11-8-2013

Why Doesn't That Traffic Signal Ever Turn Green? An Evaluation of Roadway Markings for Cyclists

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Why Doesn't That Traffic Signal Ever Turn Green?

An evaluation of roadway markings for cyclists

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Portland State University Transportation Seminar
November 8, 2013

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Presentation Overview

- The Basics of Vehicle Detection
- Issues Related to Detection and Bicycles
- History of the Stencil and Sign
- Research Question
- Existing Research
- Study Design
- Results

Where would you wait if driving a car? How about if riding a bike?

Image source: google street view

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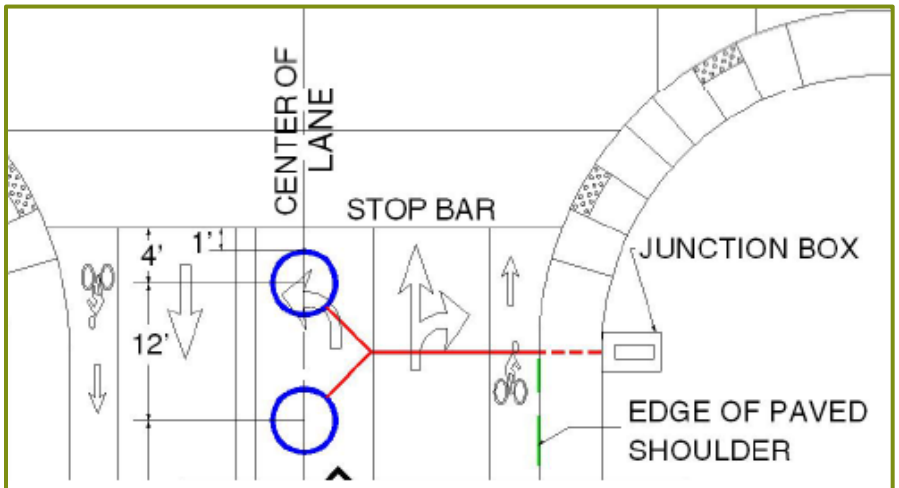
How Signalized Intersections with Detection Work

