then proceeding through the intersection…

- Motorist behavior and performance is consistent and well-known
- Cyclist behavior and performance varies significantly and has not been well quantified

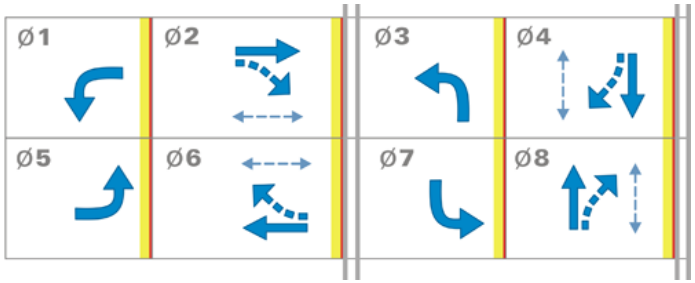
Outdated signal timing for bikes could result in:

- Inefficient Use of Green Time
- Unsafe Scenarios

Research Objectives

- To develop engineering guidelines for the design of bicycle-specific traffic signals.

- To develop operational guidelines for timing and phasing of bicycle-specific traffic signals or modifications that can be made to existing signals to better accommodate bicycles.



Performance Characteristics

- Performance characteristics were observed to better quantify cyclists' behavior starting from a standstill and traveling through an entire intersection.

- Performance Characteristics Of This Research:
  - Perception/Reaction Time
  - Acceleration Rates
  - Cruising Speeds
  - Queue Discharge Rates (separate methodology)

Data Assembly

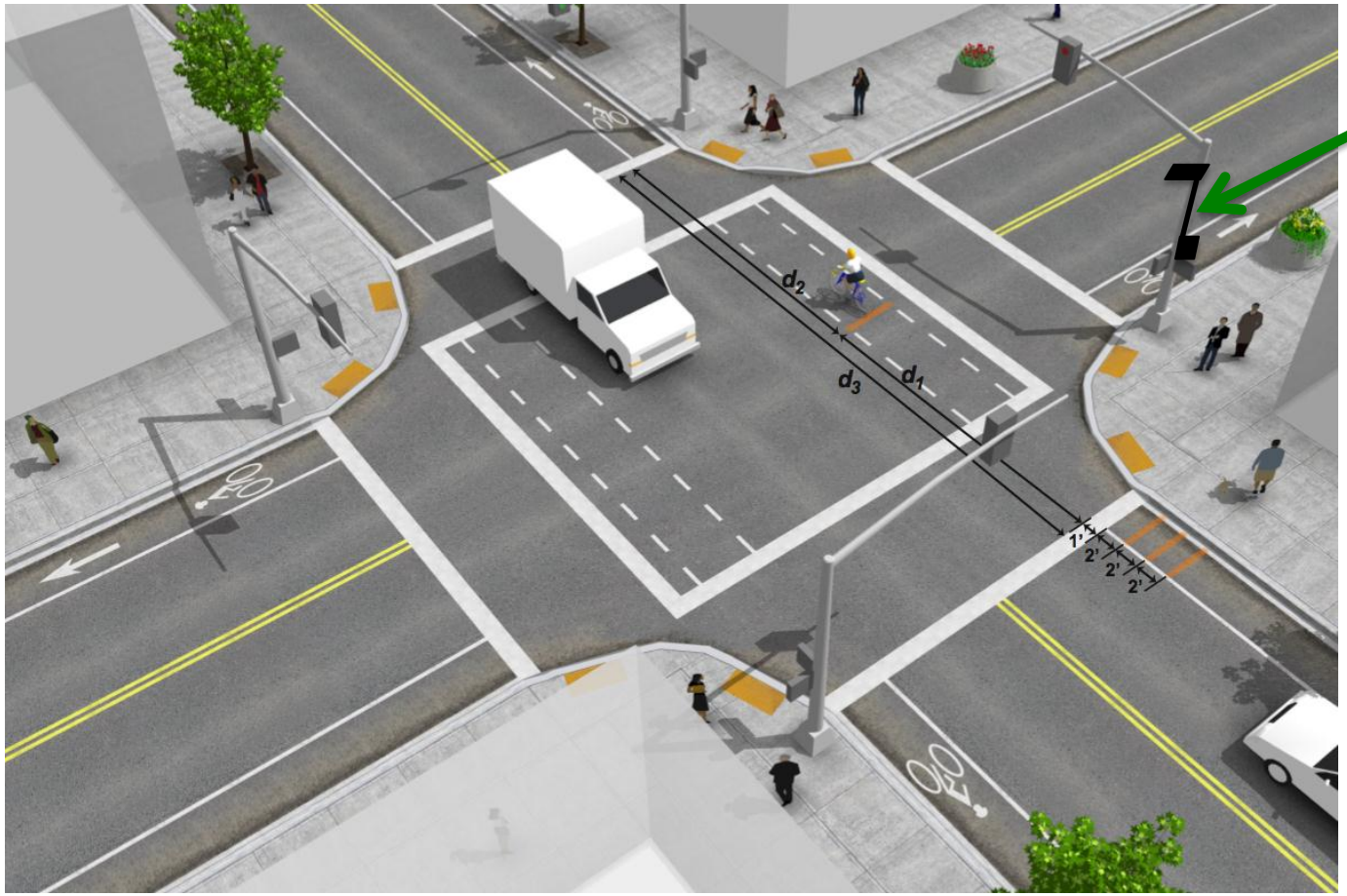
Temporary video units were placed near intersections to obtain video footage used for analysis:

Data Assembly

Data collection is often…fun?

Performance Methodology

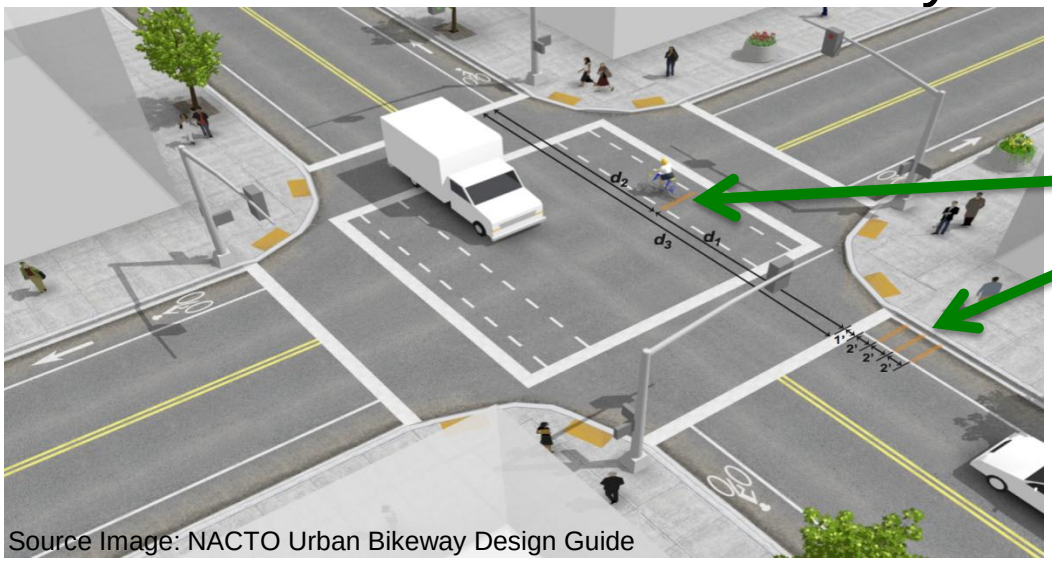
- Video units placed on nearby signal poles
- Footage was reviewed at a later date



Source Image: NACTO Urban Bikeway Design Guide

Performance Methodology

- Perception/Reaction Time easily observed
- Marks strategically painted on pavement allowed time observations to be made when cyclists crossed the lines.



- Using previously developed research[1], calculations could then be made for:
  - Acceleration Rates
  - Cruising Speeds (& the location this was obtained)

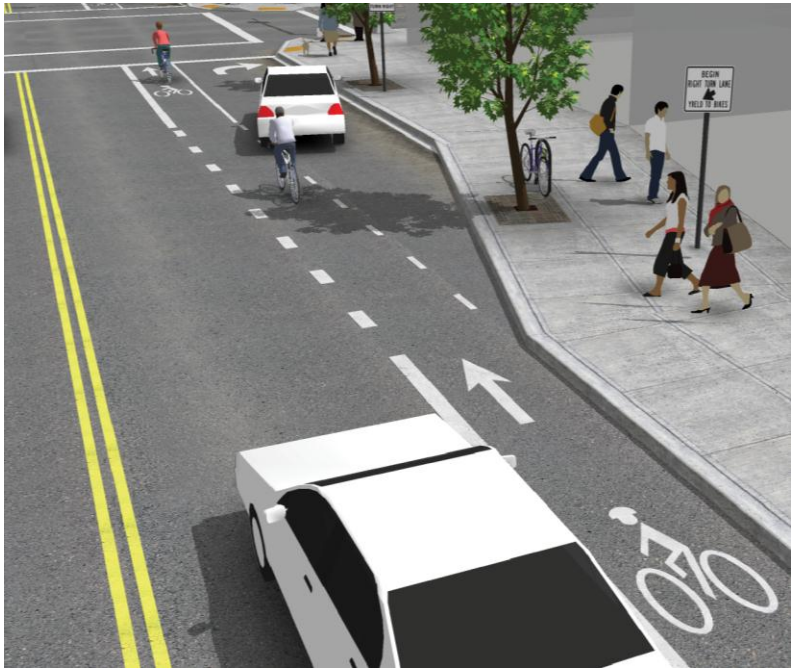
[1]Figliozzi, Miguel, et al. "A Methodology to Estimate Bicyclists' Acceleration and Speed Distributions at Signalized Intersections."

Performance Methodology

- Of all the cyclists observed, **only** the following cyclists were analyzed:
  - Those that came to a complete stop at one of the reference lines,
  - were the first cyclist in line,
  - had at least one foot placed on the ground, and
  - utilized the bike lane before and after the intersection.

Queue Discharge Methodology

Goal: to compare the discharge rates of cyclists at a **traditional bike lane** vs. **bike lane + bike box**



Utilizing the same video units as before, a different methodology was applied to obtain discharge rates.

