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Towards Effective Design Treatment for Right Turns at Intersections with Bicycle Traffic

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TOWARD EFFECTIVE DESIGN TREATMENTS FOR RIGHT-HOOK CRASHES AT INTERSECTIONS WITH BICYCLE TRAFFIC

PSU FRIDAY SEMINAR

FEBRUARY 5, 2015

Research Team:

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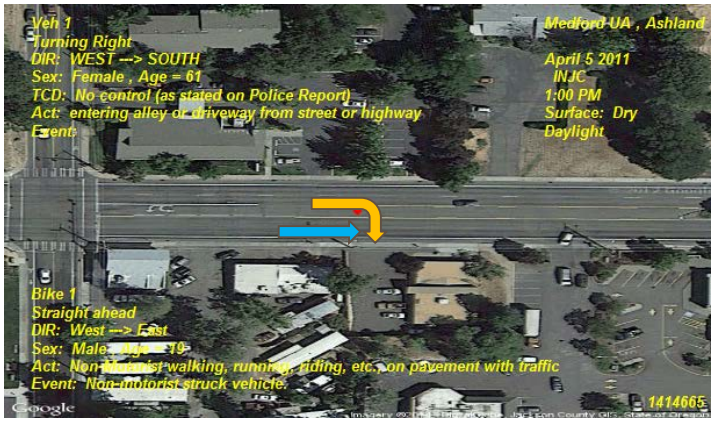
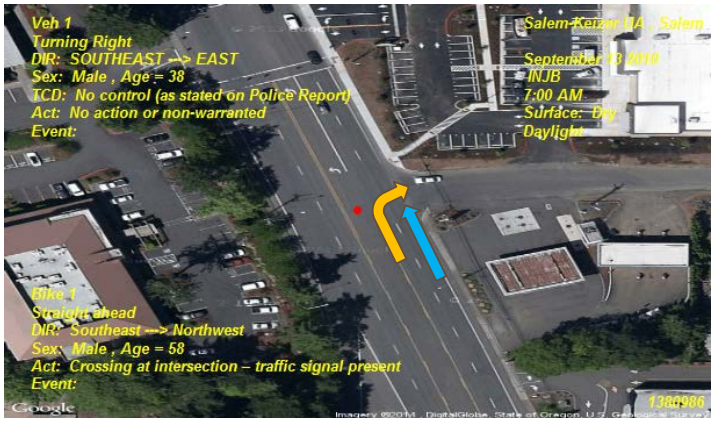
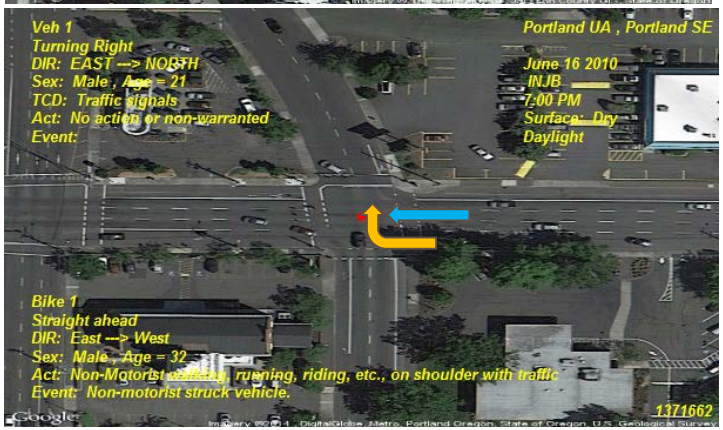
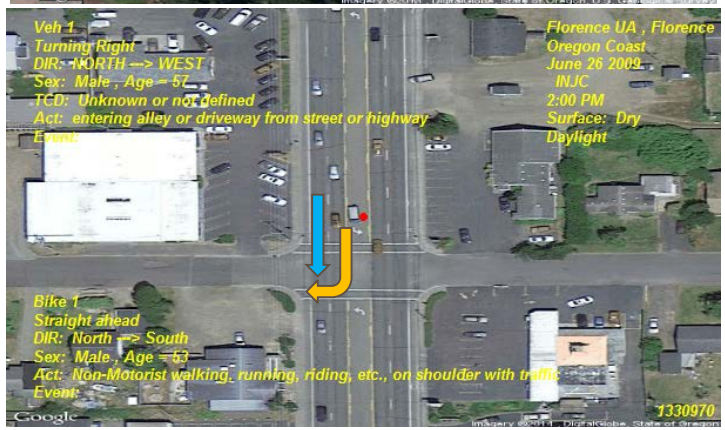
Crash Review (2007-2011), Statewide

4,072 reported bicycle-involved crashes
504 (12.3%) typed as a “potential” right-hook crash









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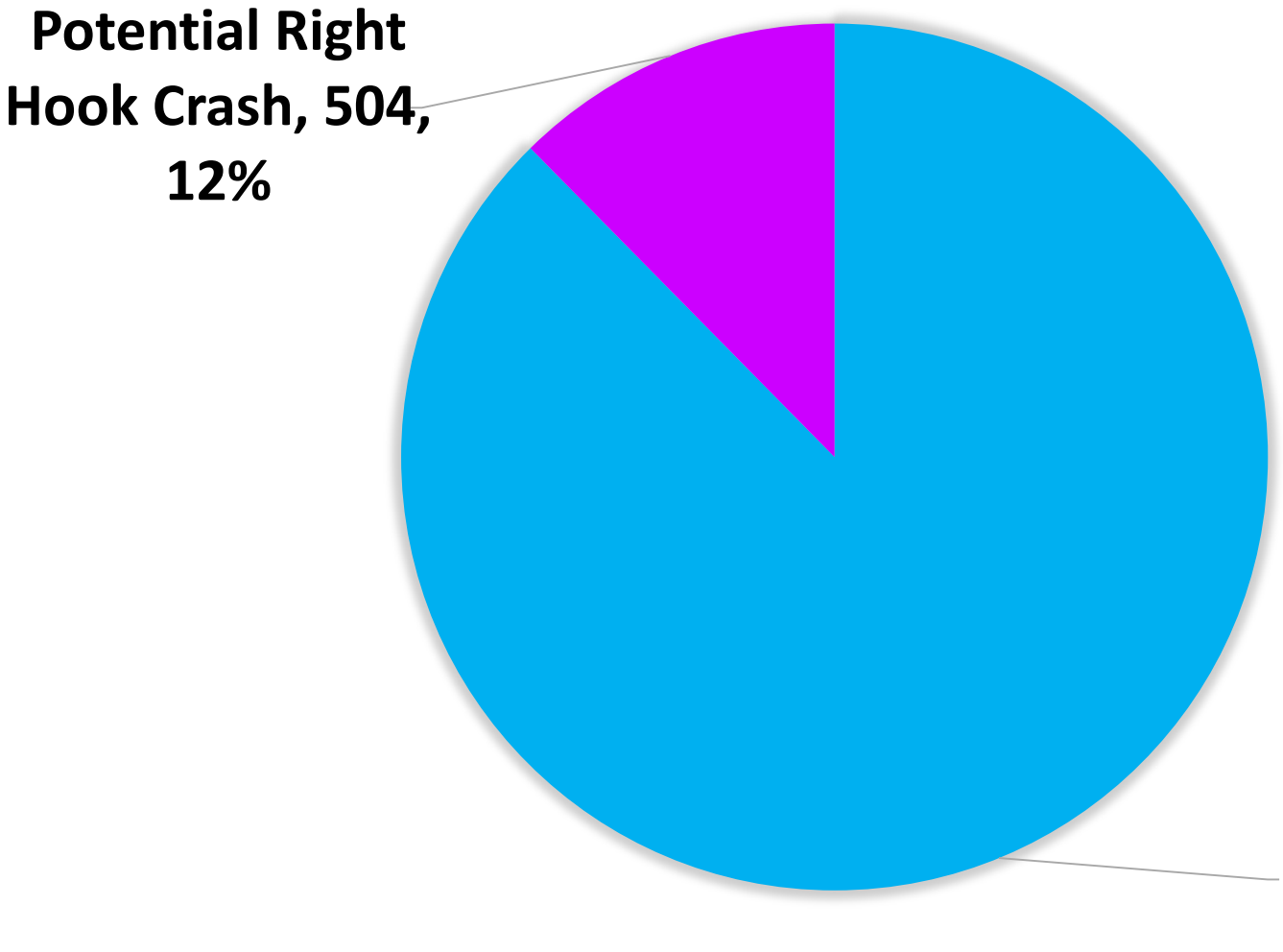

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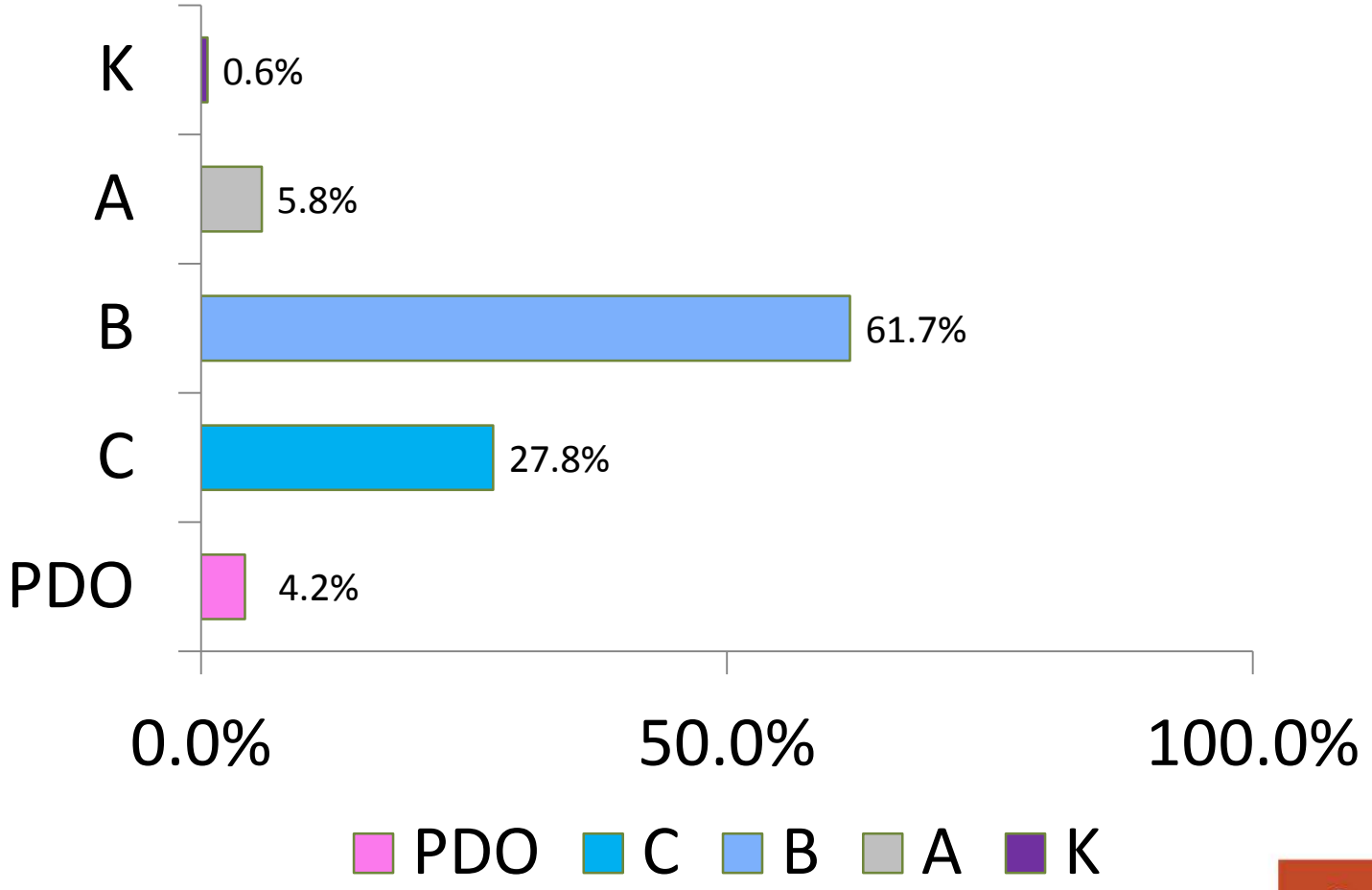
Right-Hook Severity Summary