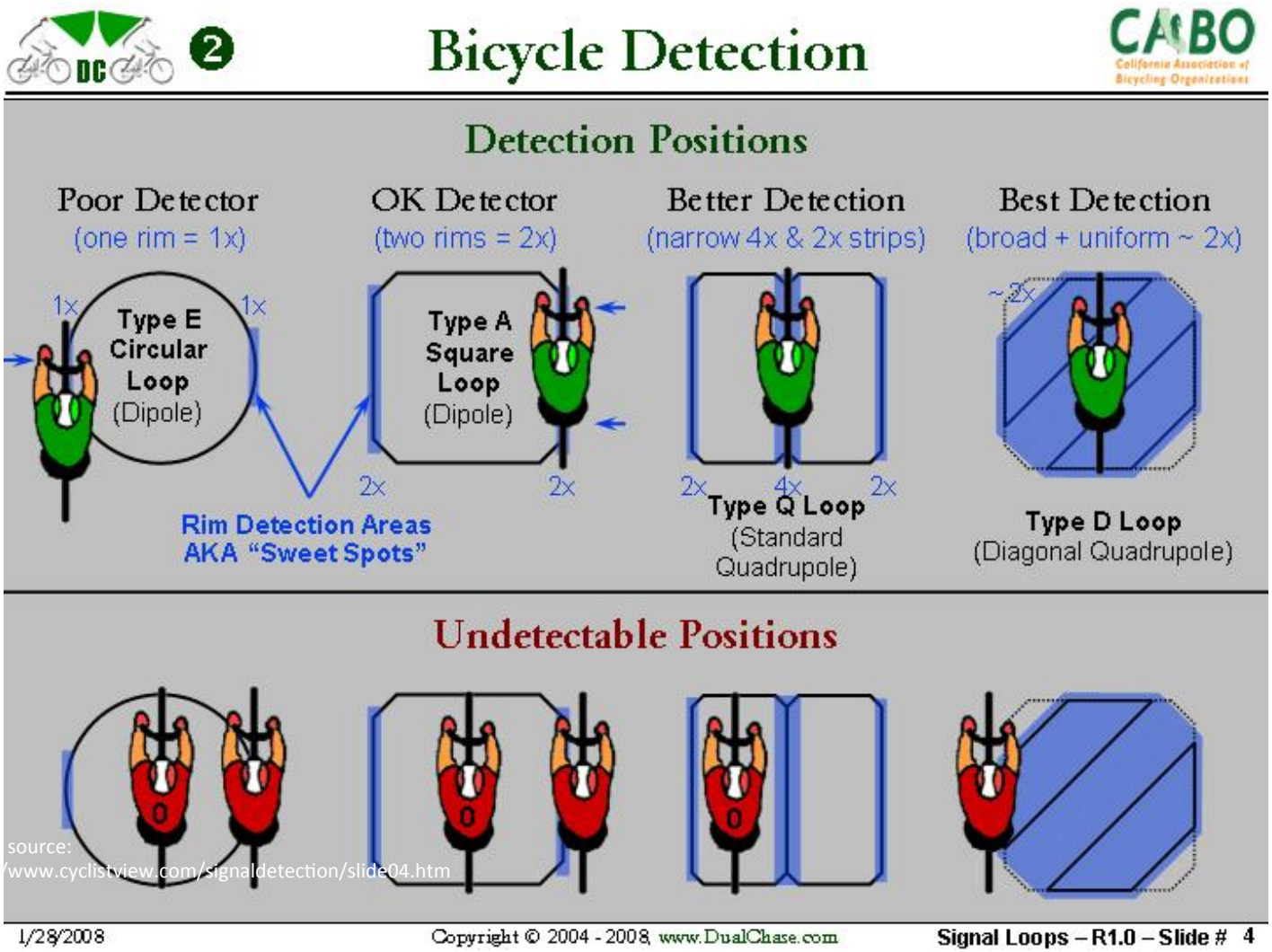


(a) Schematic design of loop detector design

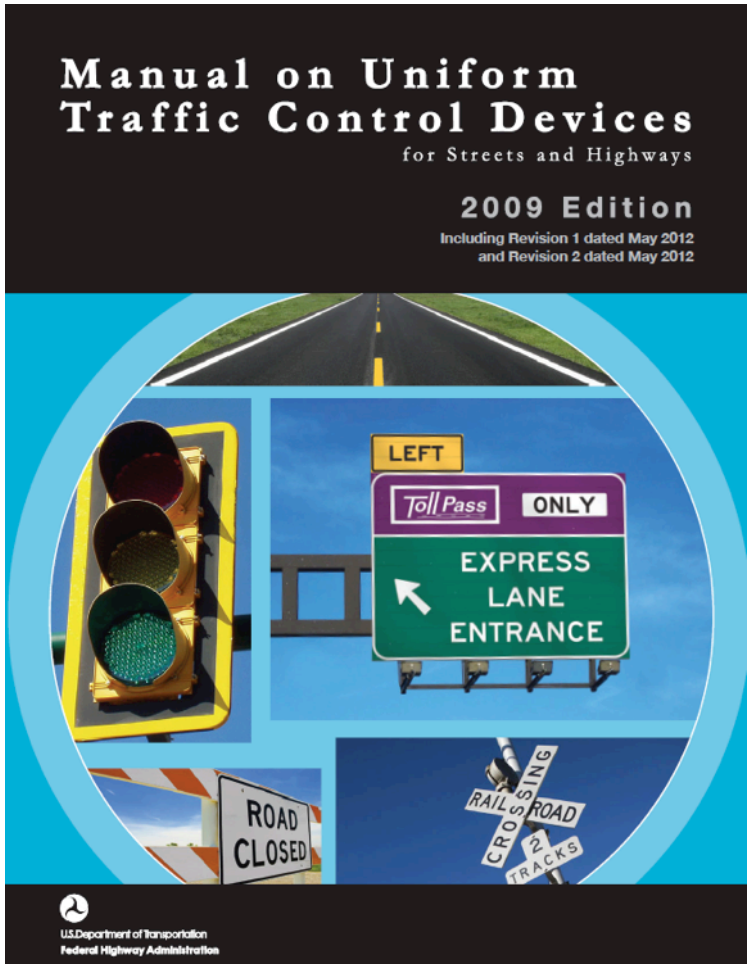
Source:

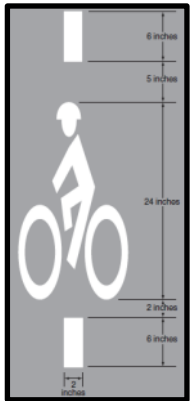
(b) Physical representation of loop detectors

Inductive Loop Detectors and Bicycles



Current Marking and Sign for Loop Detectors





9C-05 Bicycle Detector Symbol

R10-22 Sign

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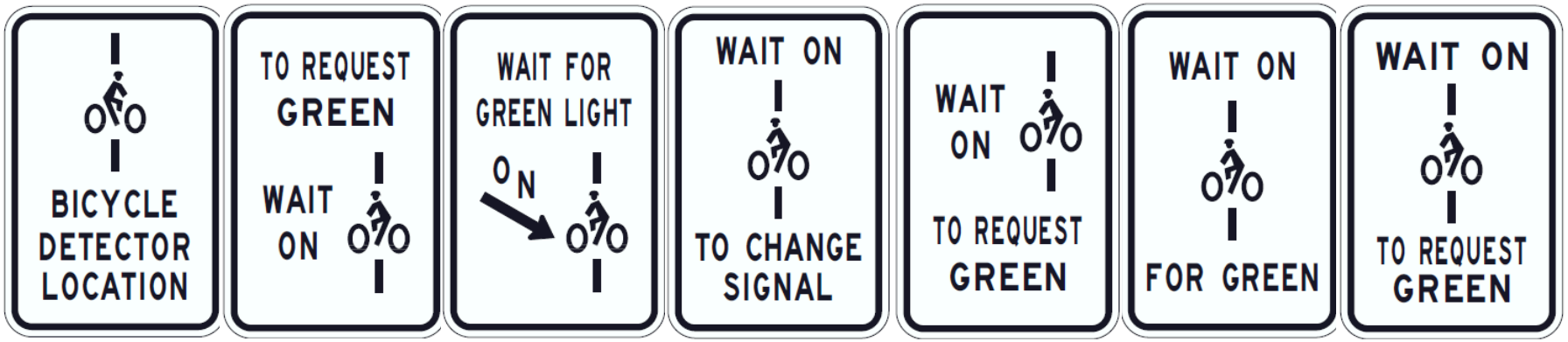
History of Sign and Stencil