Source Images: NACTO Urban Bikeway Design Guide

Queue Discharge Methodology

Bike Lane:

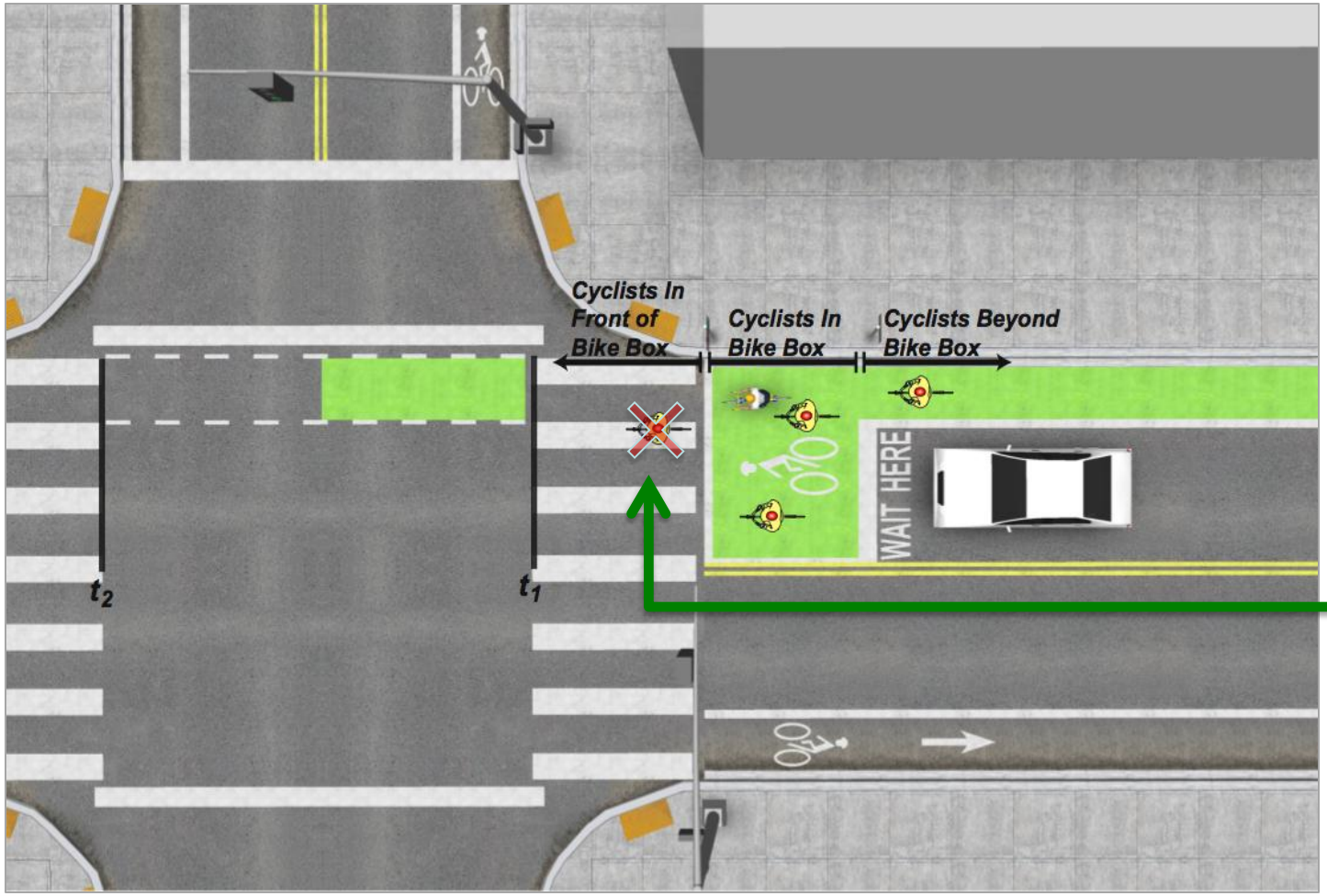
- Time Measurements Recorded:
  - Beginning of Red Indication
  - First Bike to Enter Intersection
  - Last Bike to Enter Intersection
  - Last Bike to Clear Intersection
- Due to cyclists lining up, analysis closely followed HCM methods for determining headways of a queue of cars.
  - Headway for 1st Cyclist: $h_1 = \frac{(Ref_1 - Red)}{fps} - 1s$
  - Headway for Subsequent Cyclists: $h_n = \frac{(Ref_n - Ref_{n-1})}{fps}$
- Irregular queues were not included (e.g. cyclists stopped within intx, bus merging through bike lane, etc.)

Queue Discharge Methodology

- Bike Lane + Bike Box:
- Time Measurements Recorded:
  - Beginning of Red Indication
  - First Bike to Enter Intersection
  - Last Bike to Enter Intersection
  - Last Bike to Clear Intersection
- Due to cyclists forming a group, HCM methods for determining headways was not possible.
- Cyclists split into three groups, those stopped:
  - within the bike box,
  - beyond the bike box, and
  - in front of the bike box. (Not Included in Analysis)

Queue Discharge Methodology

- Bike Lane + Bike Box Visual:



Removed from Analysis

Source Image: NACTO Urban Bikeway Design Guide

Video Footage Used

- In addition to the video footage that we collected, similar video footage from previous research was also used:

	Portland State University		City of Portland	
Analysis	At Intersections (Our Footage)	At Intersections (Previous Footage)	At Bike Box Treatment	Total
Video (Hours)	79	~12	12	~103
Performance (# of Observations)	335	418		753
Queue Discharge (# of Observations)			987	987

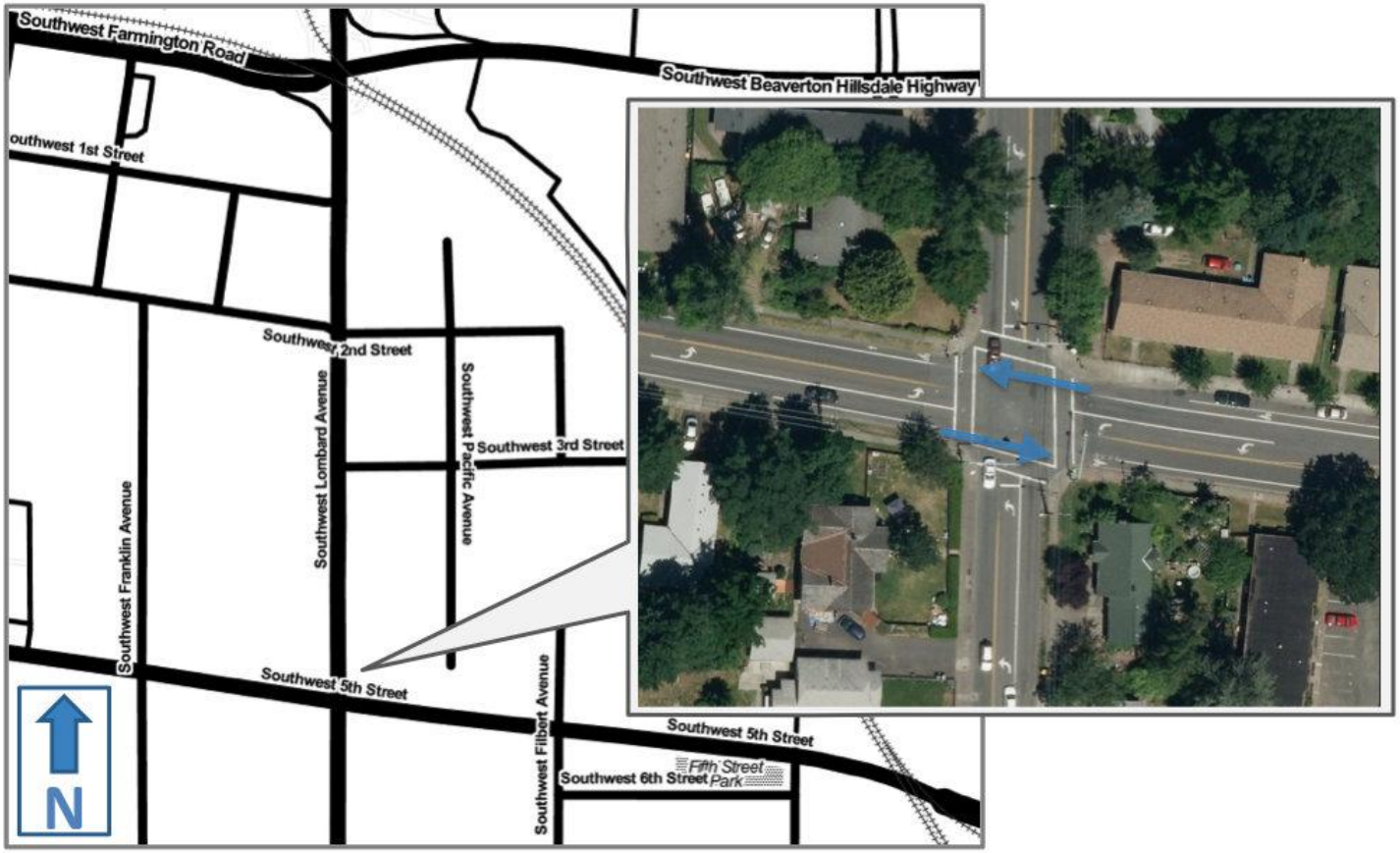
Intersections Analyzed

- Overall, a variety of intersections were observed:
  - Location: Urban / Suburban / Dedicated Path / Bike Box (Before & After)
  - Type of Signal: Regular / Bike Signal
  - Crossing Width: Short / Wide
  - Grade: Flat / Uphill

	Approach	Signal	Width (ft.)	Grade	Date	Weather
1	(EUG) SB Pearl St. at E 18th Ave.	RS	61	Flat	10/12	CLR
	(EUG) WB E 18th Ave. at Pearl St.	RS	65	Flat	10/12	CLR
2	(COR) SB NW 9th St. at NW Buchanan Ave.	RS	63	Flat	10/12	CO
	(COR) EB NW Buchanan Ave. at NW 9th St.	RS	80	Flat	10/12	CO/F
3	(BEA) EB SW 5th St. at SW Lombard Ave.	RS	55	Flat	10/12	CLR/CO
	(BEA) WB SW 5th St. at SW Lombard Ave.	RS	55	Flat	10/12	CLR/CO
4	(CC) SE Johnson Creek Blvd. and SE Bell Ave.	BS	75	Flat	9/12	CLR
5	(PDX) WB SE Madison St. at SE Grand Ave. (bike lane)	RS	61	Flat	7/08 & 9/10	CO
	(PDX) WB SE Madison St. at SE Grand Ave. (bike box)	RS	61	Flat	2/12	R/CO
6	(PDX) EB N Weidler at N Vancouver Ave.	RS	70	Up	7/08 & 12/08	CLR/CO