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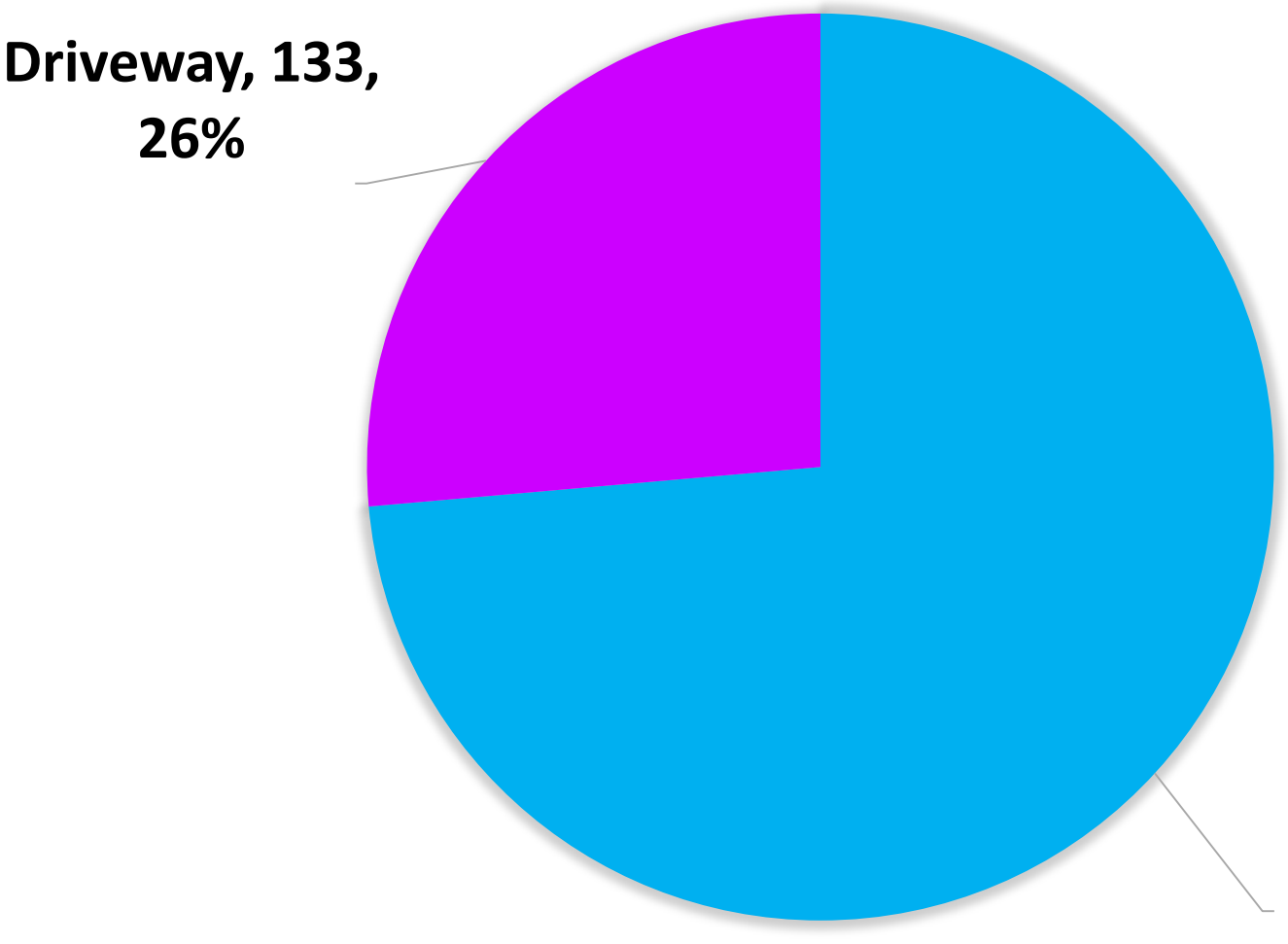
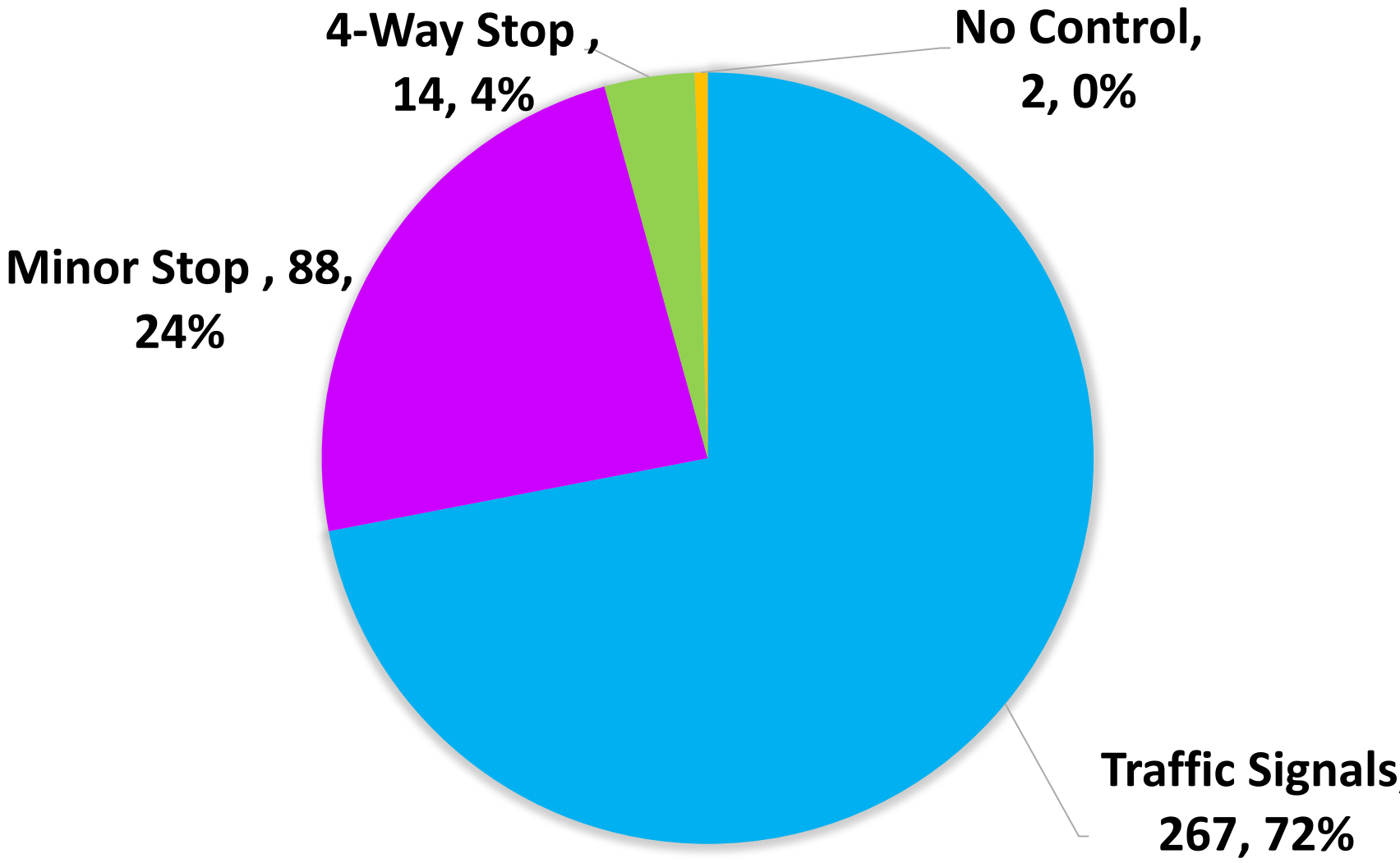

Driveway, 133, 26%
Intersection, 371, 74%



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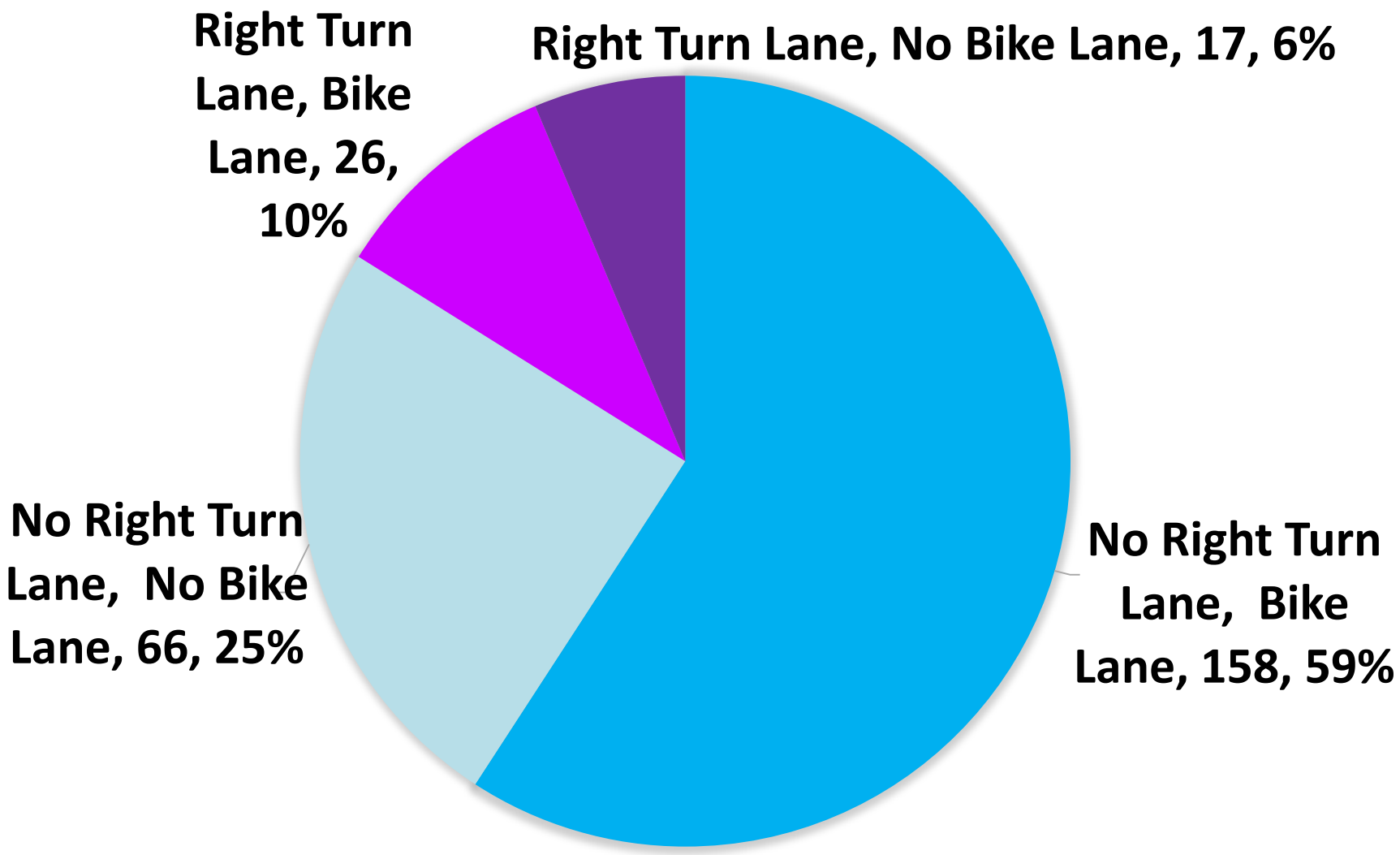

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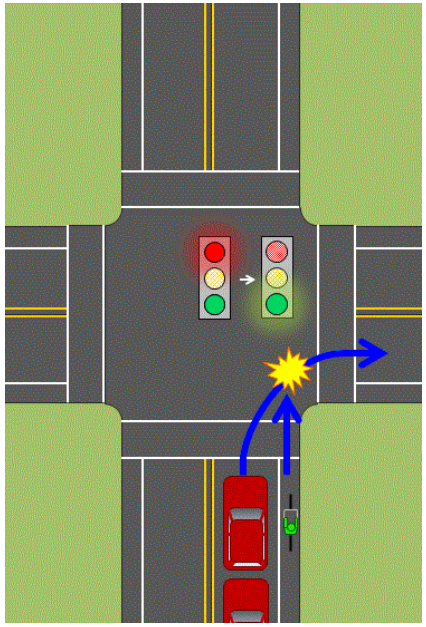
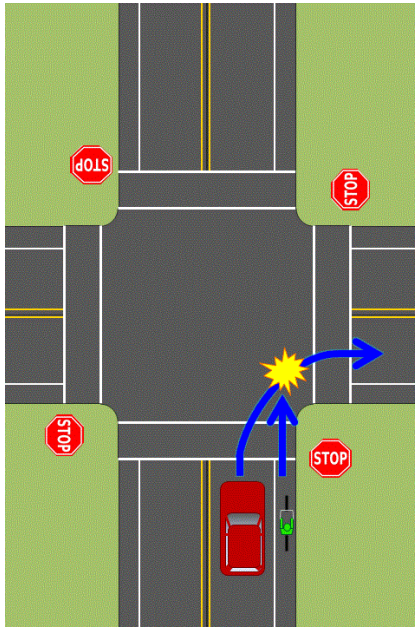
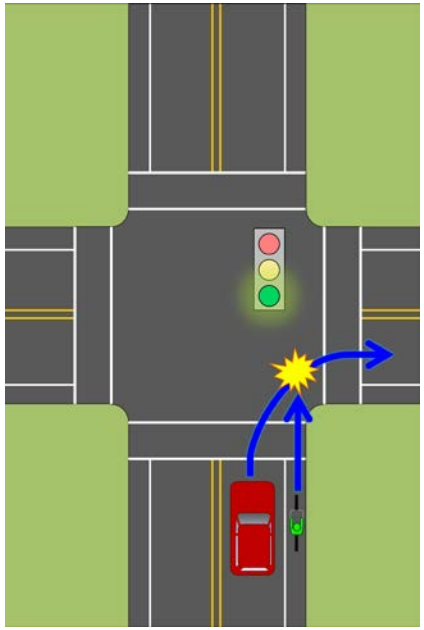
Right-Hook Crash Scenarios (Intersection with bike lane)