Sources: Richard Moeur and Ron Van Houten

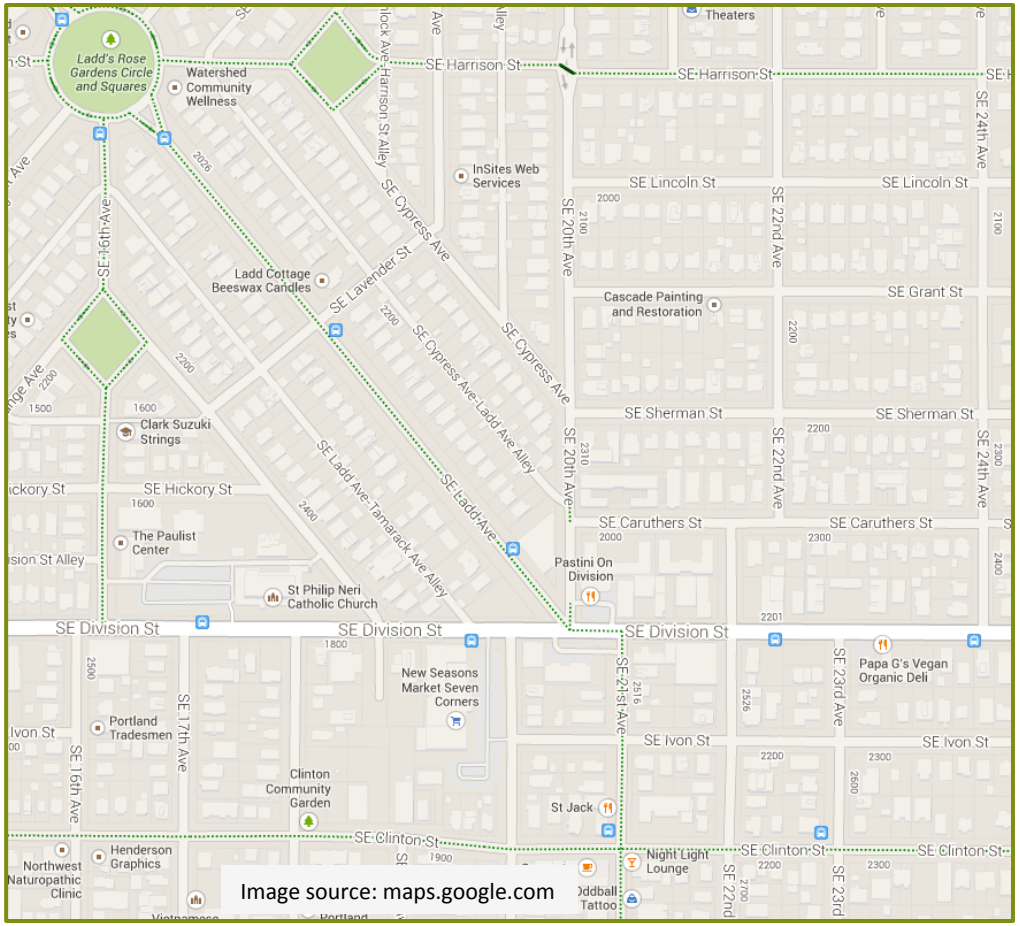
Human Factors Research for R10-22 Sign



- No research found on roadway marking
- Both first recommended for use in the 1999 AASHTO's guide for roadway design
- Adopted into the 2003 edition of the MUTCD
- No formal experimentation was required

Research Question:

Are the existing marking techniques specified in the MUTCD effective and is there a more effective alternative?



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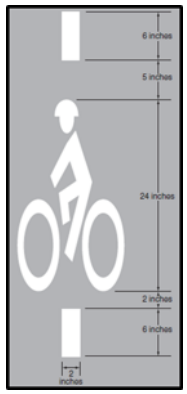
Existing Research

Boot, Walter, Neil Charness, Cary Stothart, Mark Fox, Ainsley Mitchum, Heather Lupton and Rebekah Landbeck. *Final Report: Aging Road User, Bicyclist, and Pedestrian Safety: Effective Bicycle Signs and Preventing Left-Turn Crashes BDK83 977-15.* Prepared for the Florida Department of Transportation, September 2012

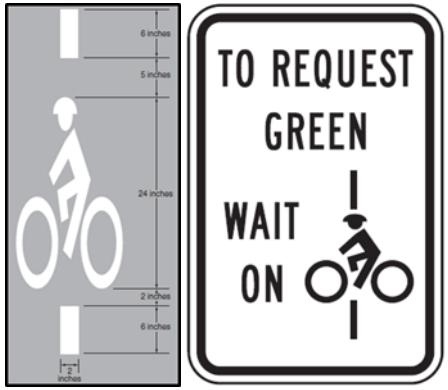
- No correct responses on the meaning of the bicycle detector symbol
- 68 participants
  - 20 cyclists (Identified as a cyclist if reported riding more than 5 miles per week)
  - 48 non-cyclists

Study Design

- In-Person and On-line Survey of Cyclists
- Observational Data Recorded by Cameras Before and After Markings Applied
- Three Test Cases