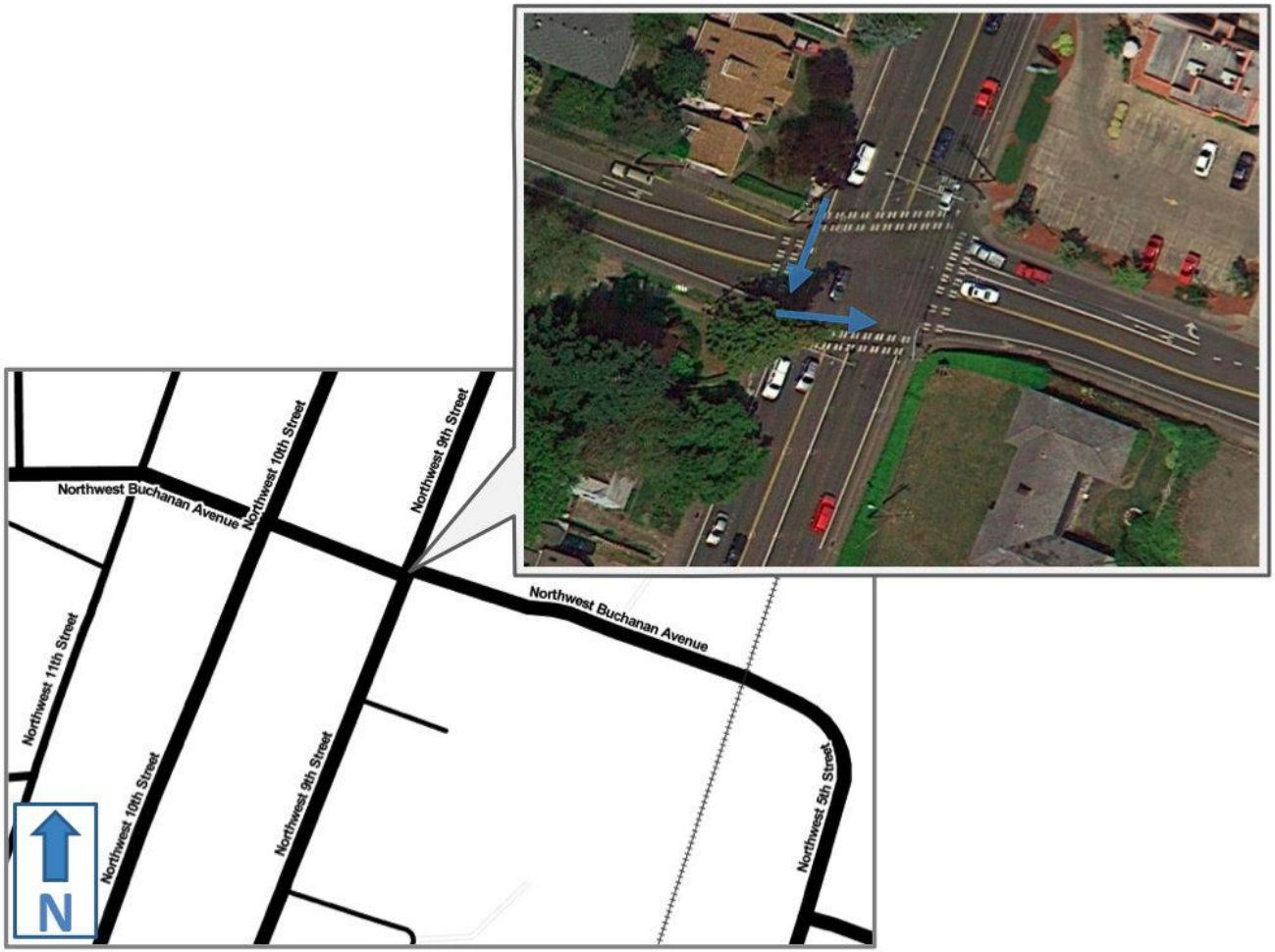
Suburban Intersection

Beaverton – SW 5th Street & SW Lombard Avenue (EB & WB)



Urban Intersection

Corvallis – NW 9th Street & NW Buchanan Avenue (SB & EB)



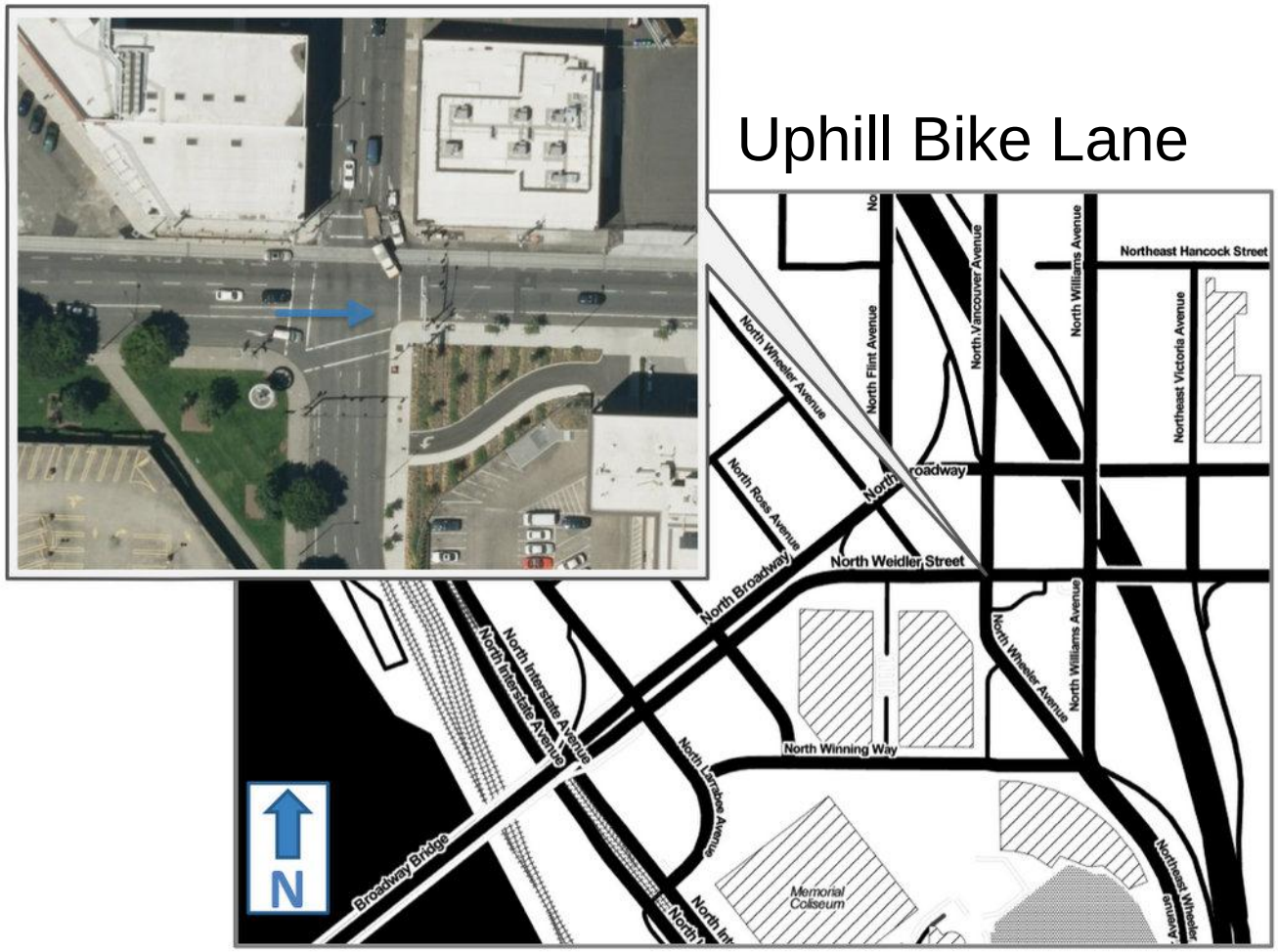
Urban Intersection

Eugene – Pearl Street & E 18th Avenue (SB & WB)

Left-hand Bike Lane

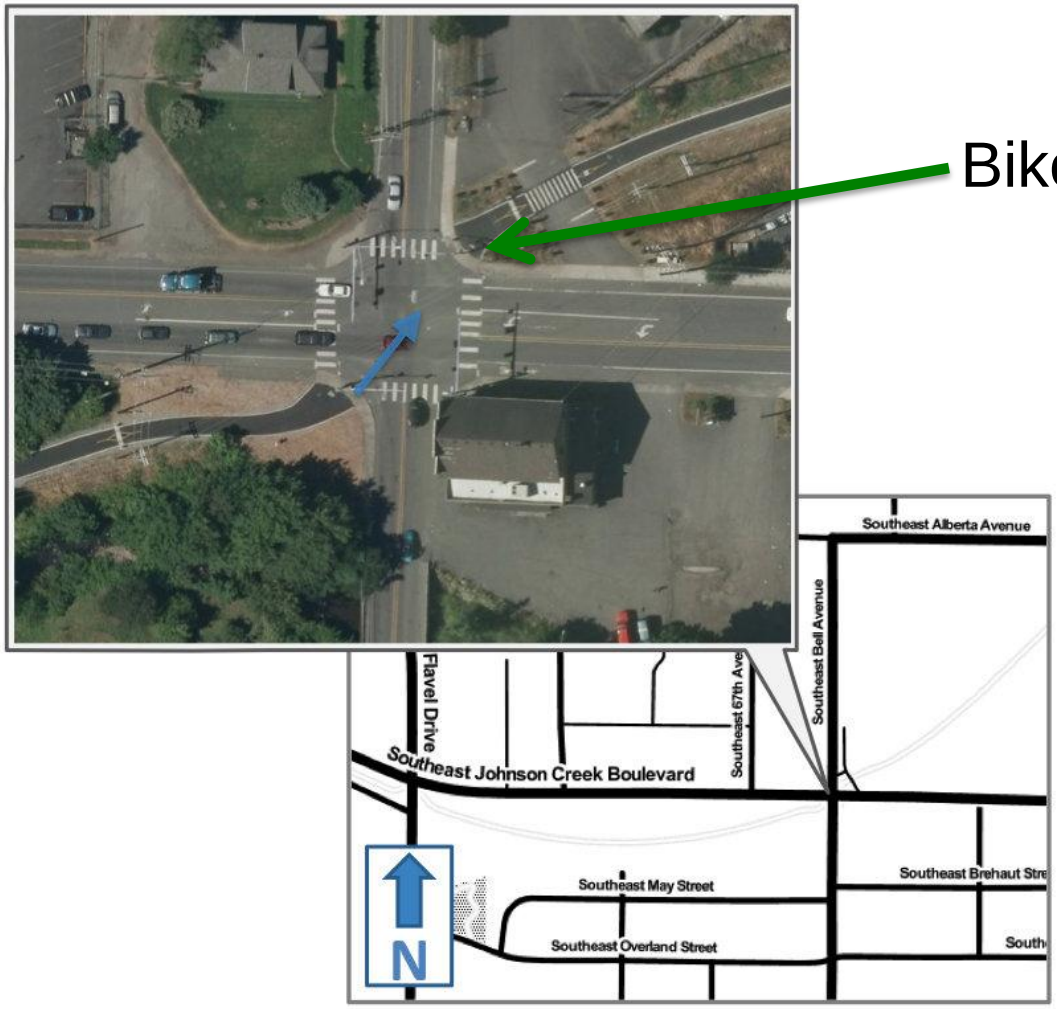
Urban Intersection

Portland – N Weidler Street & N Vancouver Avenue (EB)