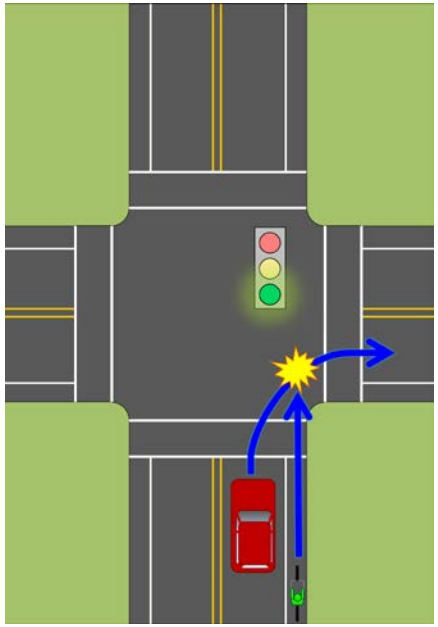
onset of the green indication



at a stop sign



cyclist passing motorist



motorist passing cyclist

Latter portion of green indication

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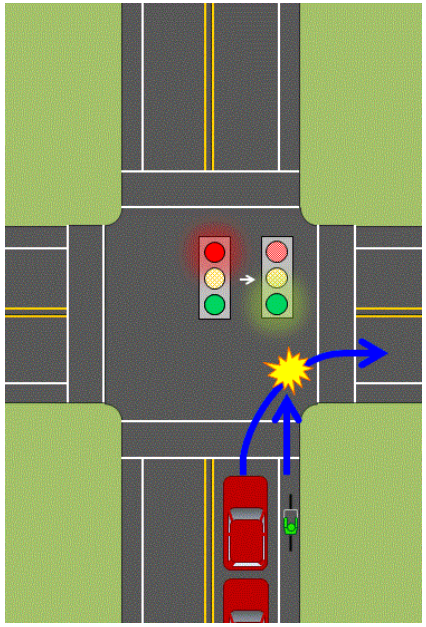
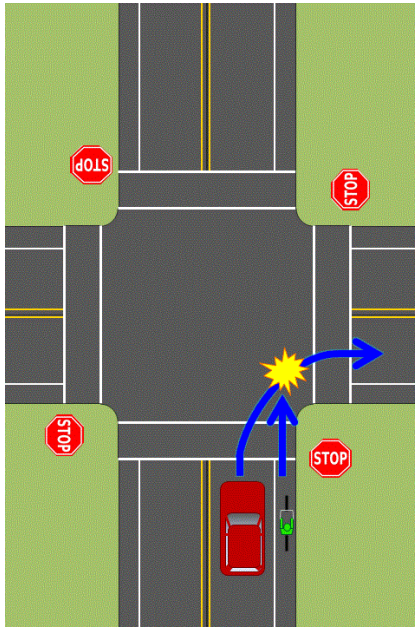
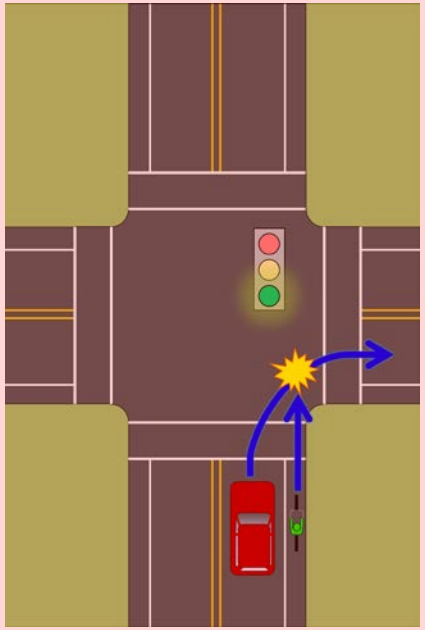
Right-Hook Crash Scenarios (Intersection with bike lane)



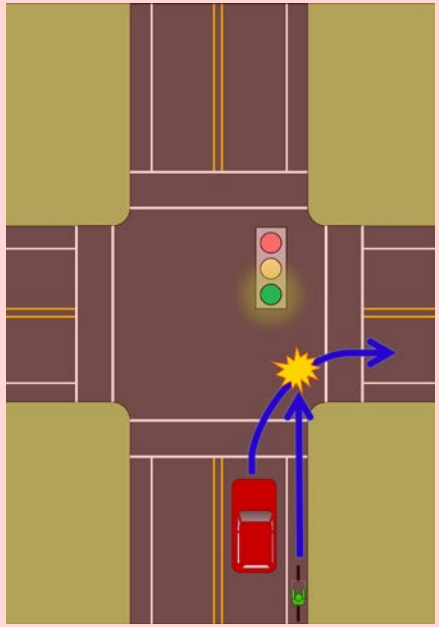
onset of the green indication



at a stop sign



cyclist passing motorist



motorist passing cyclist

Latter portion of green indication

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Methodology

Simulator Experiment 1

- Experimentally verify the influence of four factors that potentially contribute to right-hook crashes.

Field Validation

- Validate through field observations the motorist-bicyclist interaction exhibited in Simulator Experiment 1.

Simulator Experiment 2

- Evaluate the effectiveness of four categories of treatments to mitigate right-hook crashes.

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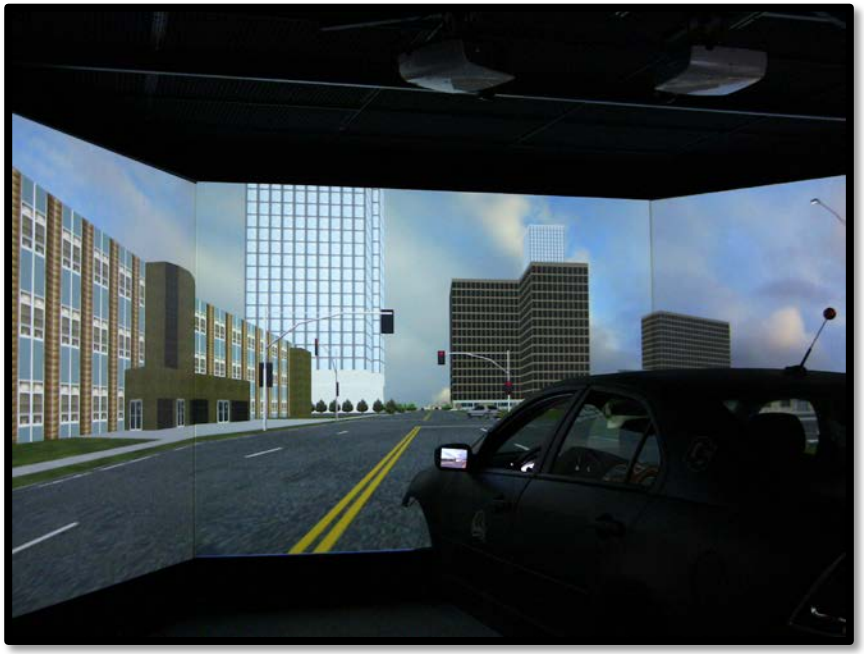
OSU Driving Simulator



View from outside the car

View from inside car w/bicycle

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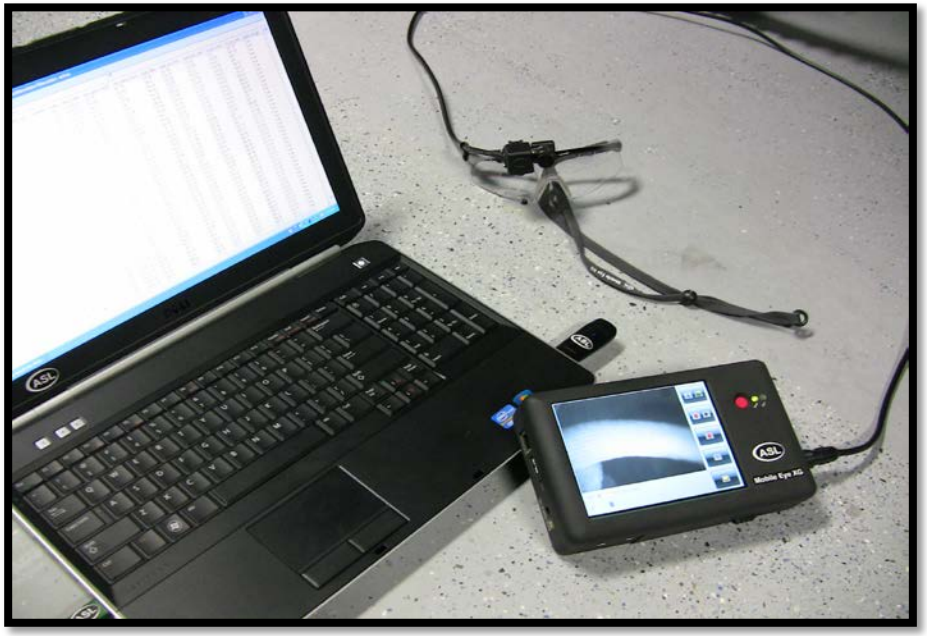
ASL Mobile Eye-Tracker

Scene & Eye Camera



Computer & Control Unit

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Simulator Experiment 1

Purpose:

- Examine motorist behavior in response to four factors that potentially contribute to right-hook crashes.

Research Objectives:

- Determine how motorists':
  - **visual attention**
  - **situational awareness**
  - **crash avoidance**
- is influenced by the experimental factors.

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Experiment 1 – Independent Variables

Name of the Variable	Levels
Relative position of bicyclist	None
	One (1) bicyclist riding in front of the motorist in an adjacent bicycle lane to the right
	One (1) bicyclist coming from behind the motorist in an adjacent bicycle lane to the right
Speed of bicyclist	Lower (12 mph)
	Higher (16 mph)
Presence of oncoming vehicular traffic	None
	Three (3) vehicles
Presence of conflicting pedestrian	None
	One (1) pedestrian walking towards the motorist

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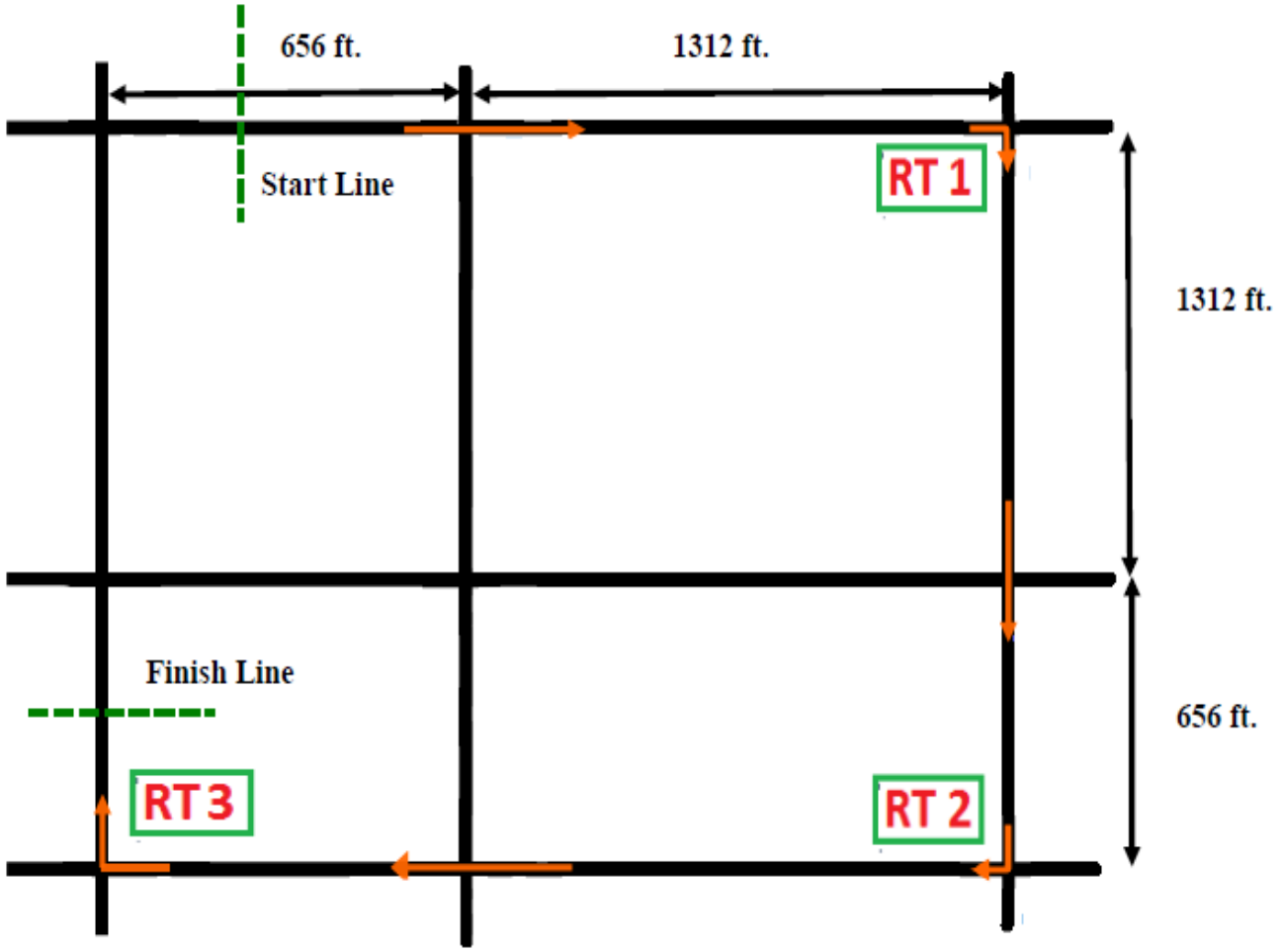
Experiment I – Experimental Drives