Case 1: Stencil Only



Case 2: Stencil and Sign

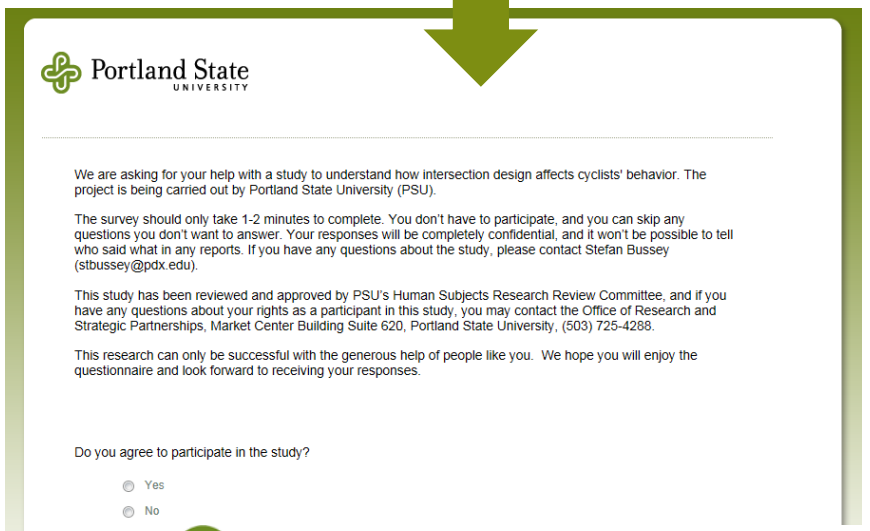
Case 3: “Green Backed” Stencil

Survey – Data Collection

- 227 Complete Responses
  - 81 in person, 94.2% response rate
    - 13.6% did not meet requirements to participate
  - 146 on-line, 16.1% response rate
- Distribution
  - High-density bike parking (on-line)
  - Portland Timbers games (on-line)
  - Providence Bridge Pedal (on-line)
  - Sunday Parkways (in person and on-line)
  - Portland's Downtown Farmers' Market (in person)
- An average of 4 minutes to complete

In Person

On-line



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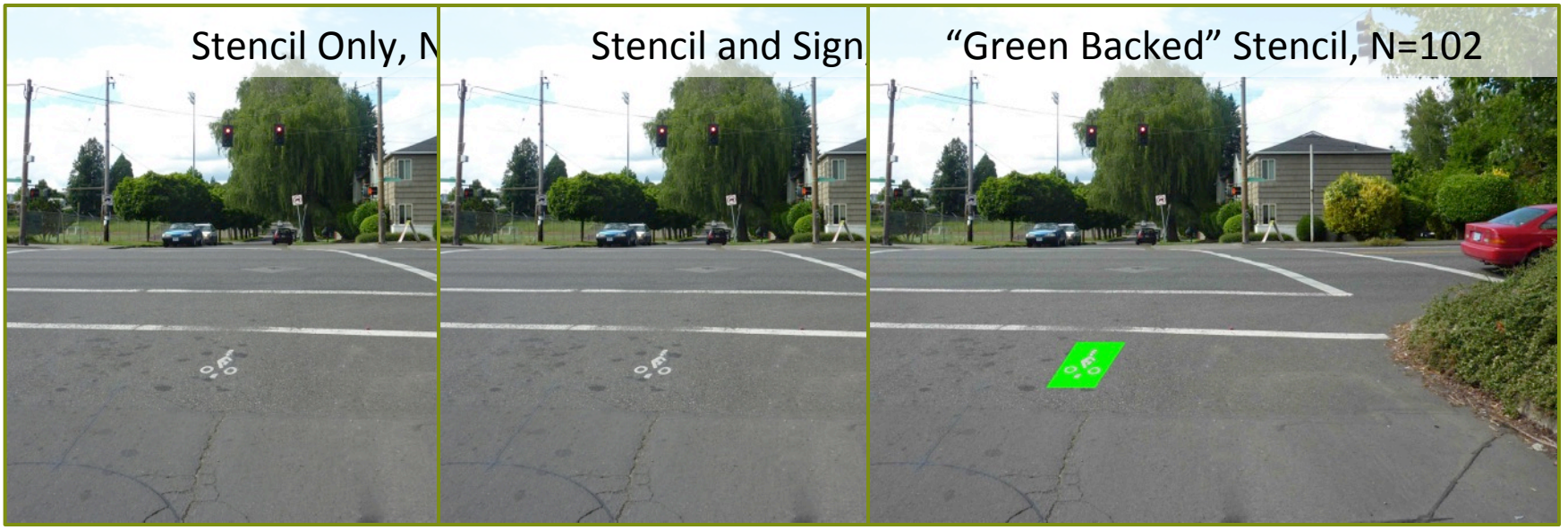
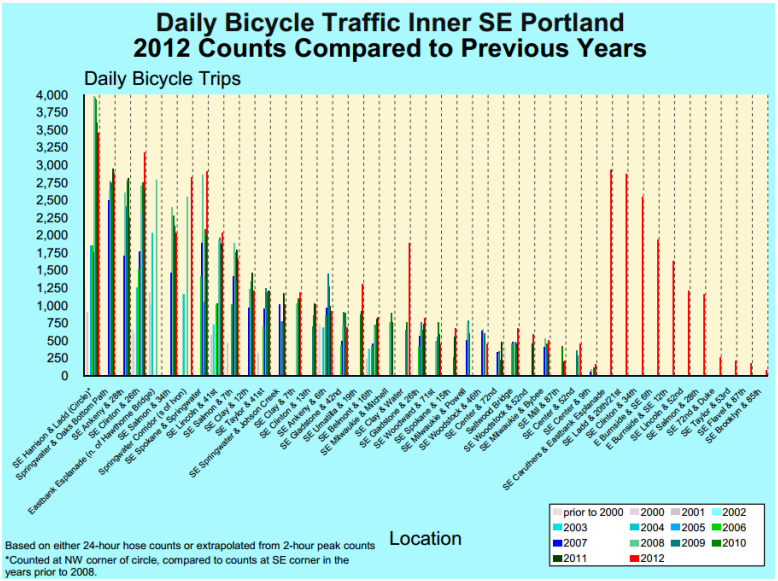
Survey – Questions