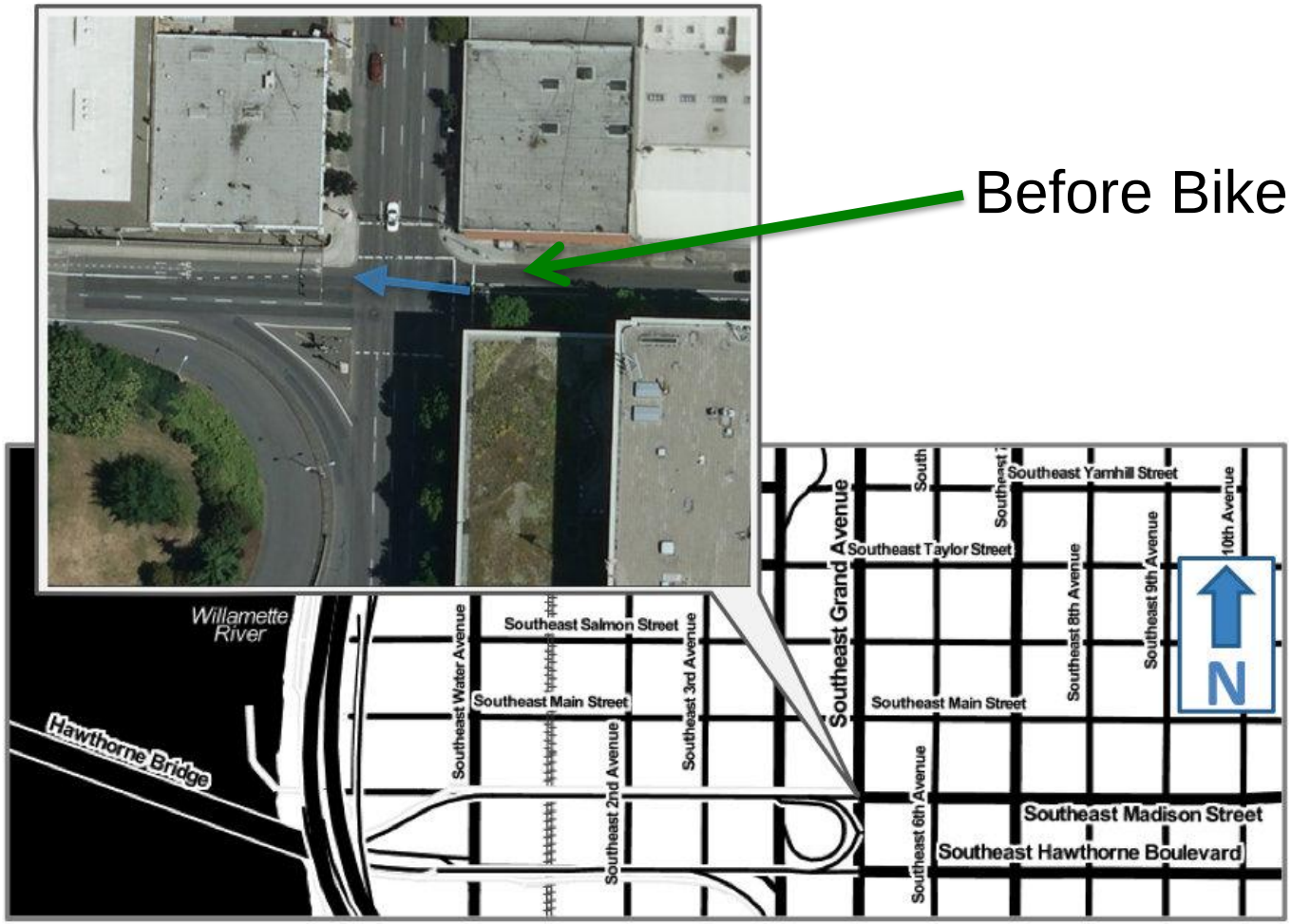
Dedicated Path Intersection

Clackamas County – Springwater Trail & SE Johnson Creek Blvd (EB) / SE Bell Avenue



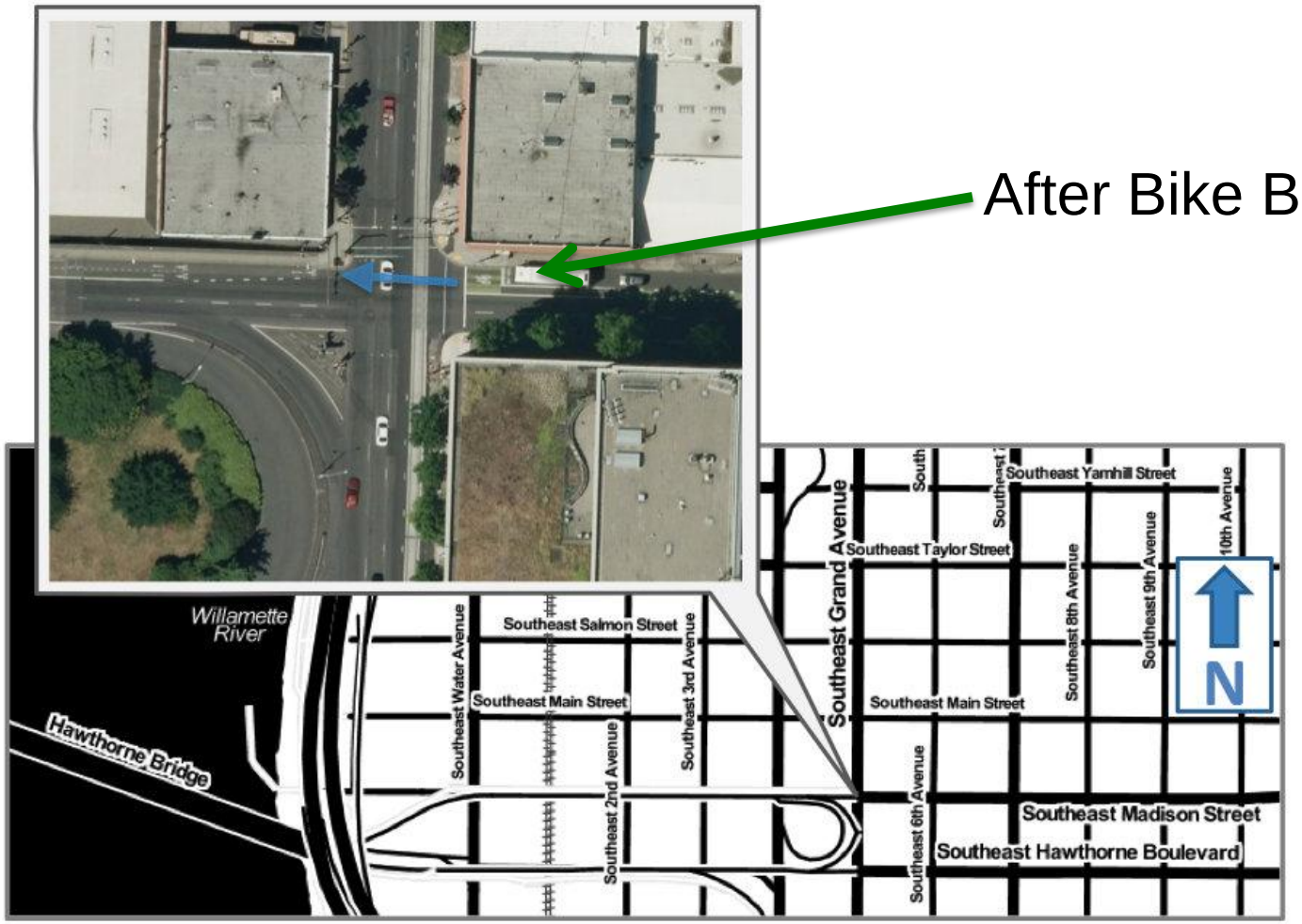
Bike Box Intersection (Before)

Portland – SE Grand Avenue & SE Madison Street (WB)

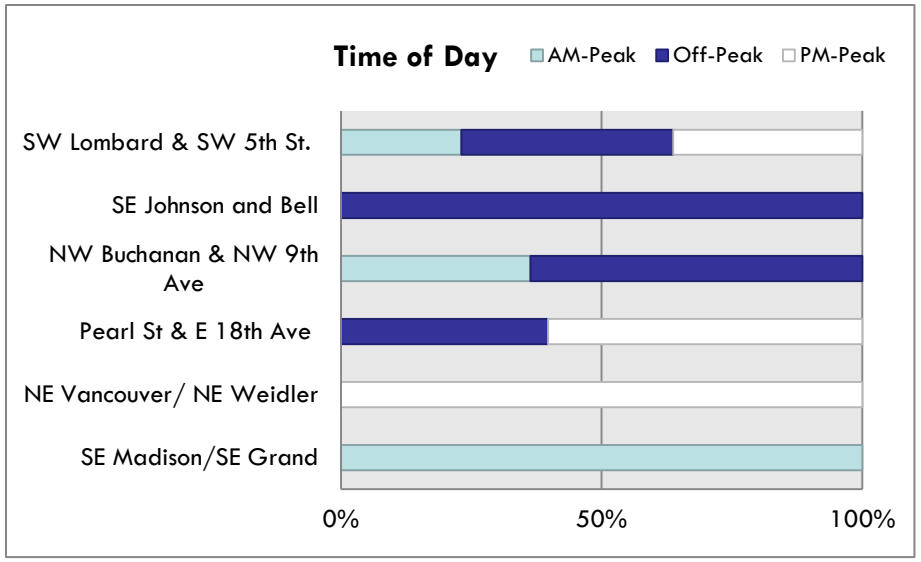


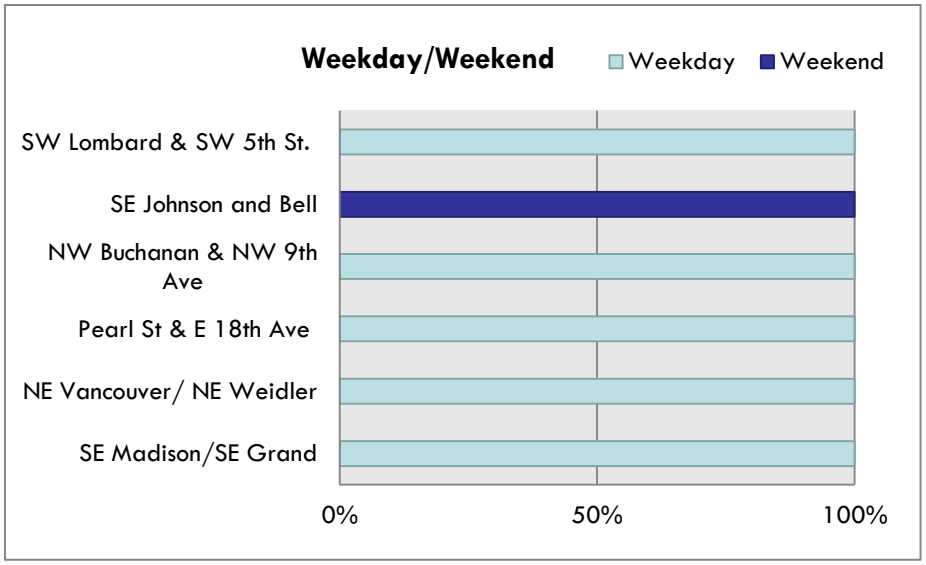
Bike Box Intersection (After)