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Experiment 1 – Data Acquisition

Participants:

- 67 Participated
- 16 Simulator Sickness
- 51 Usable
- 1,071 total-right turn scenarios

Data:

- Visual attention
- SAGAT responses
- Observed crashes
- Position and speed of vehicles, bicycles, and pedestrians

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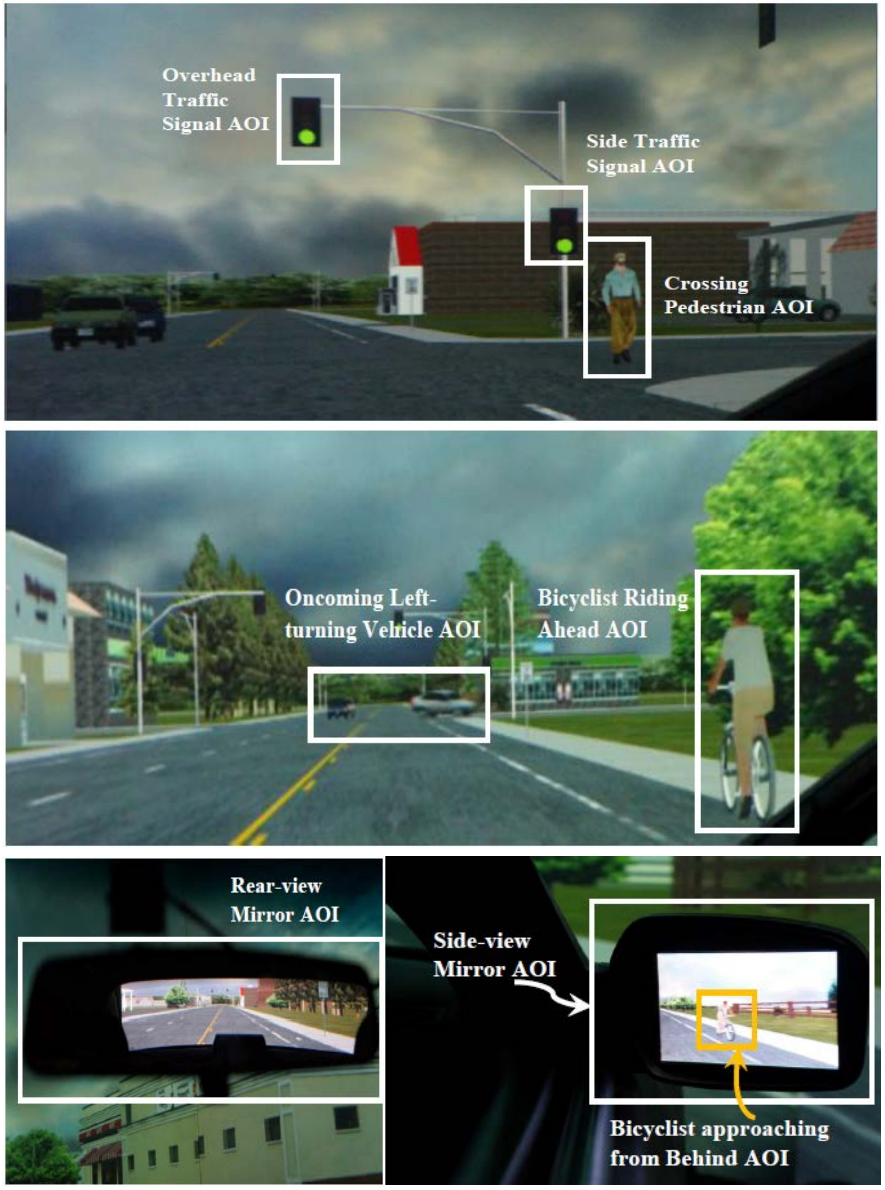
Visual Attention – Areas of Interest (AOIs)



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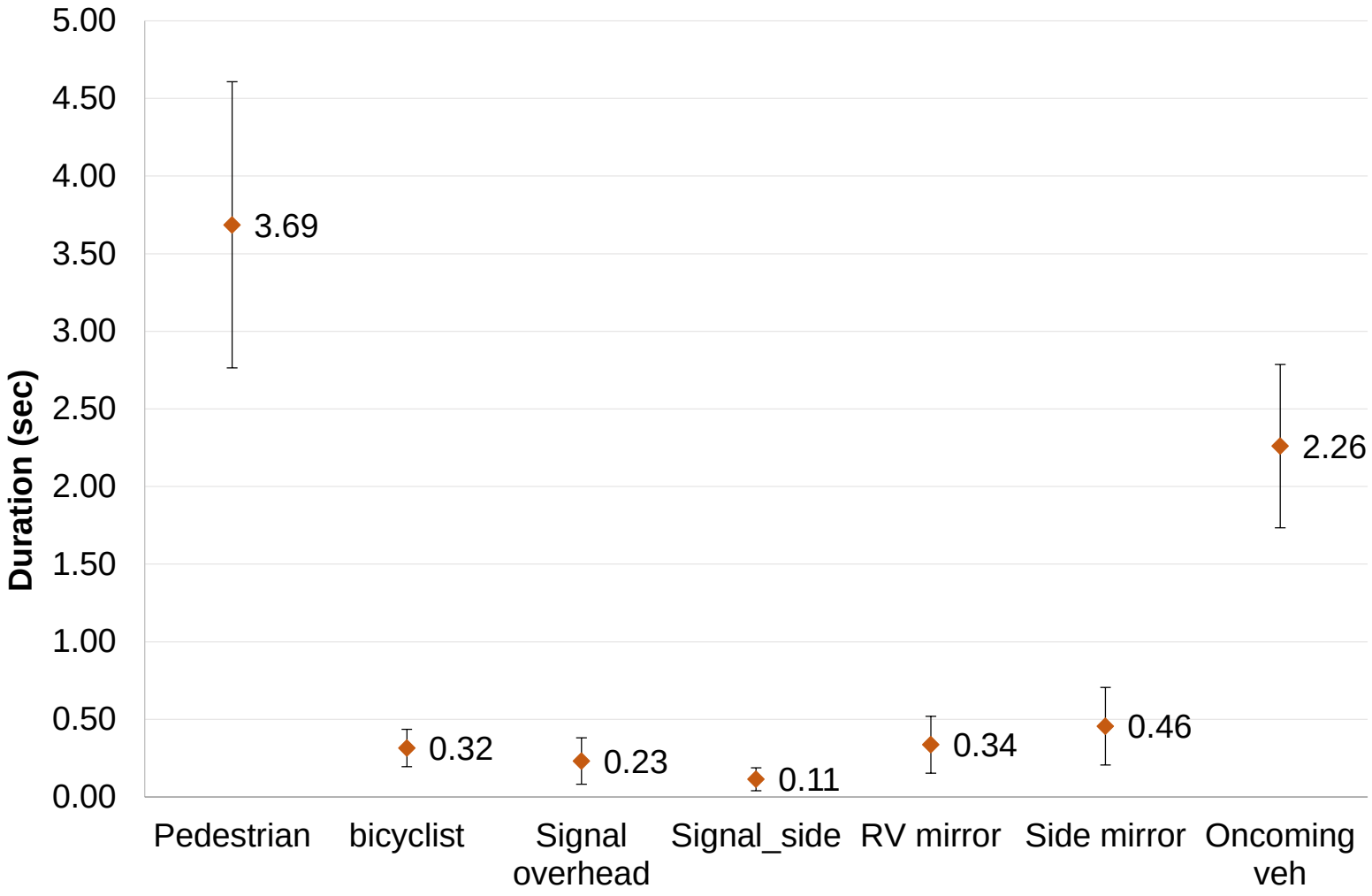
Visual Attention – Avg Total Fixation Durations (ATFD)



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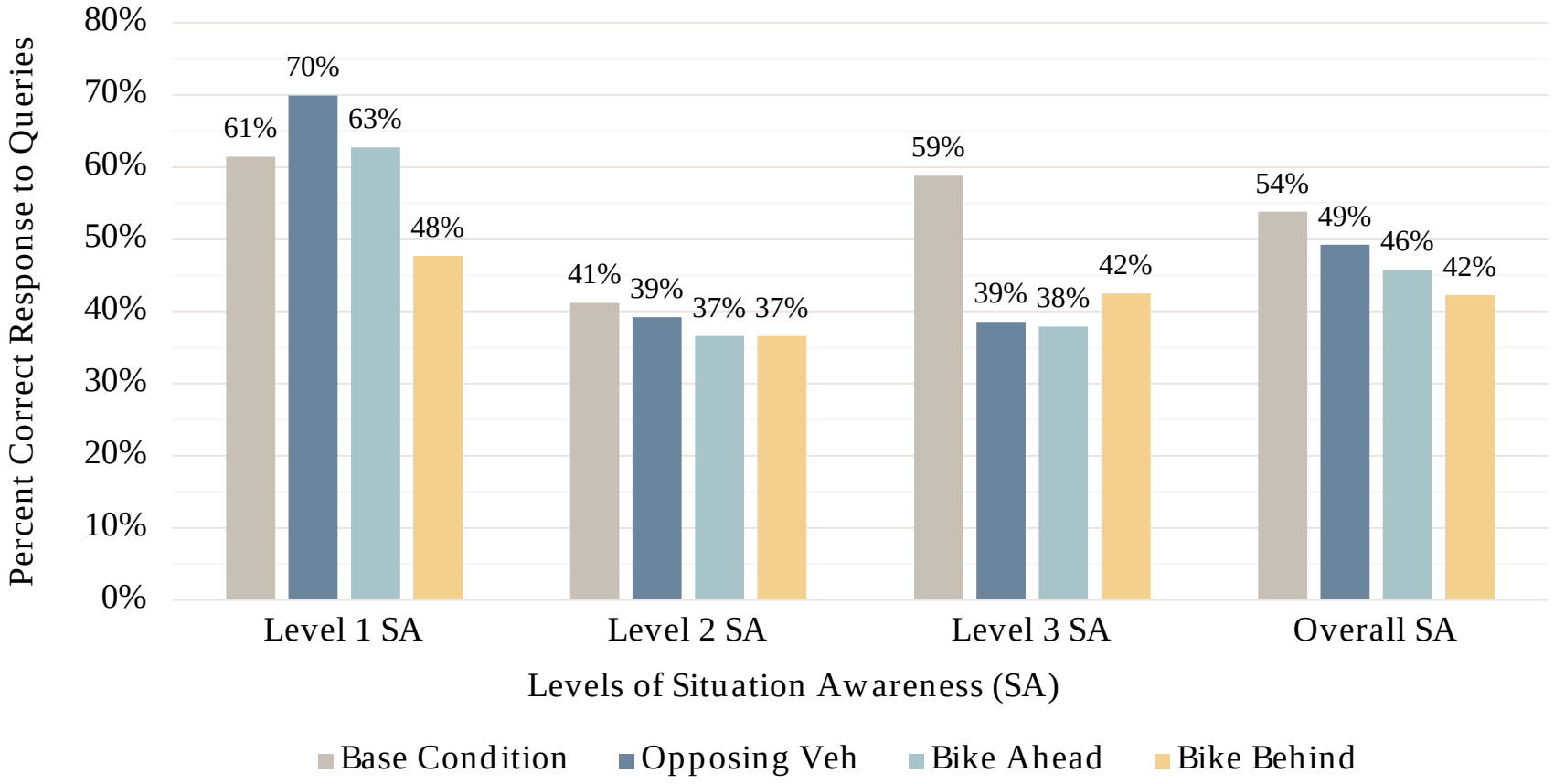
Mean percentage of correct responses to situation awareness (SA) queries for different intersection conditions