- Demographic Information
- Stopping Position at Signalized Intersections (Randomly selected marking variation)
- Reason for Choosing Stopping Position
- Interpretation of Detector Symbol
- Interpretation of Blue Indicator Light (Research in Progress)

Video – Data Collection

- 302 hours of video recorded and reviewed
- 955 observations logged
  - 688 used in analysis
- Only questioned once by the police



- Site Selection
  - No existing marking or signage
  - Visible loops
  - Semi actuated signal operation
  - Similar geometry and lane configurations
  - Popular bike route
- Collection Period
  - Sunday – Tuesday
  - 5:00 AM – 11:00 PM

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Video – Data Collection


Dekum and MLK

Ainsworth and MLK

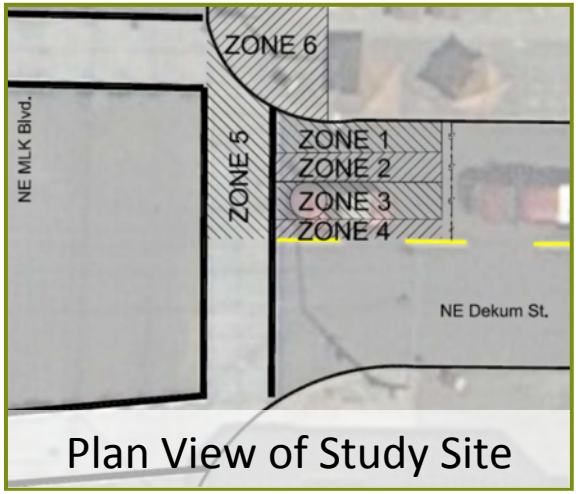

33rd and Grant

Variable	NE Dekum St. and NE MLK Blvd.- WB Approach	NE Ainsworth and NE MLK Blvd. - EB Approach	NE U.S. Grant Place and NE 33rd Ave, WB Approach
Lane Width (ft)	20	14	20
Number of Travel Lanes	1	1	1
Movements Allowed	Thru, Left, Right	Thru, Left, Right	Thru, Left Right
Loop Type	6' Diameter Circle	6' Diameter Circle	6' Diameter Circle
Distance from Curb to Edge of Loop (ft)	10	4	10

Video – Data Collection

Establishing Zones for Analysis

Example of Analysis in Progress



Plan View of Study Site

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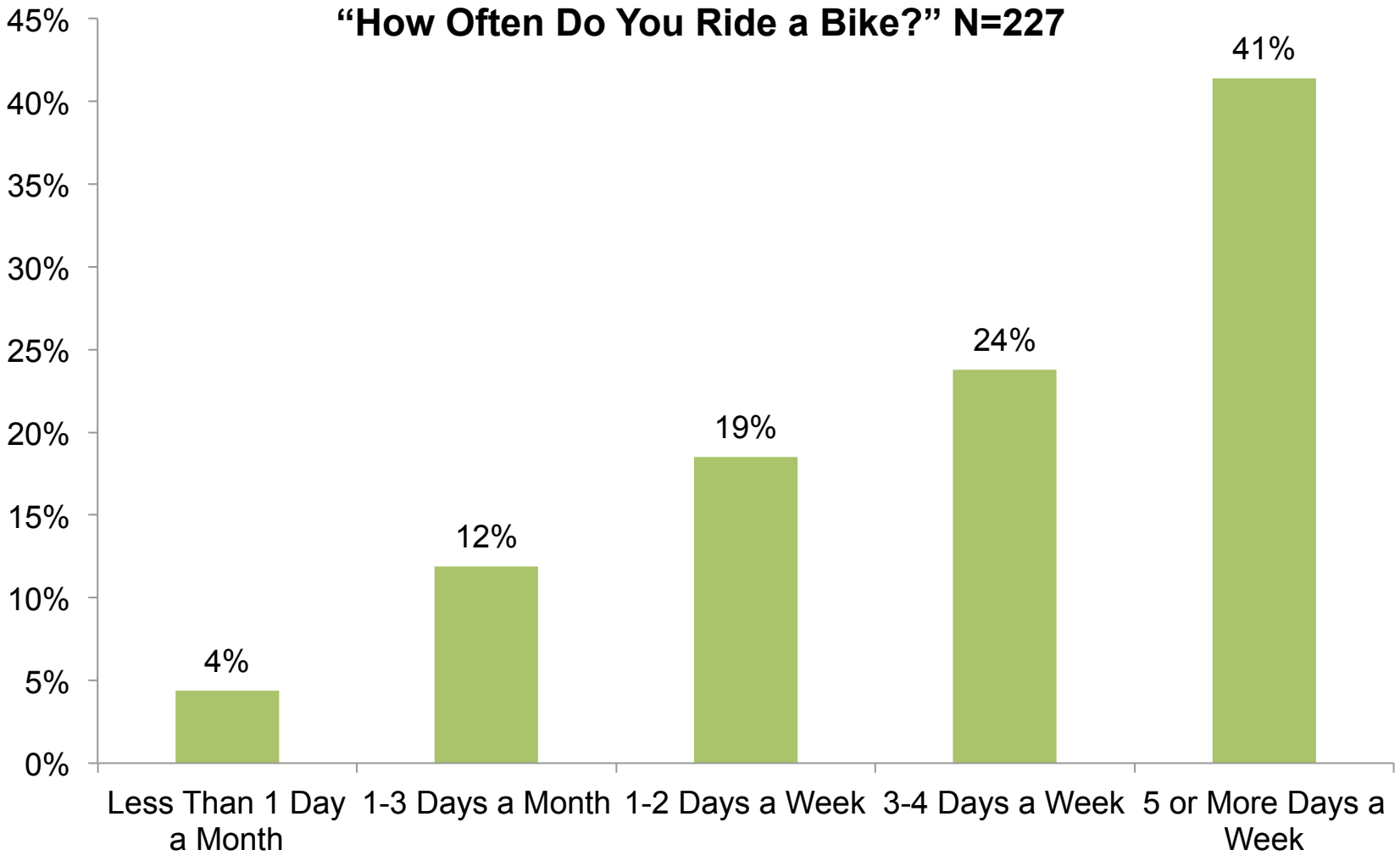
Survey – Results