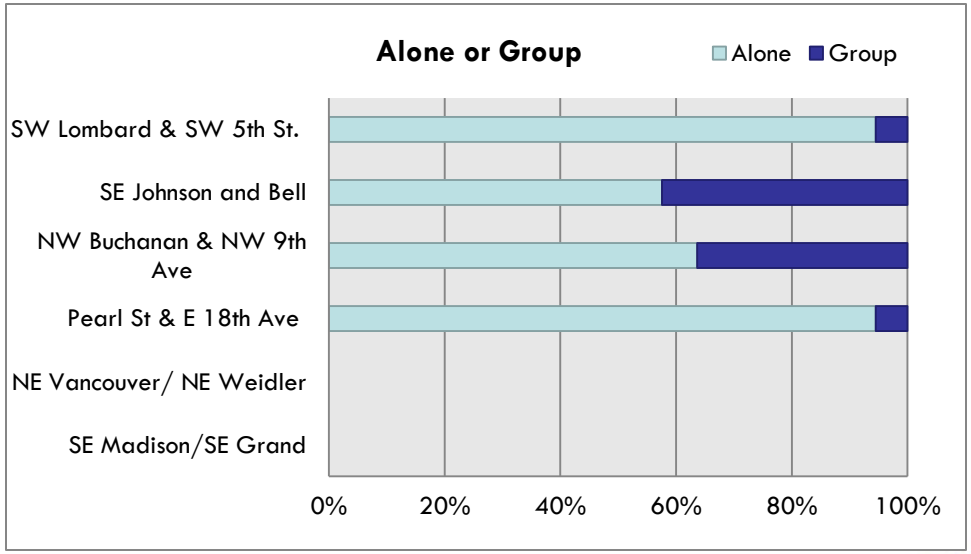
Portland – SE Grand Avenue & SE Madison Street (WB)