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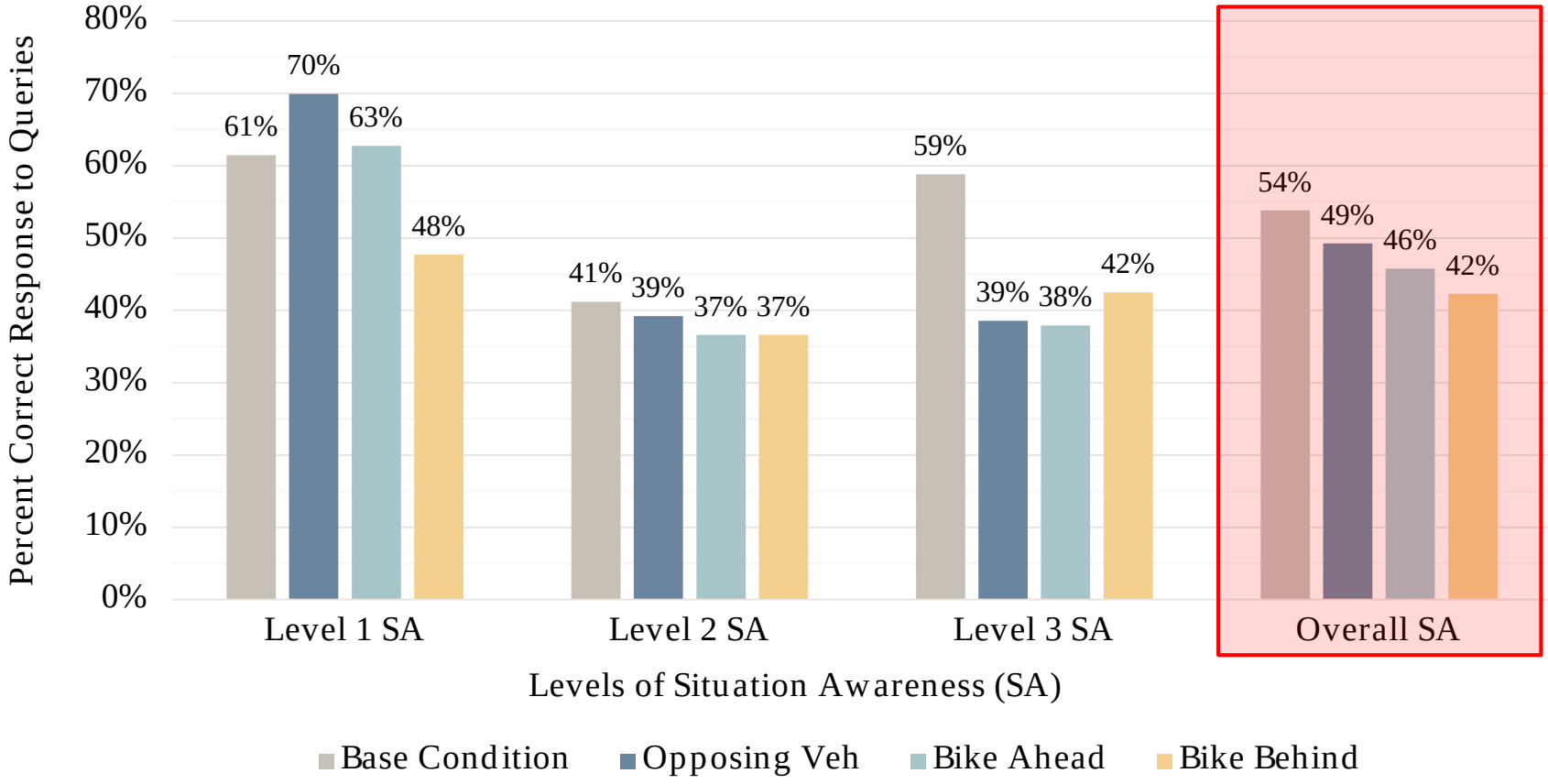
Mean percentage of correct responses to situation awareness (SA) queries for different intersection conditions



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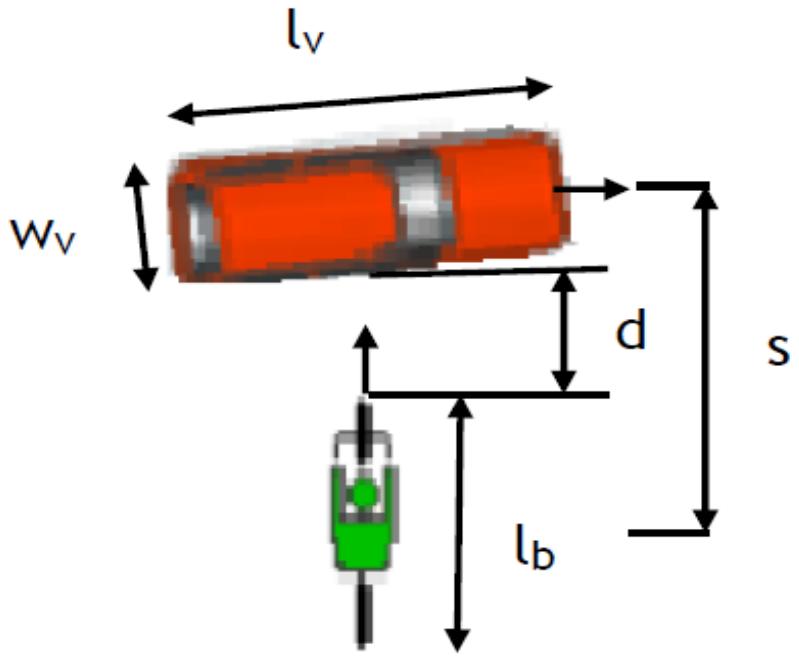
Crash Avoidance: Time-to-Collision (TTC)



- Simulator:
  - Time-to-collision is a continuous value that changes in time
  - Bikes in simulator do not change speed.
- Field
  - Post-encroachment time (PET) is a discrete time measurement

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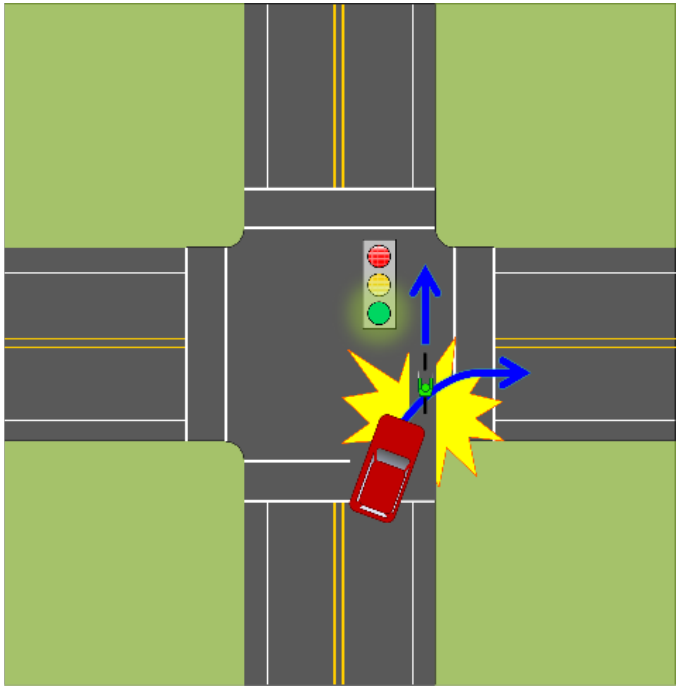
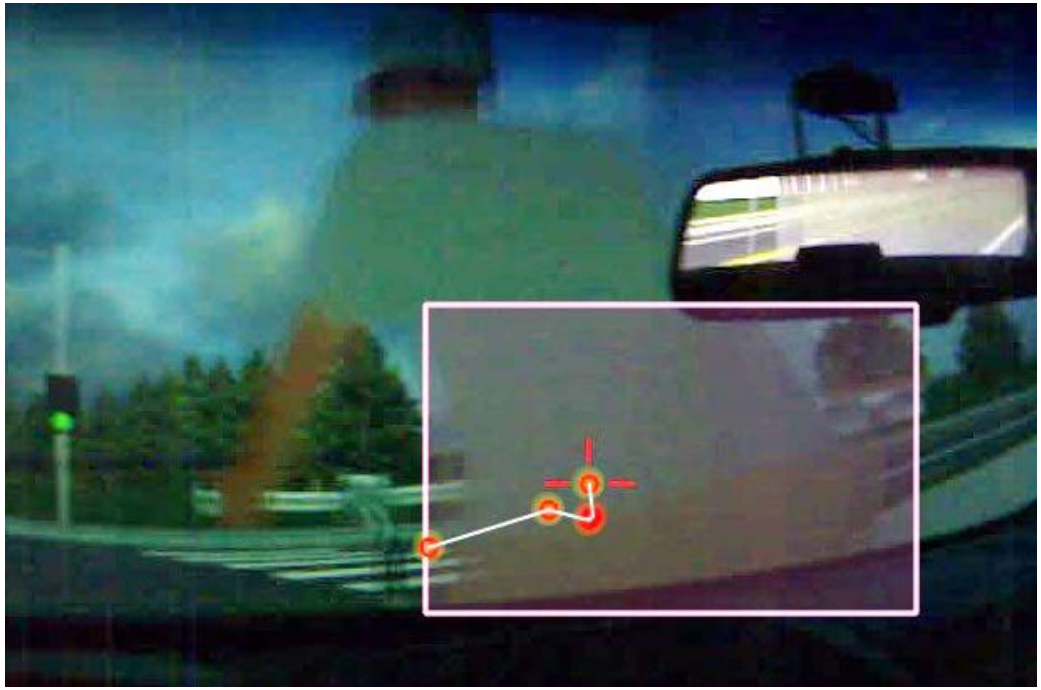
Crash Avoidance: Crashes





From 1,071 right turns, 26 collisions observed:

- 66% did not check mirror before turning
- 5% looked but didn't see
- 18% assumed the bike would yield or there was enough time

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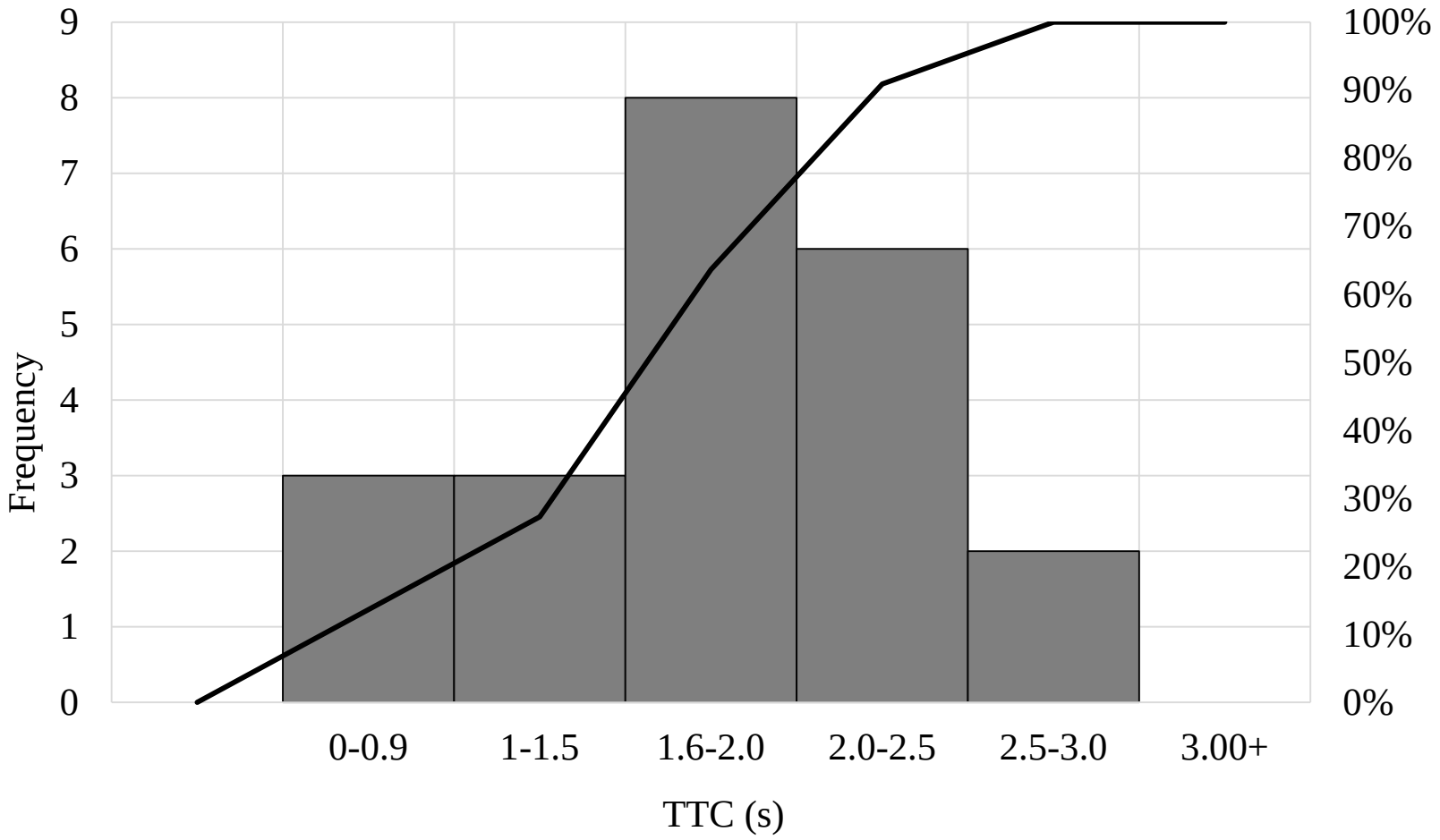
Crash Avoidance: Time To Collision (TTC)