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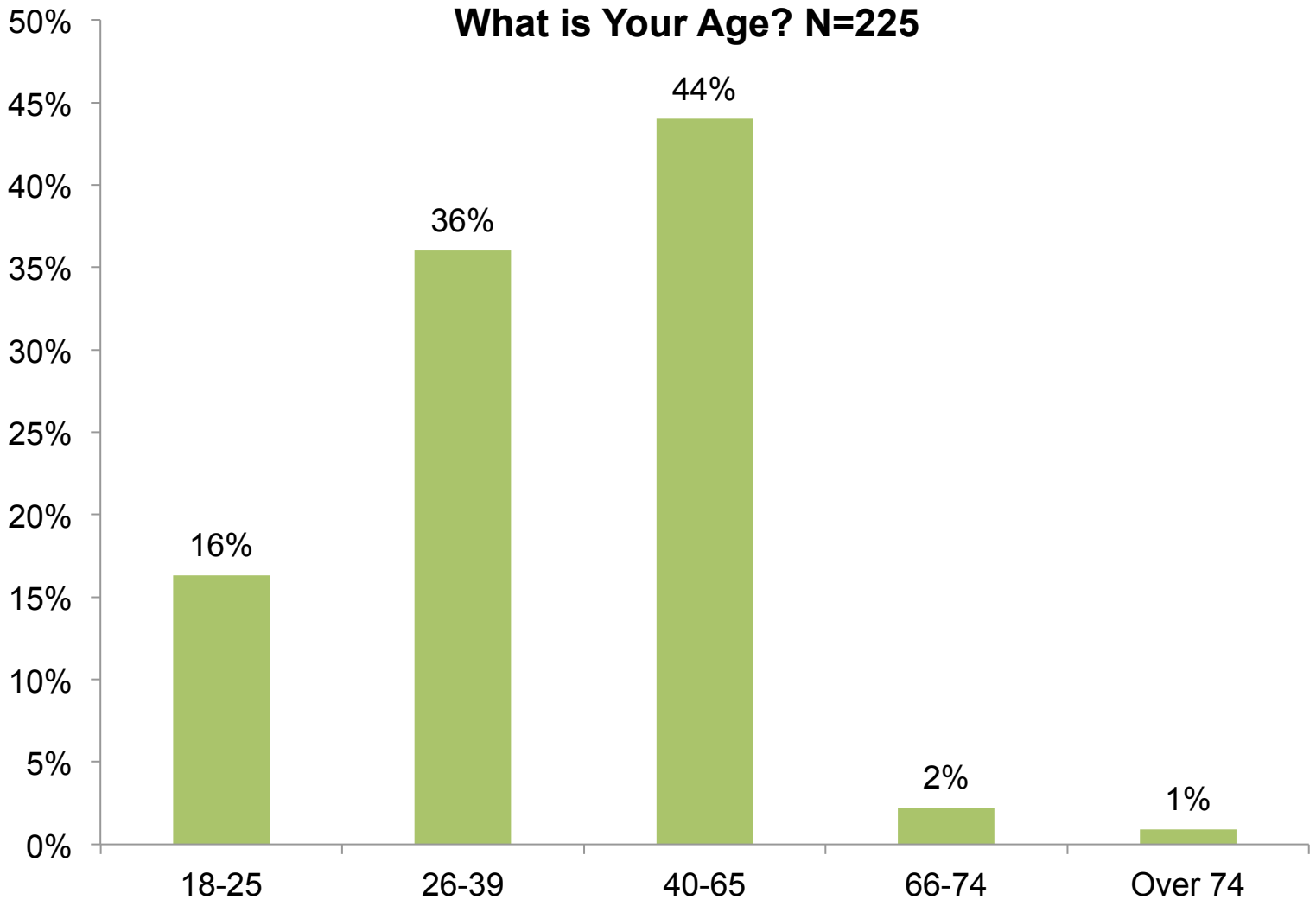
Survey – Results