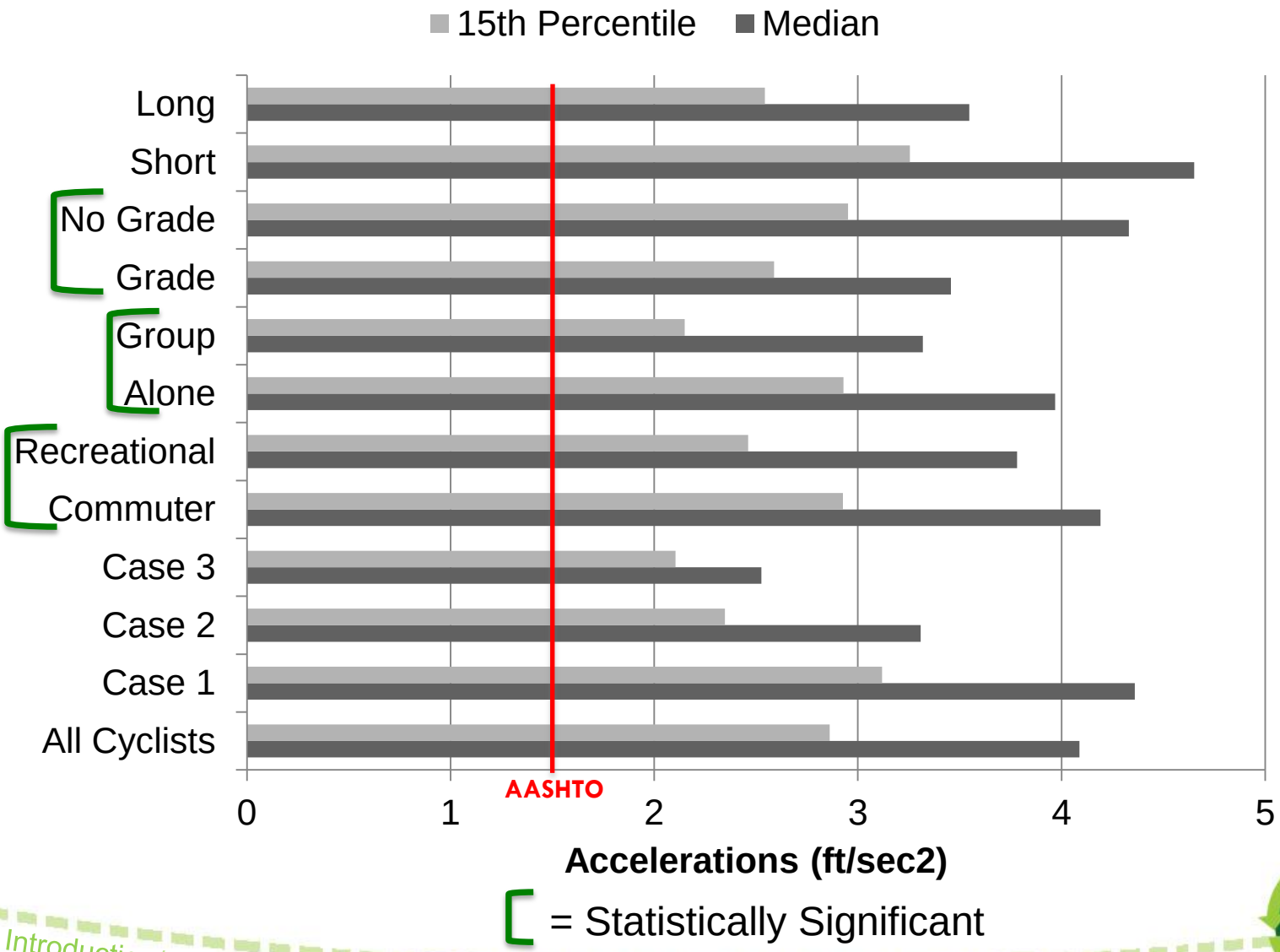
Categorical Summary by Intersection



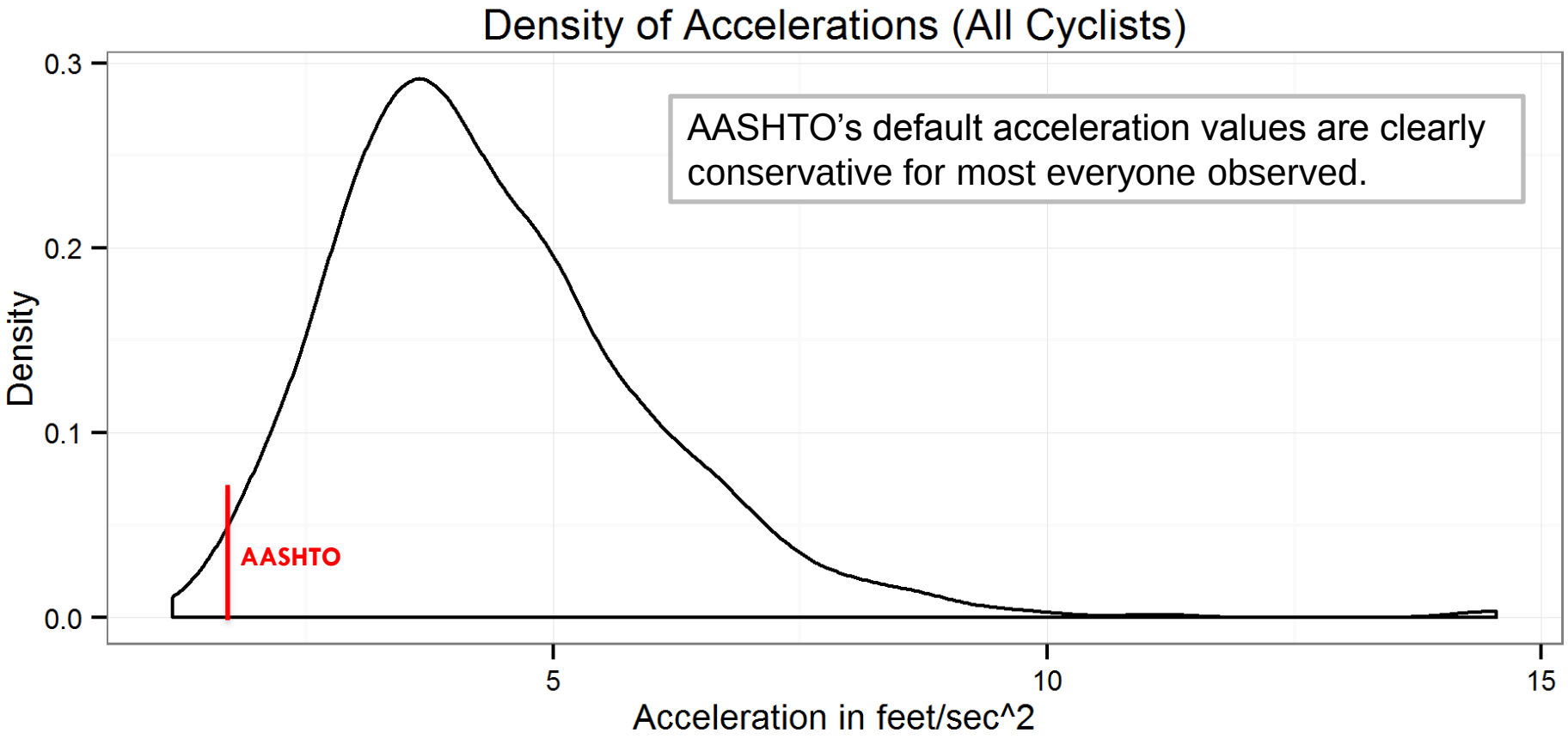




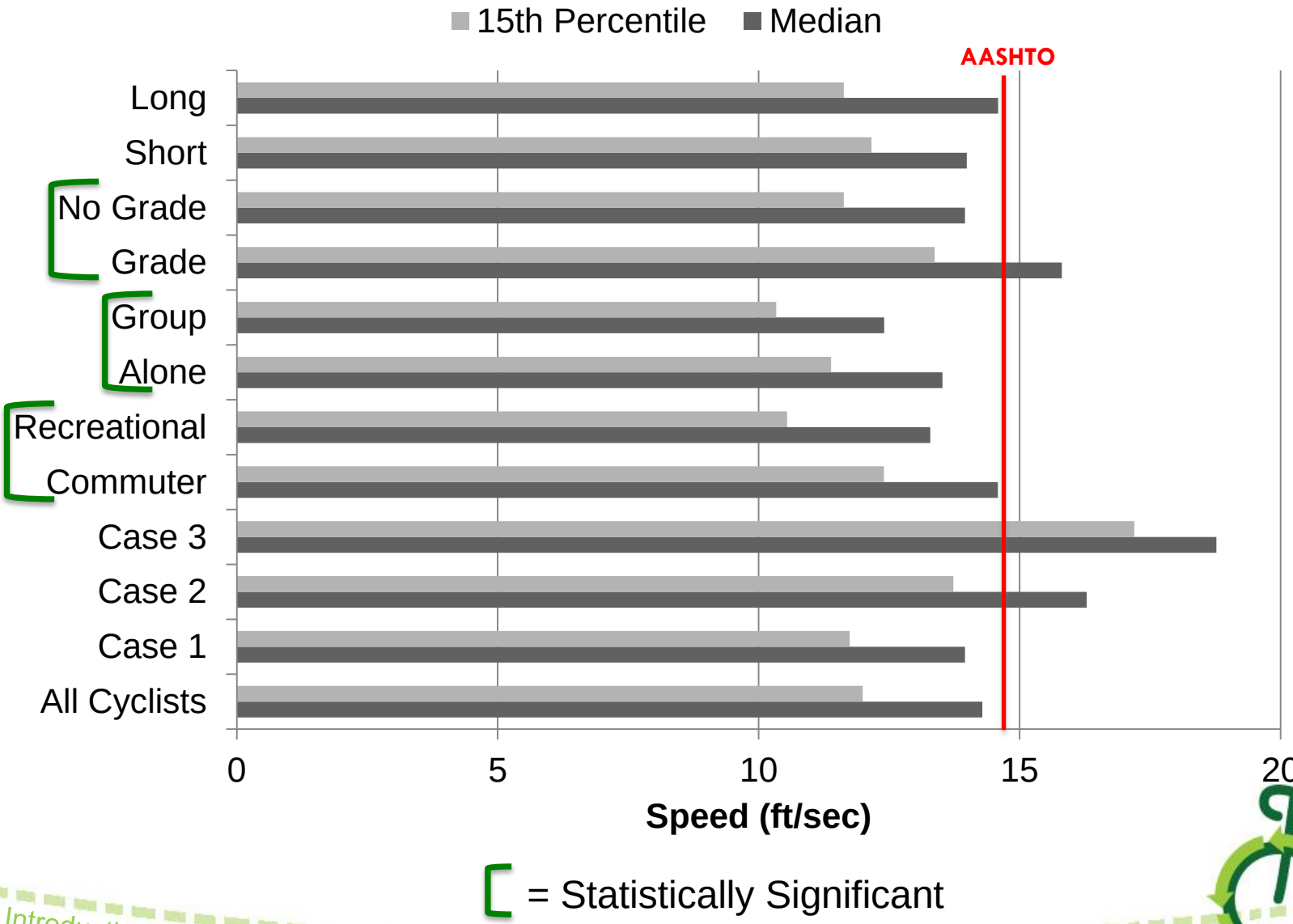
Summary of Observed Accelerations



Density Plot of Observed Accelerations

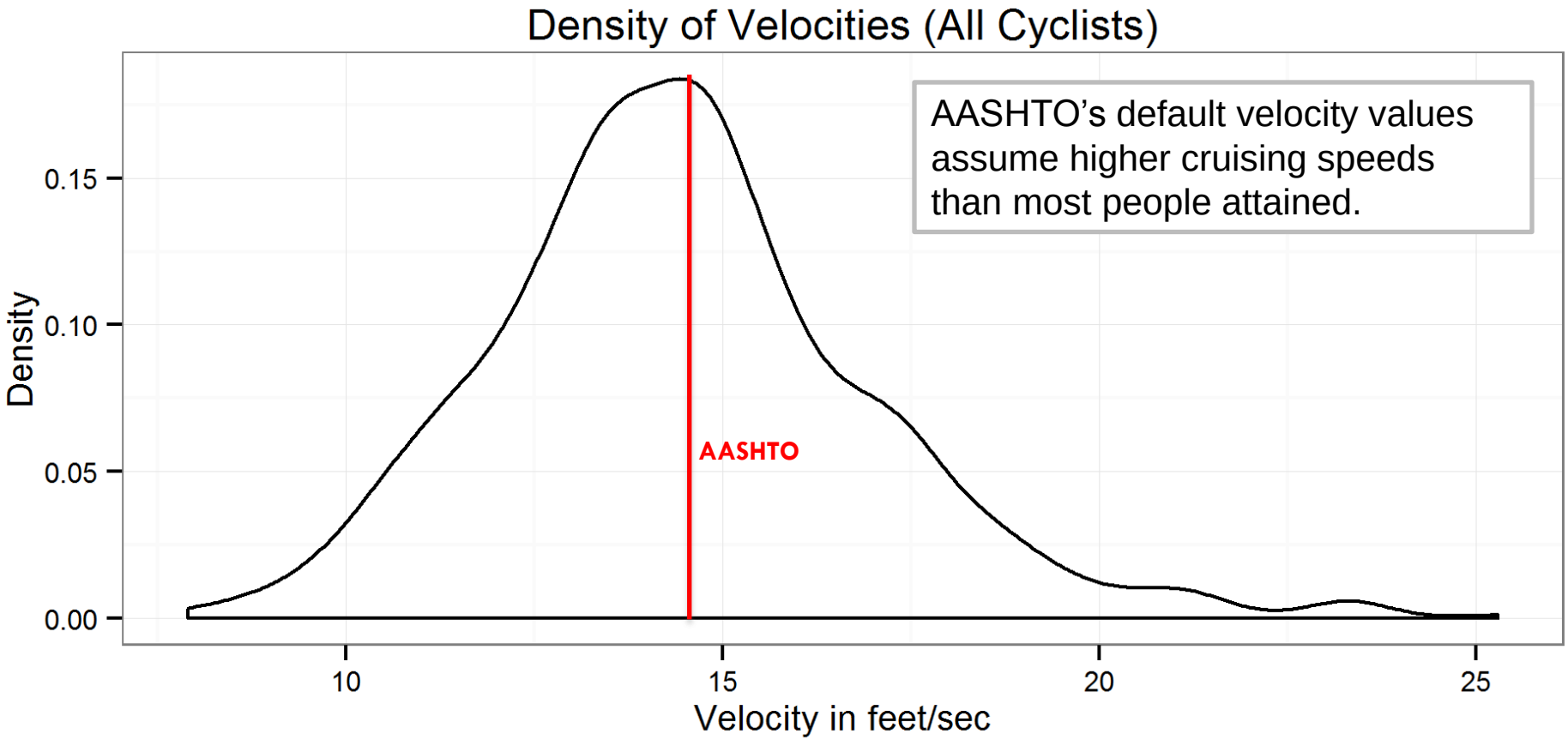


Summary of Observed Cruising Speed

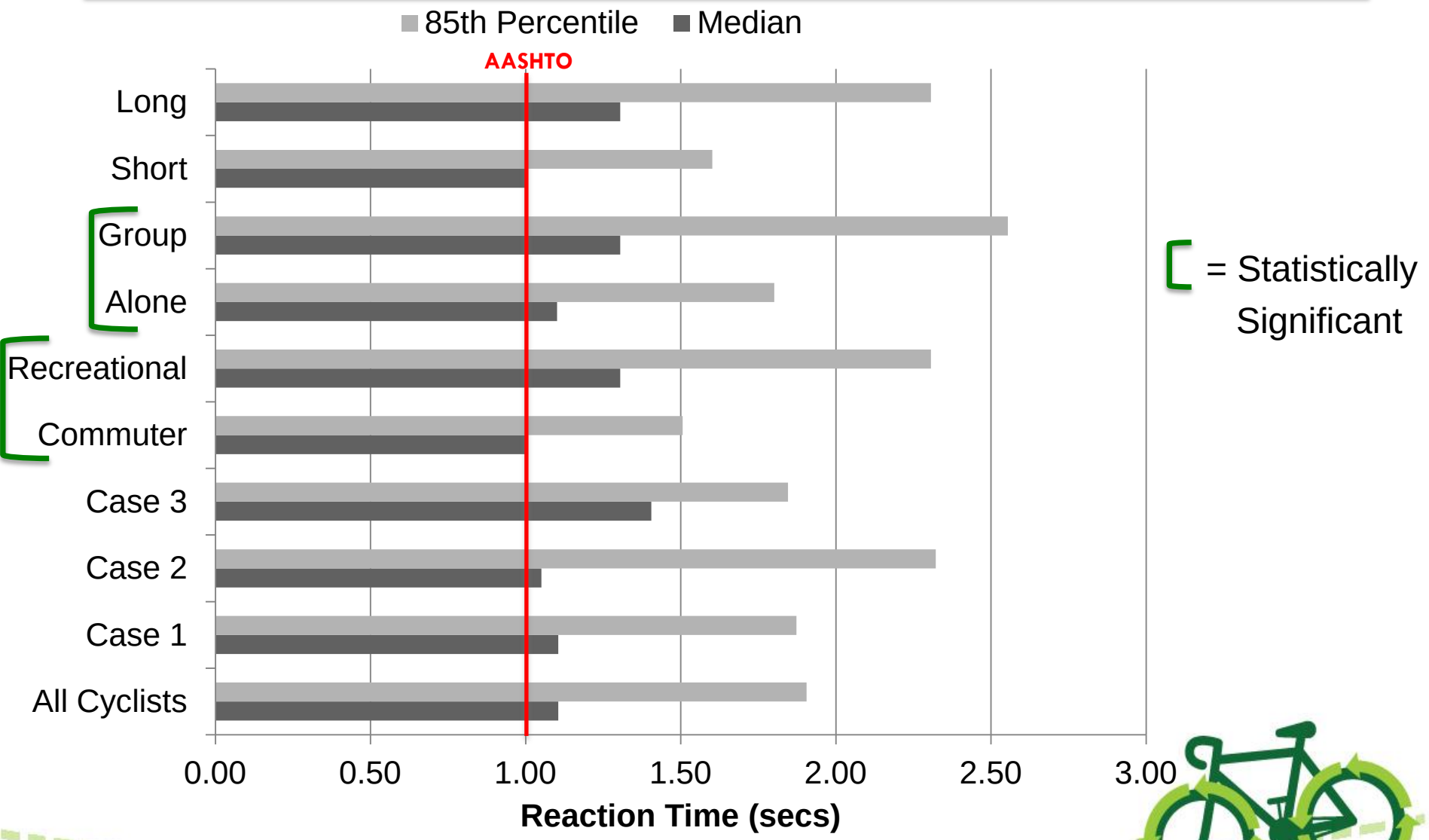


[= Statistically Significant

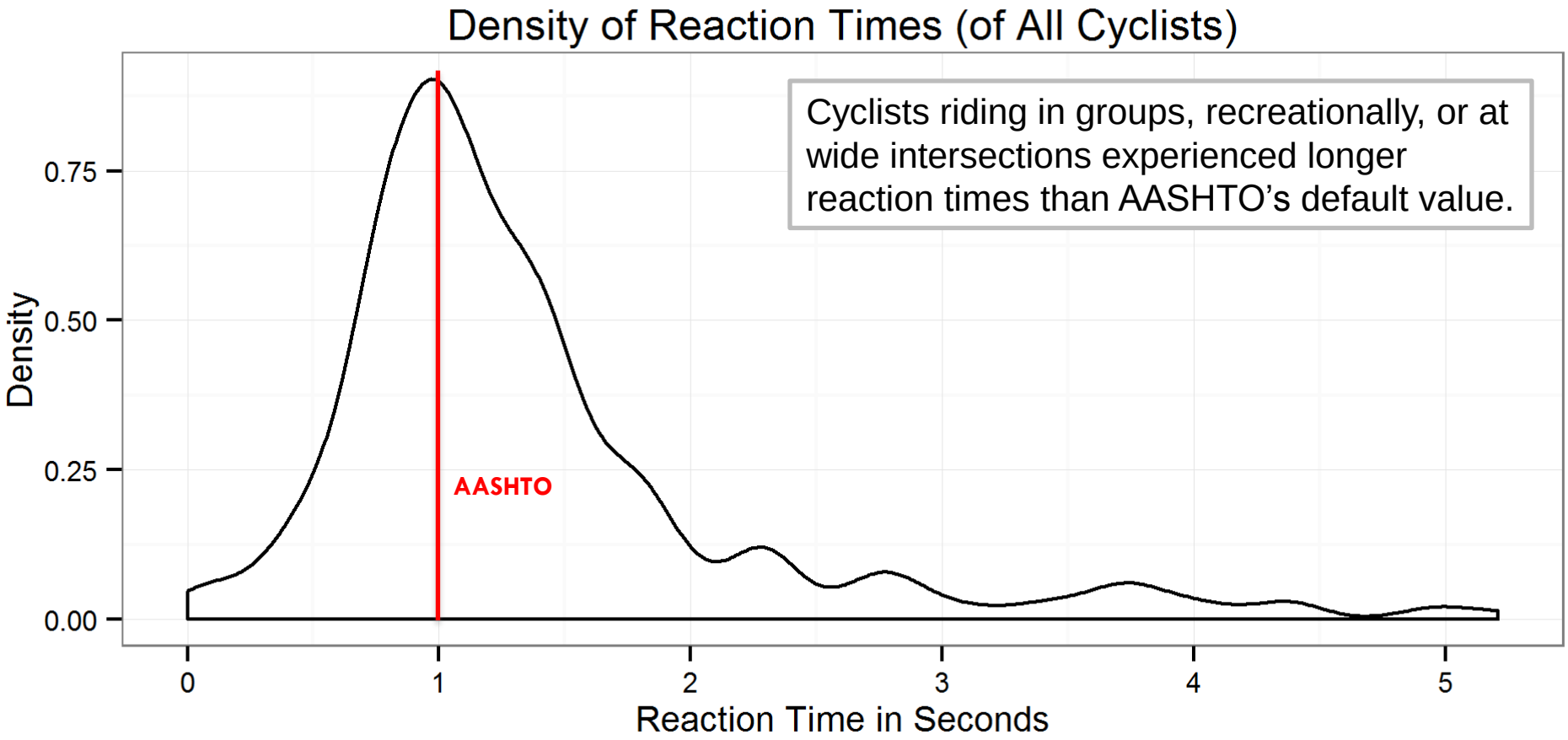
Density Plot of Observed Cruising Speed



Summary of Observed Reaction Times