Scenario: Bicyclist (16 mph) behind, three oncoming vehs, and no ped



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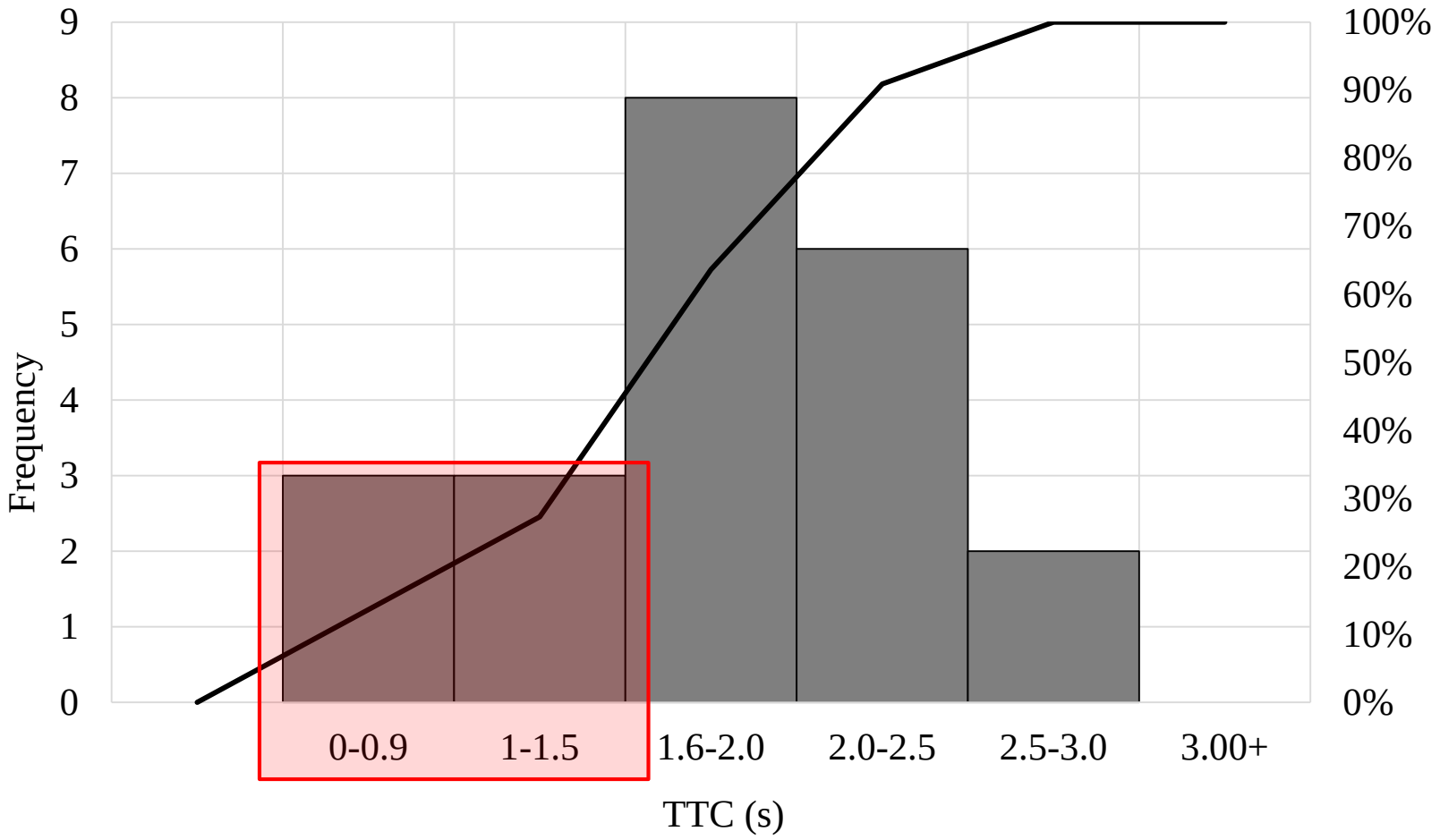
Crash Avoidance: Time To Collision (TTC)

Scenario: Bicyclist (16 mph) behind, three oncoming vehs, and no ped



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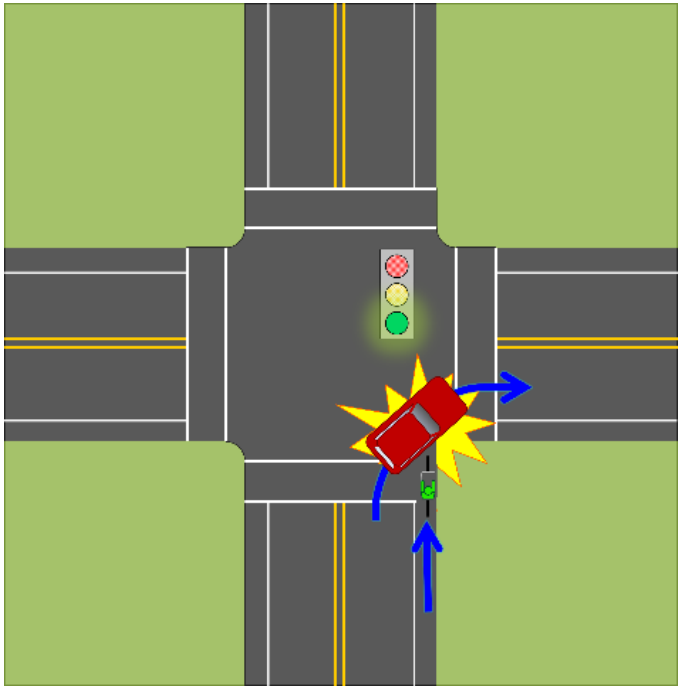
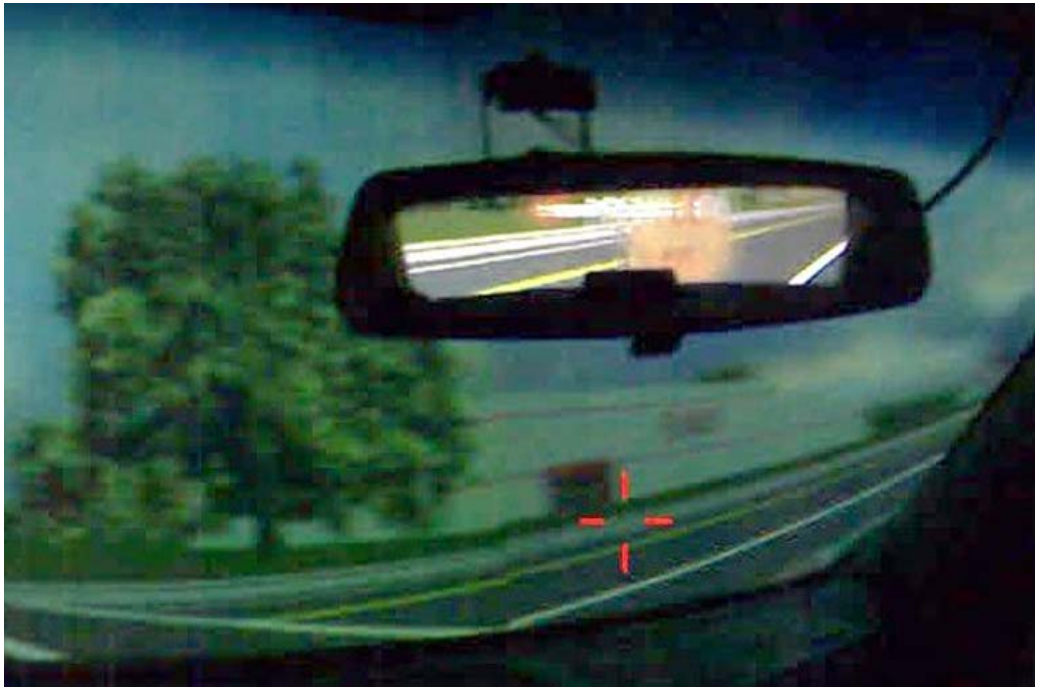
Crash Avoidance: Near-Crashes





From 408 right turns, 28 near-collisions observed:

- 58% did not check mirror before turning
- 23% looked but didn't see
- 19% assumed bike would yield or there was enough time

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Field Validation

- November 5, 2014 to February 12, 2015
- All days of week
- 144 hours

- Extraction of 43 events with measured PET < 5 seconds

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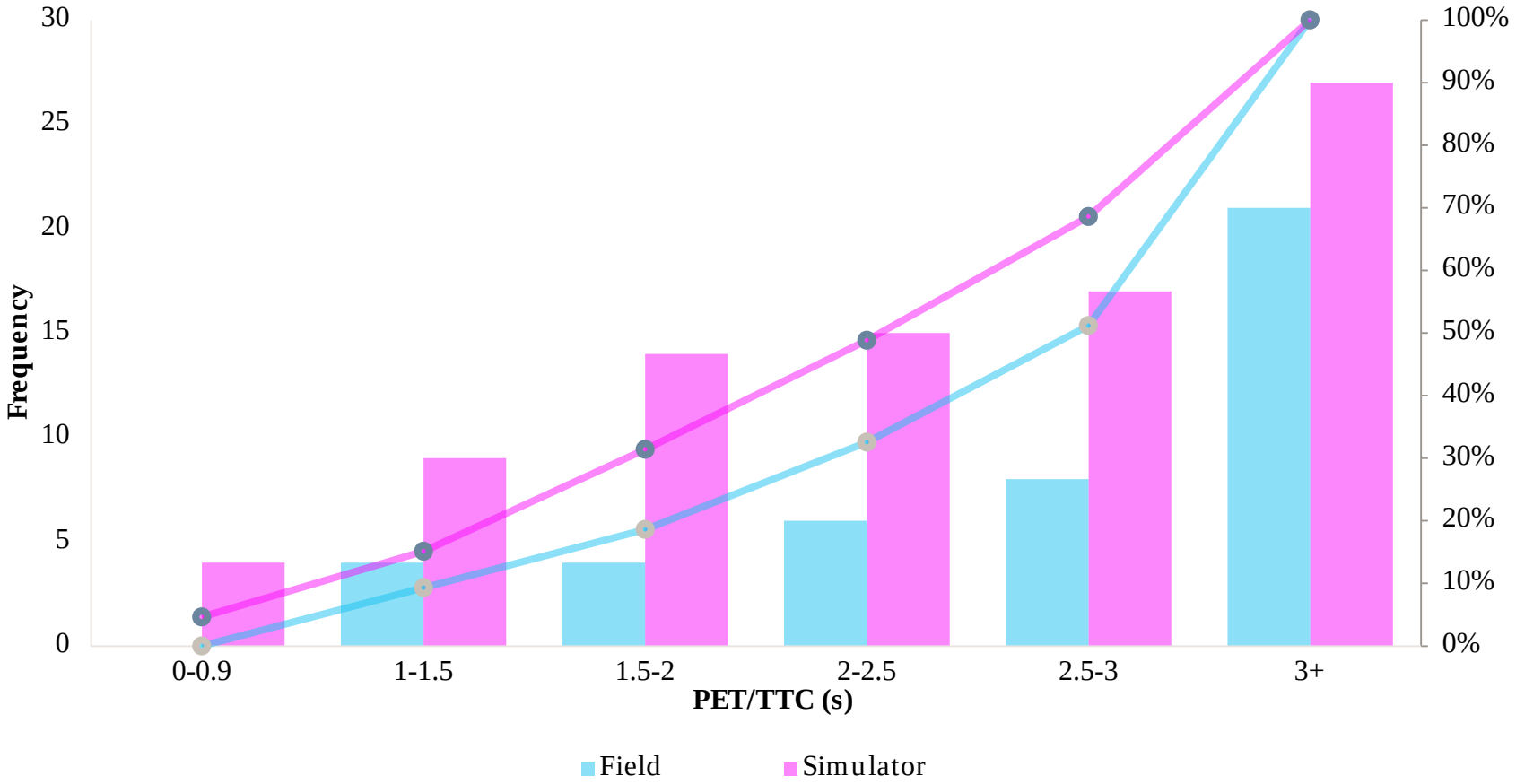
Comparison of All Field and Simulator PET/TTCs



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Simulator Experiment 2

Purpose:

- Examine motorist behavior in response to four different categories of right-hook crash treatments

Research Objectives:

- **Identify engineering countermeasures** that will reduce *frequency* and *severity* of RH crashes
- **Evaluate and compare** these countermeasures
- **Provide guidance to ODOT** regarding the selection of design countermeasures

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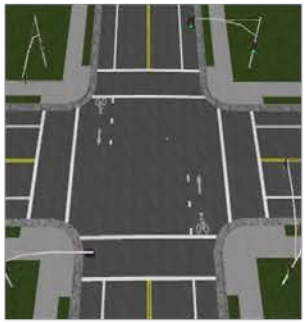
Experiment 2- Independent Variables

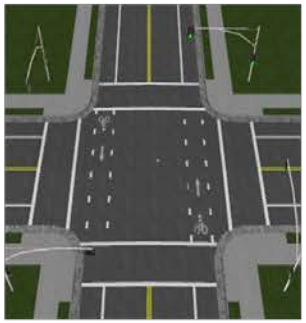
SIGNAGE

ODOT OR10-15b
"Turning Vehicles Yield to Bicycles"

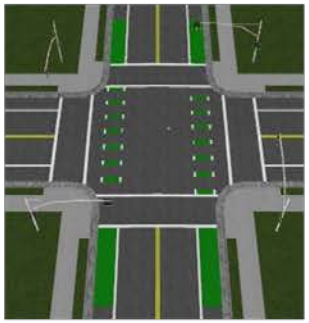
PAVEMENT MARKINGS



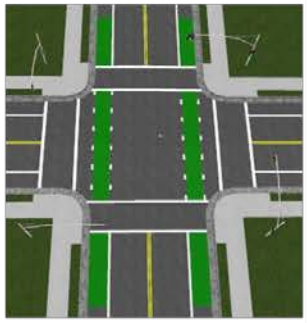
Dashed white bike line with stencil, single line



Dashed white bike line with stencil, double line



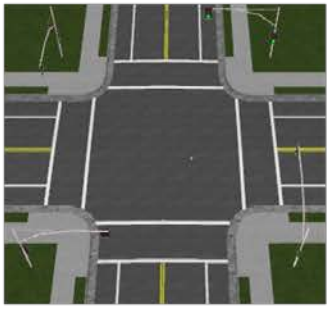
Dashed green bike lanes with white outline



Full green bike lane with dashed white outline

CURB RADII

Larger curb radii, 30ft



Smaller curb radii, 10ft

PROTECTED INTERSECTIONS

With islands

With islands and green pavement markings

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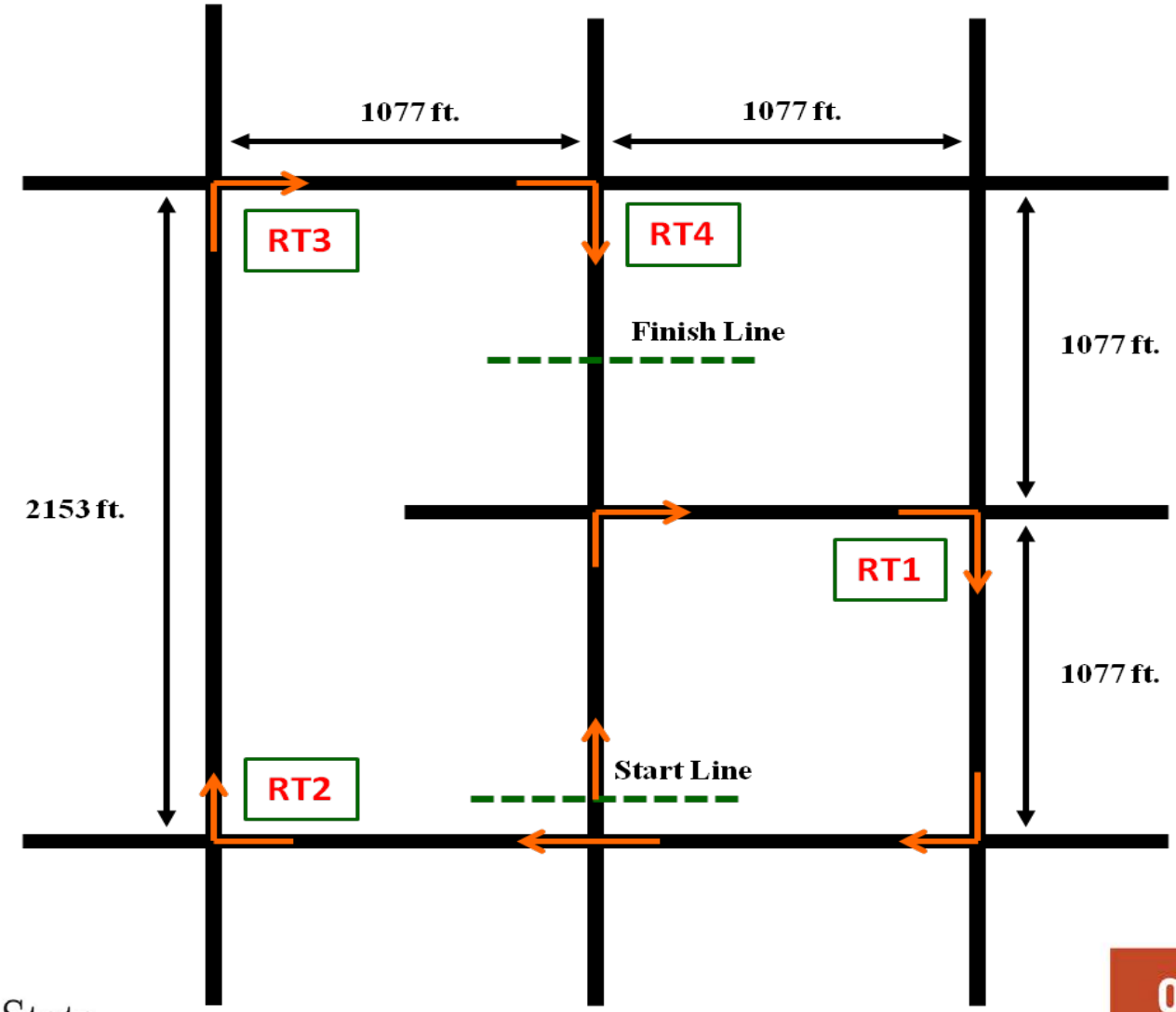
Experiment 2- Experimental Drives



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Experiment 2- Data Acquisition

Participants:

- 46 Participated
- 18 Simulator Sickness
- 28 Usable
- 616 total-right turn scenarios

Data:

- Observed crashes
- Visual attention
- Position and speed of vehicles, bicycles, and pedestrians

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Experiment 2- Visual Attention… ATFD

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Experiment 2- Visual Attention… ATFD

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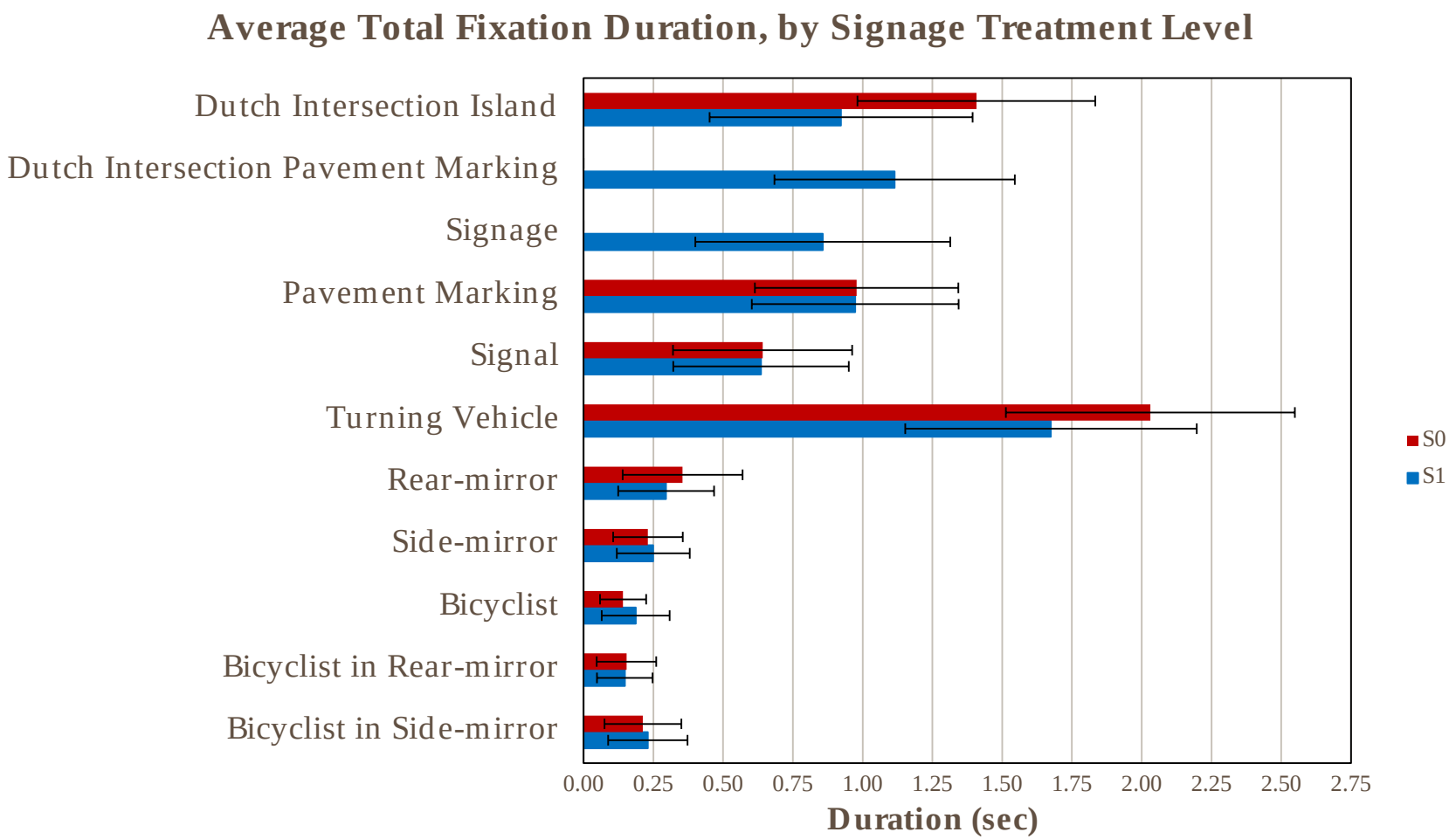
Experiment 2- Visual Attention… ATFD



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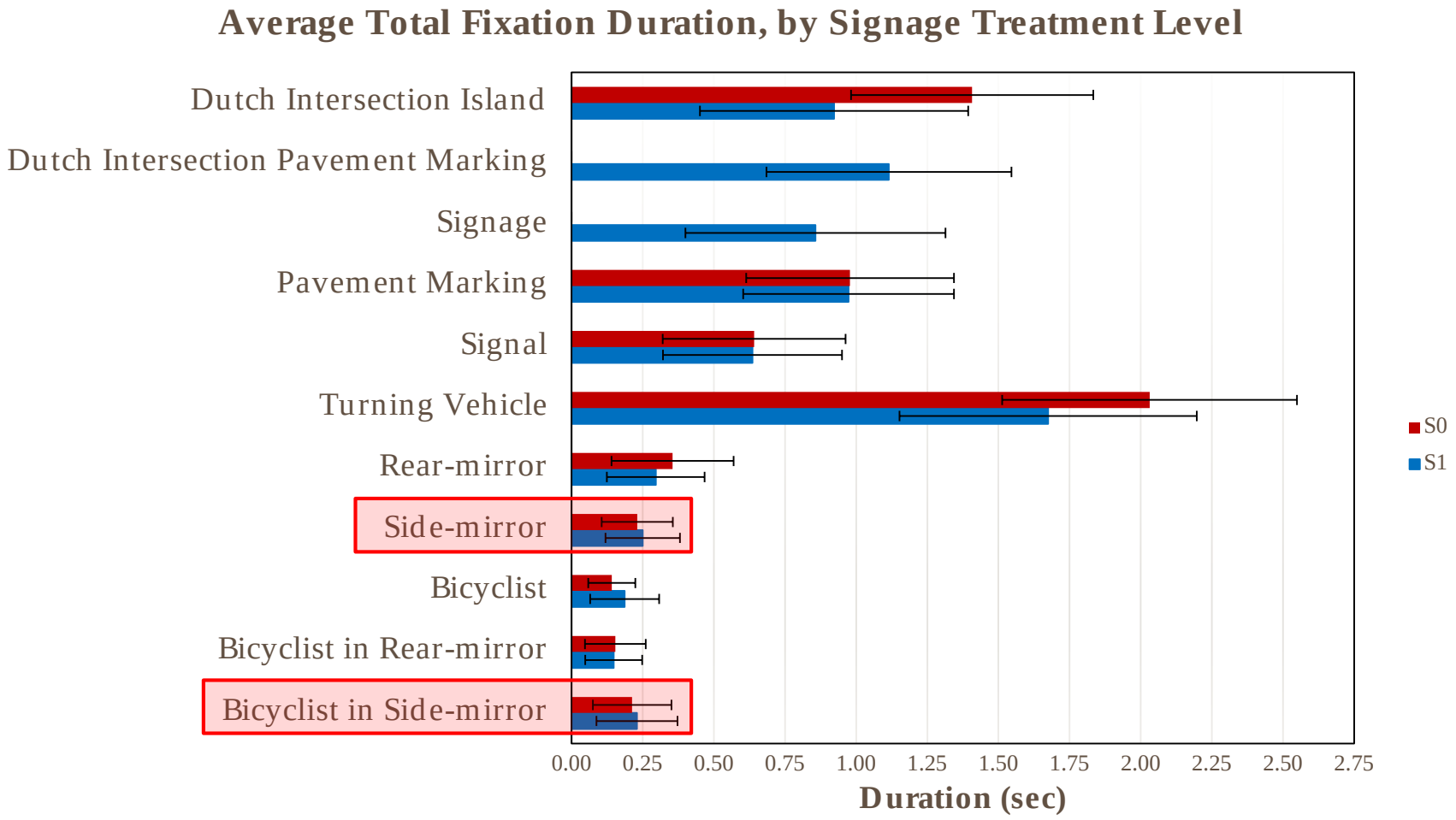
Experiment 2- Visual Attention… ATFD