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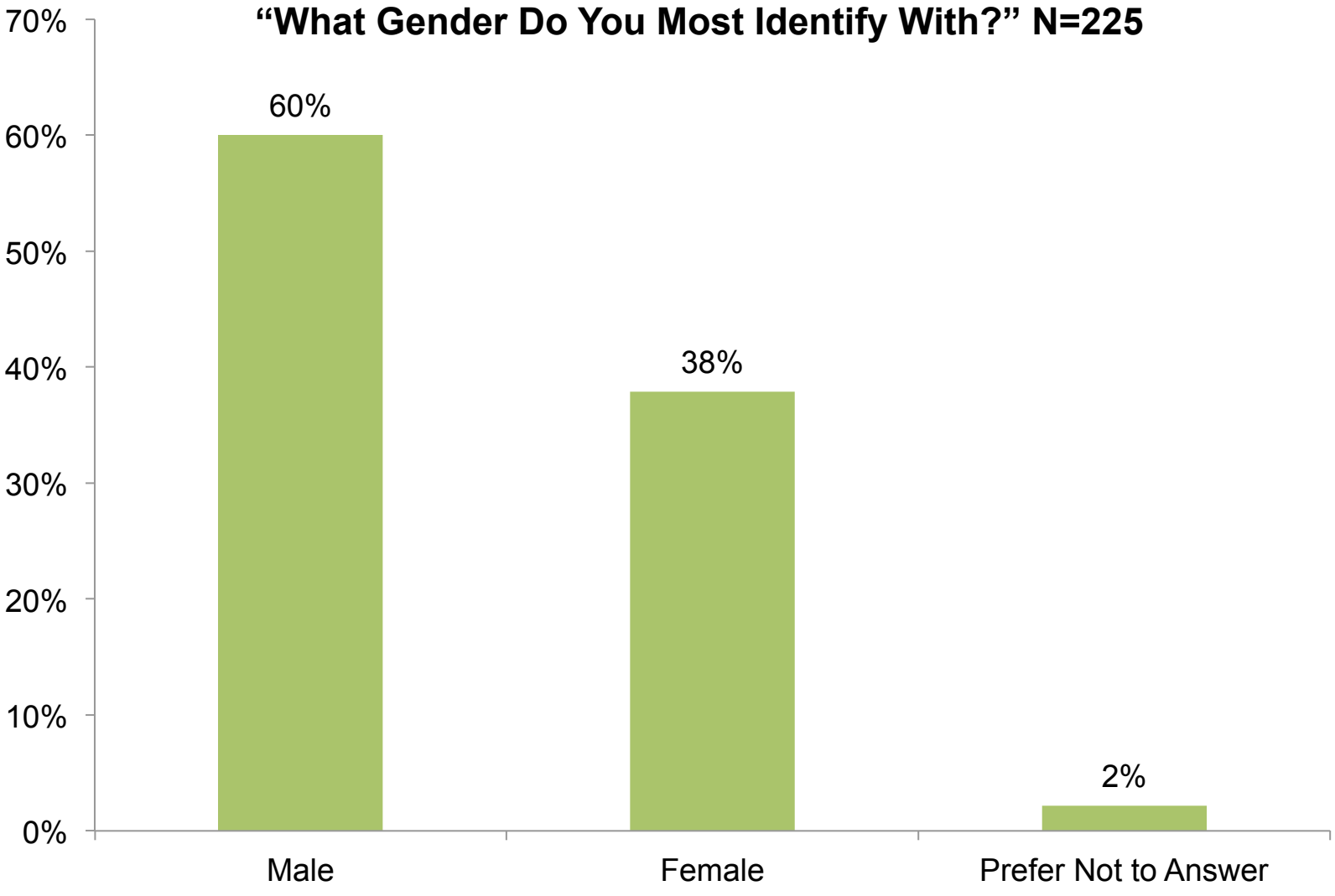
Survey – Results



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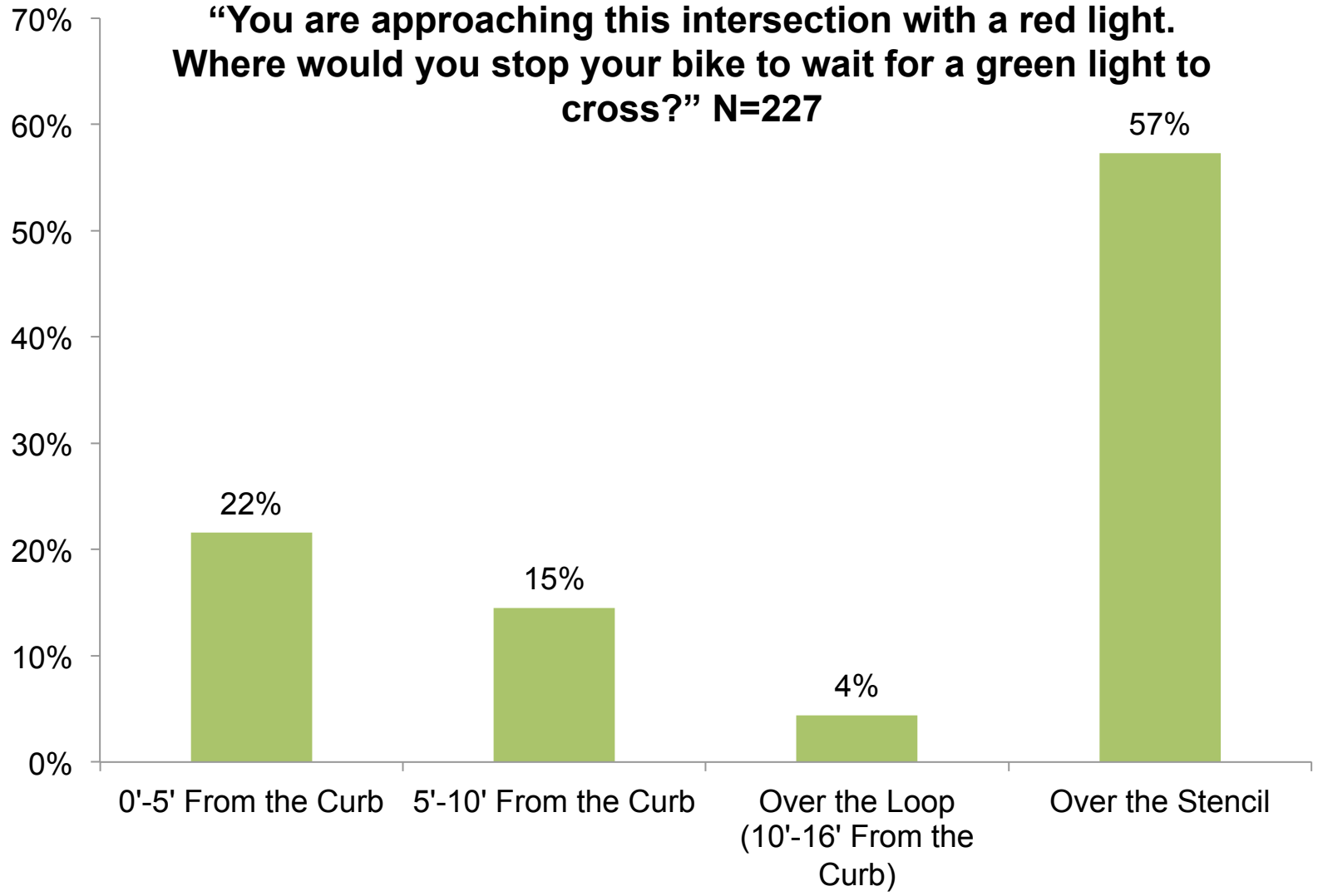
Survey – Results