Density Plot of Observed Reaction Times

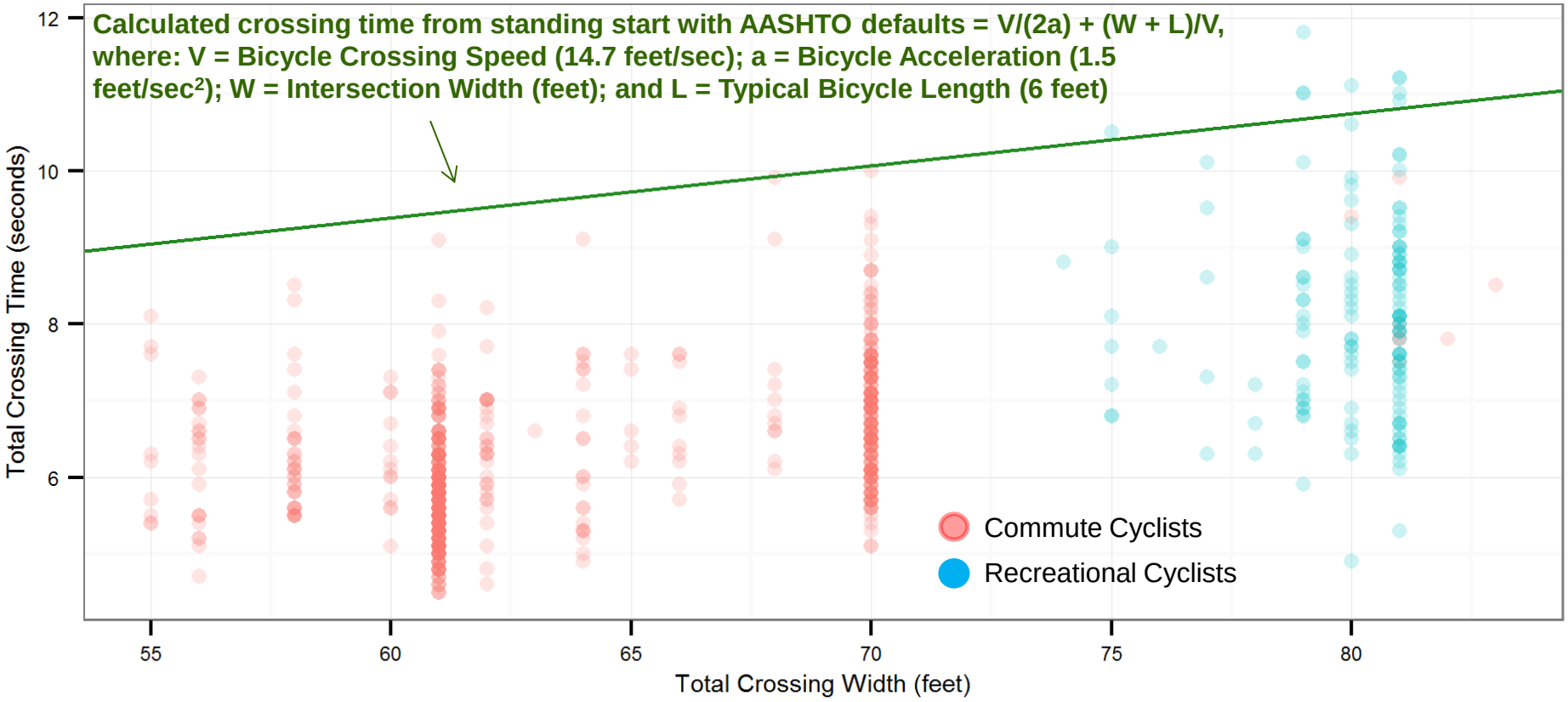


Overall Performance Summary

Value	AASHTO	All Cyclists Observed		AASHTO Percentile (Estimated)
		Median	Percentile (Values)	
Acceleration (ft./sec^2)	1.5	4.09	15th (2.86)	<2
Cruising Speed (ft./sec)	14.7	14.29	15th (11.99)	52
Perception Reaction Time (sec)	1.0	1.11	85th (1.91)	32-39
BMG + Y + AR for a 60 ft. intersection (sec)	10.39	7.48	85th (9.51)	

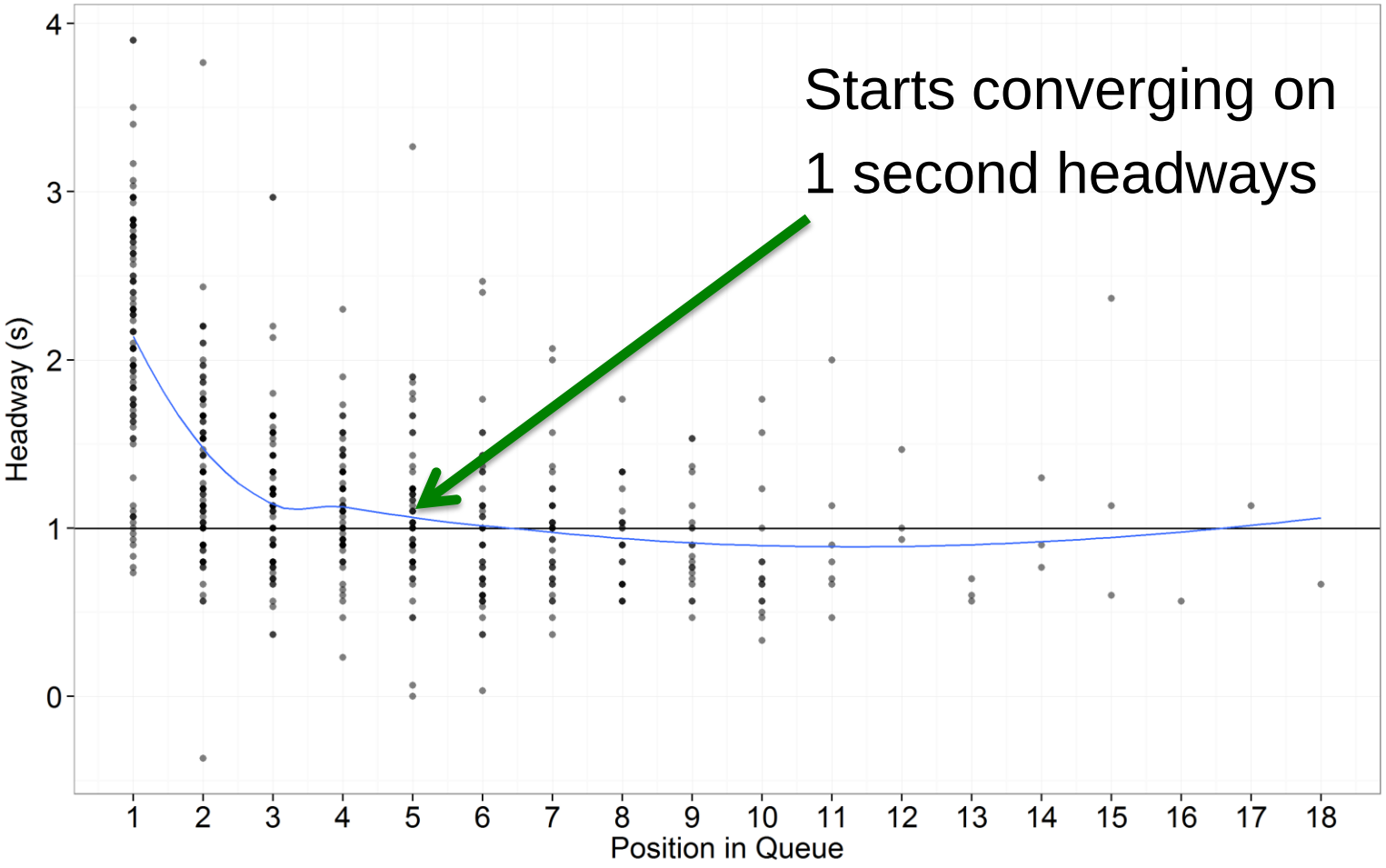
$$BMG + Y + R_{clear} = PRT + \frac{V}{2a} + \frac{(W + L)}{V}$$