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Experiment 2- Visual Attention… Motorist Fixation on Bicyclist

Frequency of fixation	Signage	
	S0	S1
Total (n)	296	300
Fixated	228	242
%	77%	81%

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Experiment 2- Crash Avoidance

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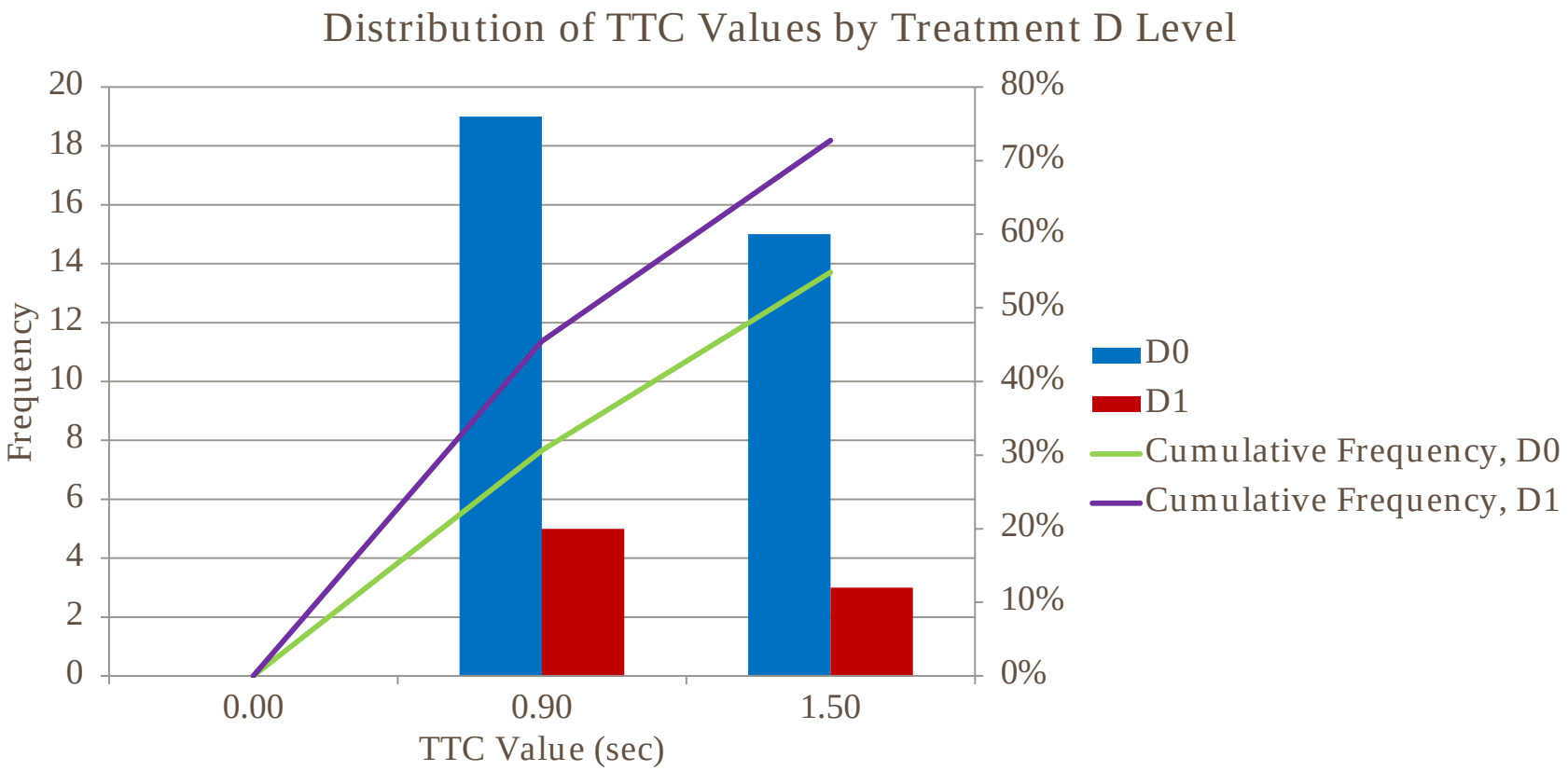
Experiment 2- Crash Avoidance



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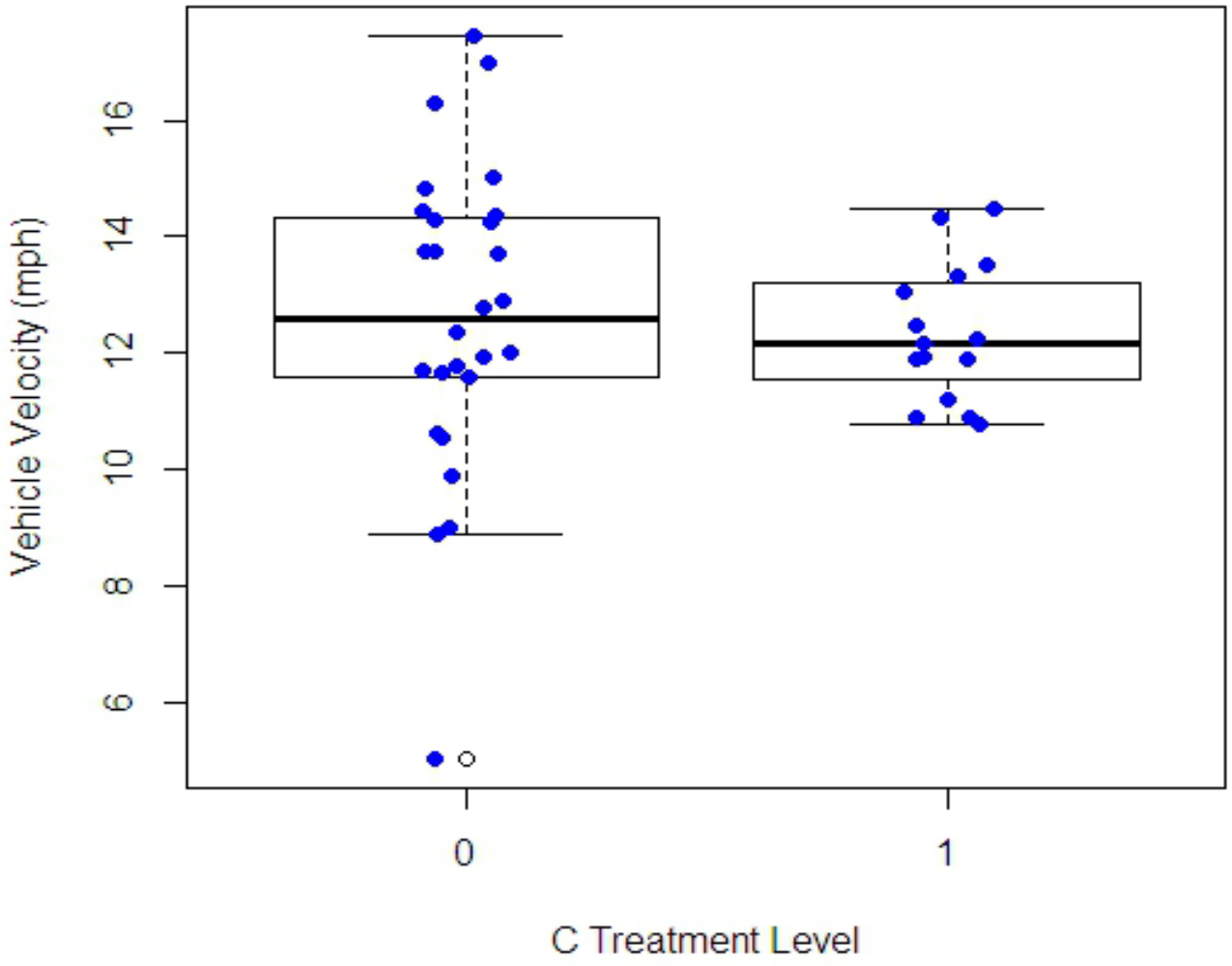
Experiment 2- Crash Severity



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Final Comparison

- Each treatment was evaluated based on the following:

- Visual attention
  - Measurable change in longer AFTD towards bicycle targets
- Crash avoidance
  - Frequency of low and moderate TTC observations
- Crash severity
  - Speed of turning vehicles and variance of speed

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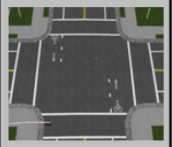
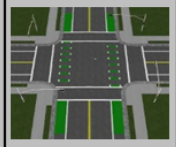
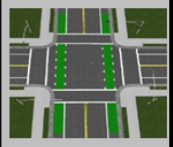
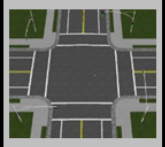
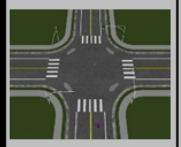
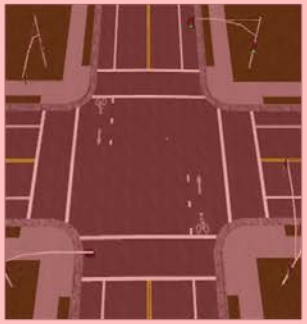
Performance Measures	S1	PM1	PM2	PM3	PM4	C1	PI1	PI2
								
Visual Attention	✓	–	✓	–	✗	–	✗	–
Crash Avoidance	–	✓	–	✓	✓	✓	–	–
Potential Crash Severity	–	–	✗	✗	✓	✓	✓	–
Survey	n/a		✓ *			n/a	✗ **	✓ **

Recommendations

SIGNAGE

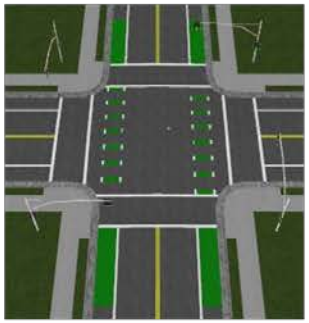
ODOT OR10-15b
"Turning Vehicles Yield to Bicycles"

PAVEMENT MARKINGS

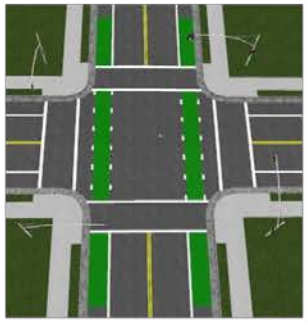


Dashed white bike line with stencil, single line

Dashed white bike line with stencil, double line

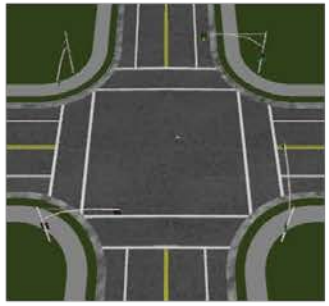


Dashed green bike lanes with white outline

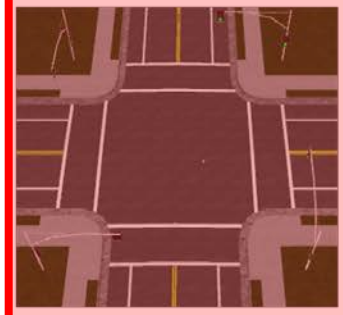


Full green bike lane with dashed white outline

CURB RADII



Larger curb radii, 30ft



Smaller curb radii, 10ft

PROTECTED INTERSECTIONS

With islands

With islands and green pavement markings

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Acknowledgements

PhD Student:

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- Katie Mannion, BSCE anticipated spring 2016, OSU
- Amber Meeks, BSCE anticipated spring 2018, OSU

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