Observed Crossing Times by Width

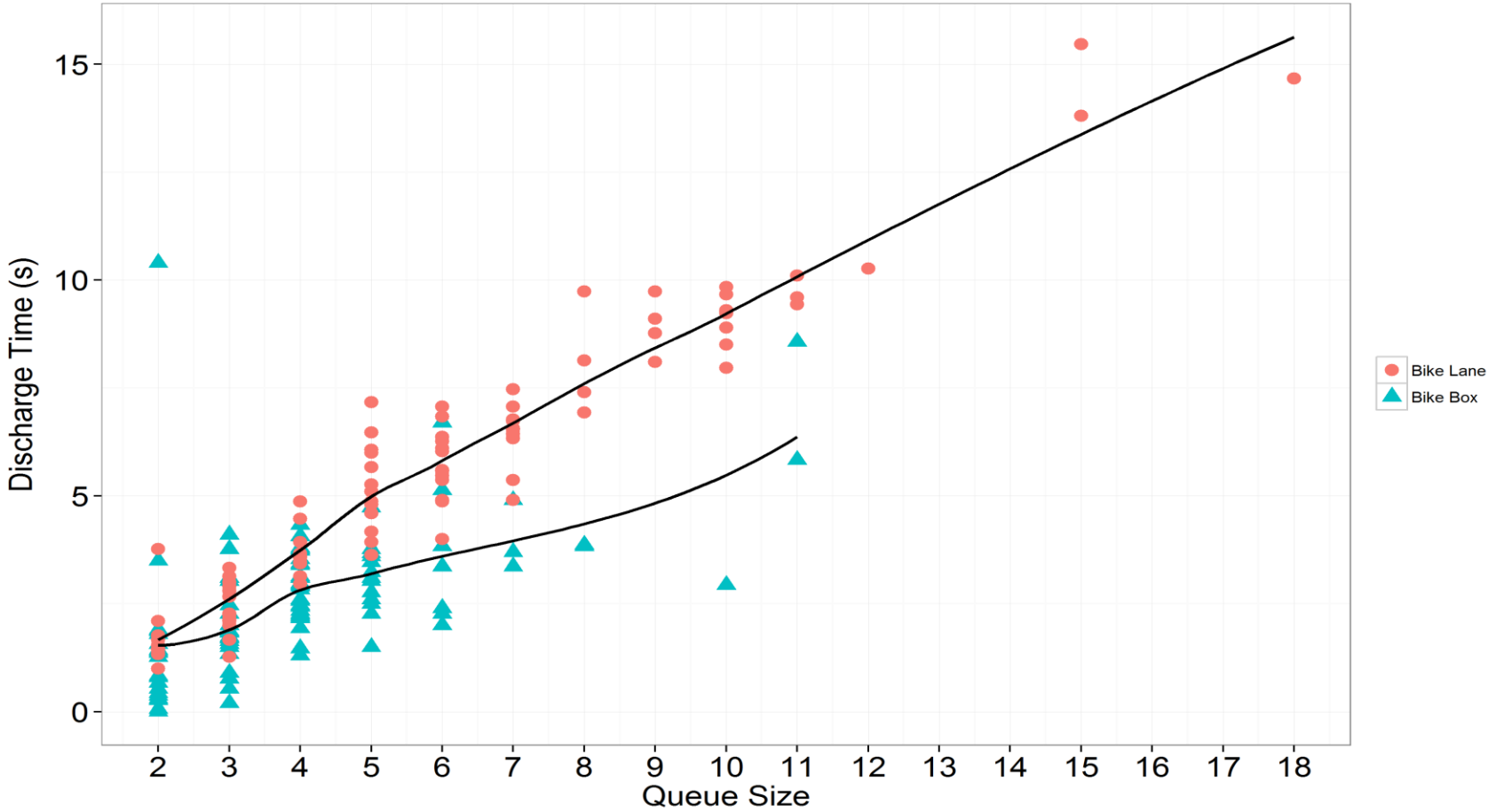


$$BMG + Y + R_{clear} = PRT + \frac{V}{2a} + \frac{(W+L)}{V}$$

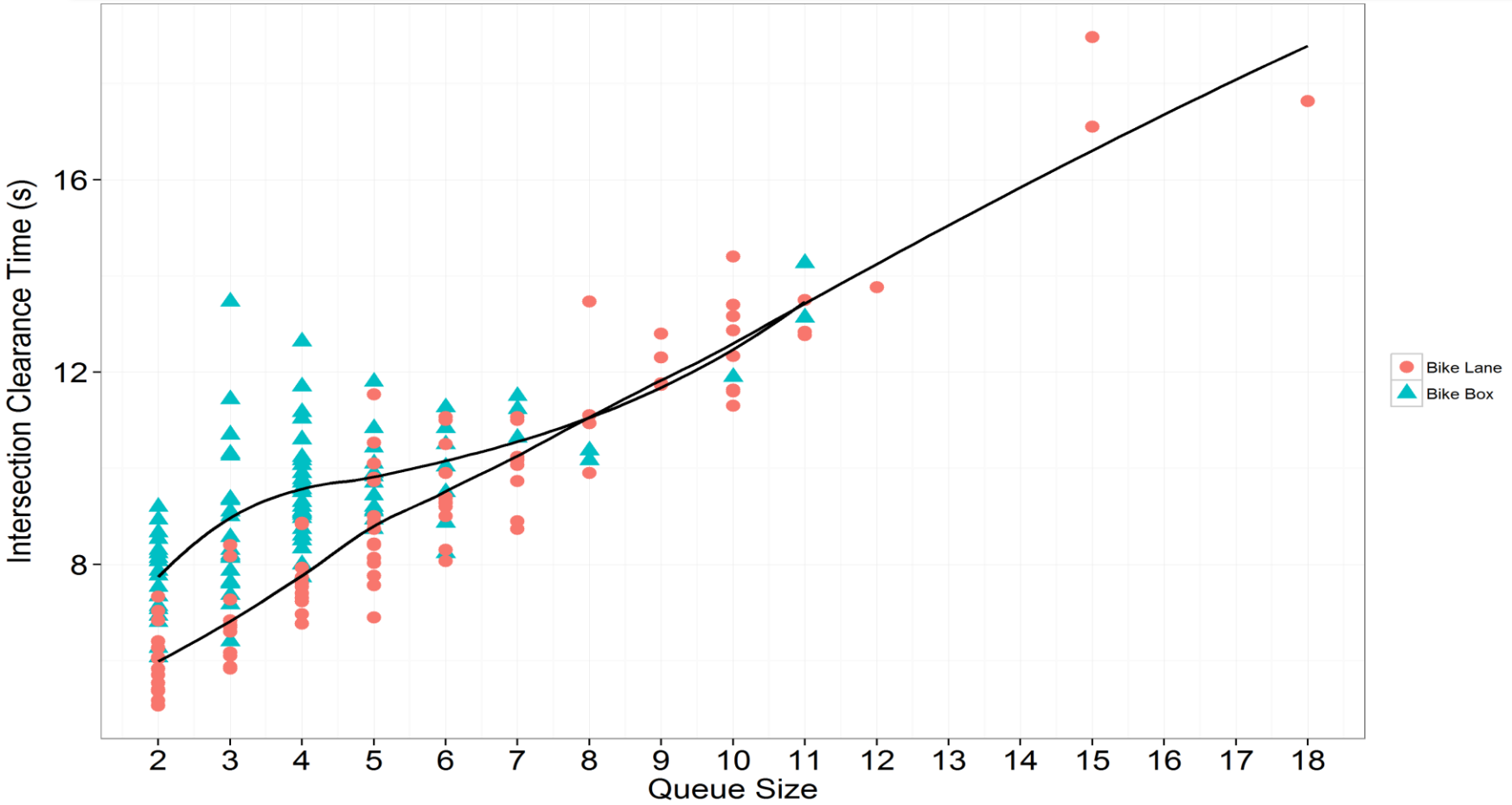
Observed Queue Discharge Headways by Position in Queue



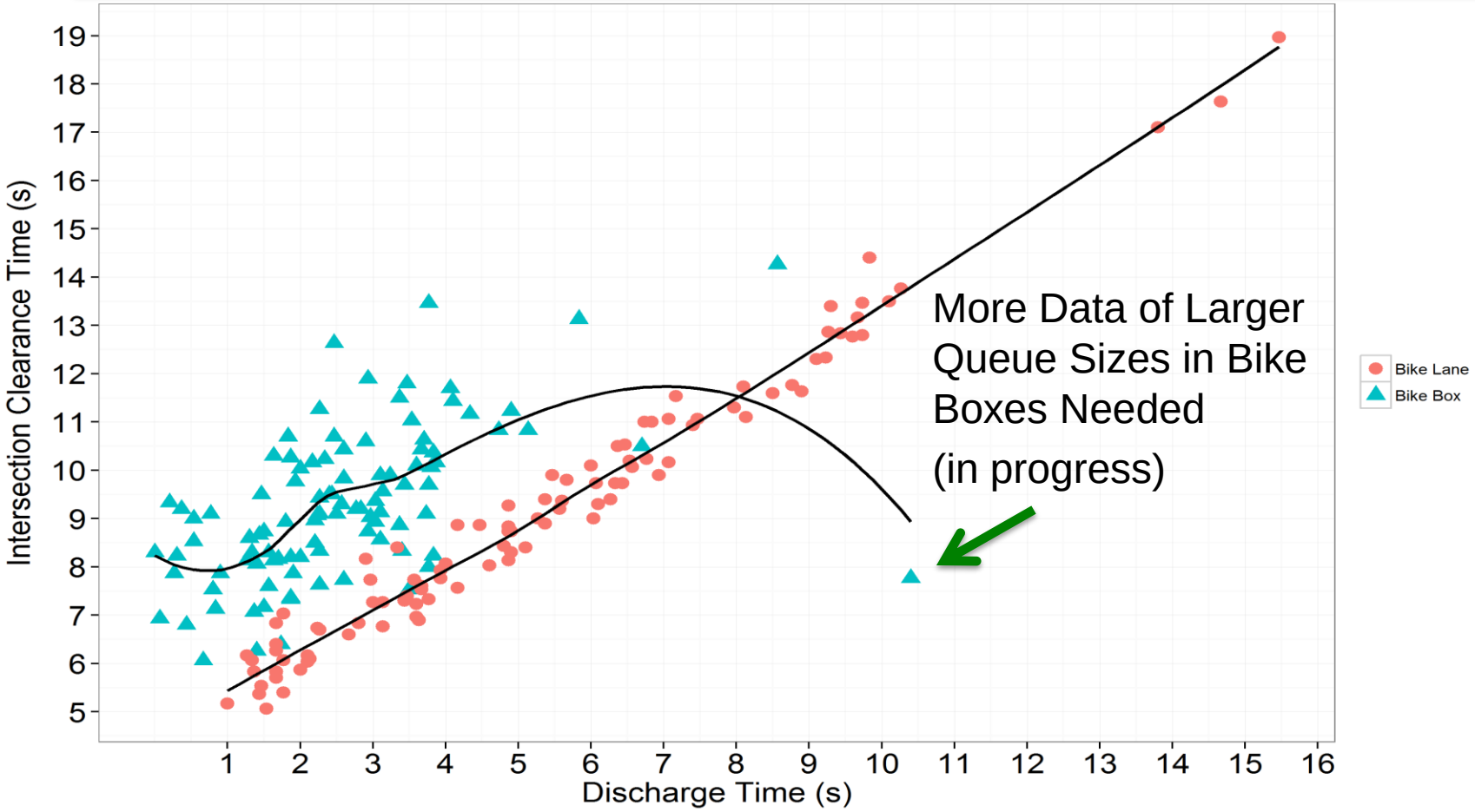
Queue Discharge Time by Queue Size



Queue Clearance Time by Queue Size



Intersection Clearance Time by Queue Size



Conclusions (Performance)

- The AASHTO defaults seem to be **conservative for acceleration**, **fairly accurate for cruising speed**, and **liberal for perception-reaction times**.

- The **combination of AASHTO defaults** in the clearance formula, hence, produces timing values that are **sufficient for most riders in most locations** (more **care should be put into wider intersections** though).

- Statistically significant differences were found between **alone and group**, **recreational and commuter**, and **grade or no grade** in each of the performance categories.

Conclusions (Queue Discharge)

- The **average cyclist headway was found to be 0.997 seconds** (5th or higher in queue).
- The **addition of a bicycle box decreases the discharge time**.
- The **decrease in discharge time** between bike boxes and bike lanes **becomes more evident with larger queue sizes**.
- Cyclists utilizing a bike box appear to have **longer** clearance times for **smaller** queue sizes.

Acknowledgements

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  - Mark Joerger (ODOT)
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  - Dr. Christopher Monsere
  - Dr. Miguel Figliozzi
  - Sam R. Thompson

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Thank You! Questions/Comments?

e-mail: pkirk@pdx.edu

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Find the interim report here:

http://bit.ly/SxRrZd

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