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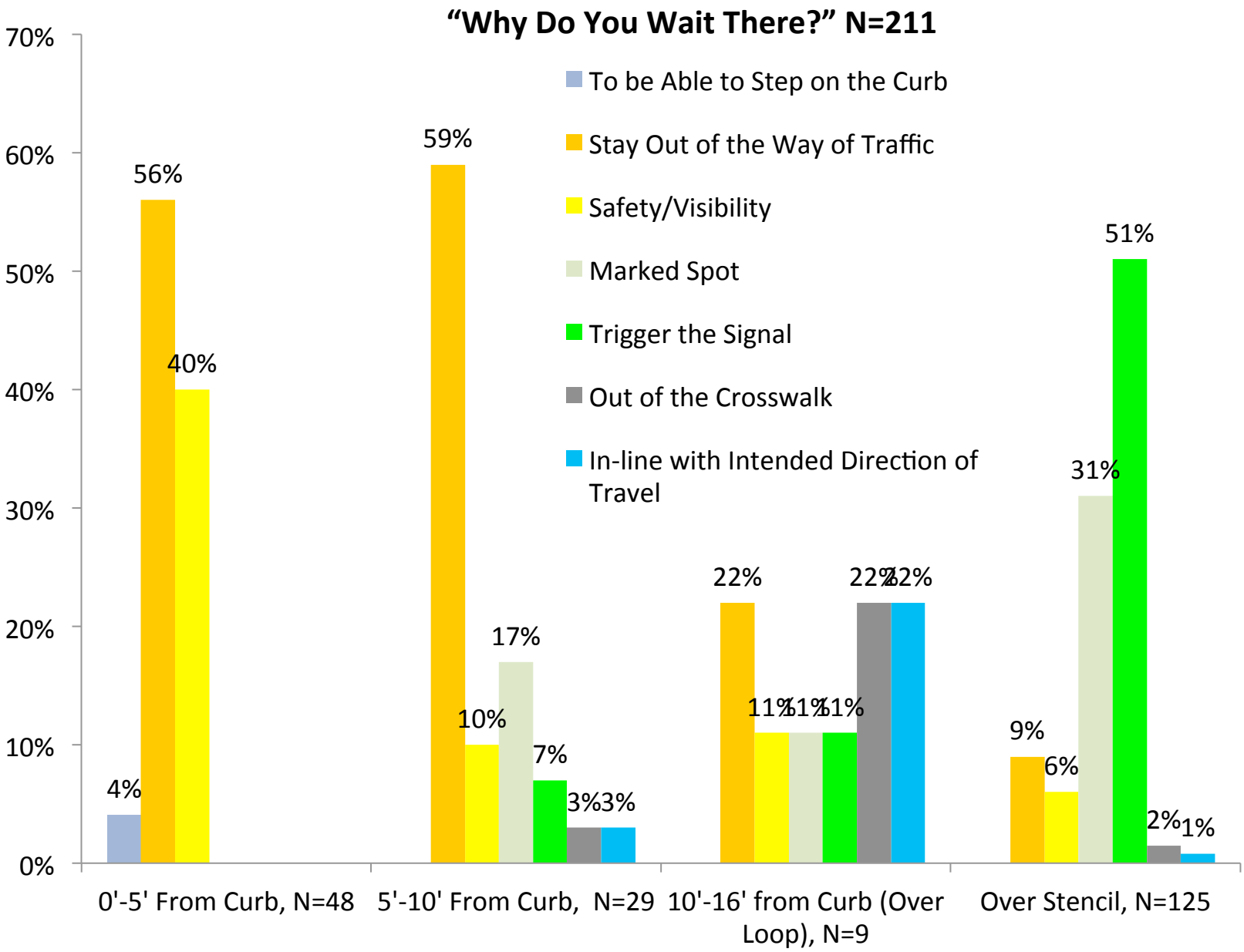

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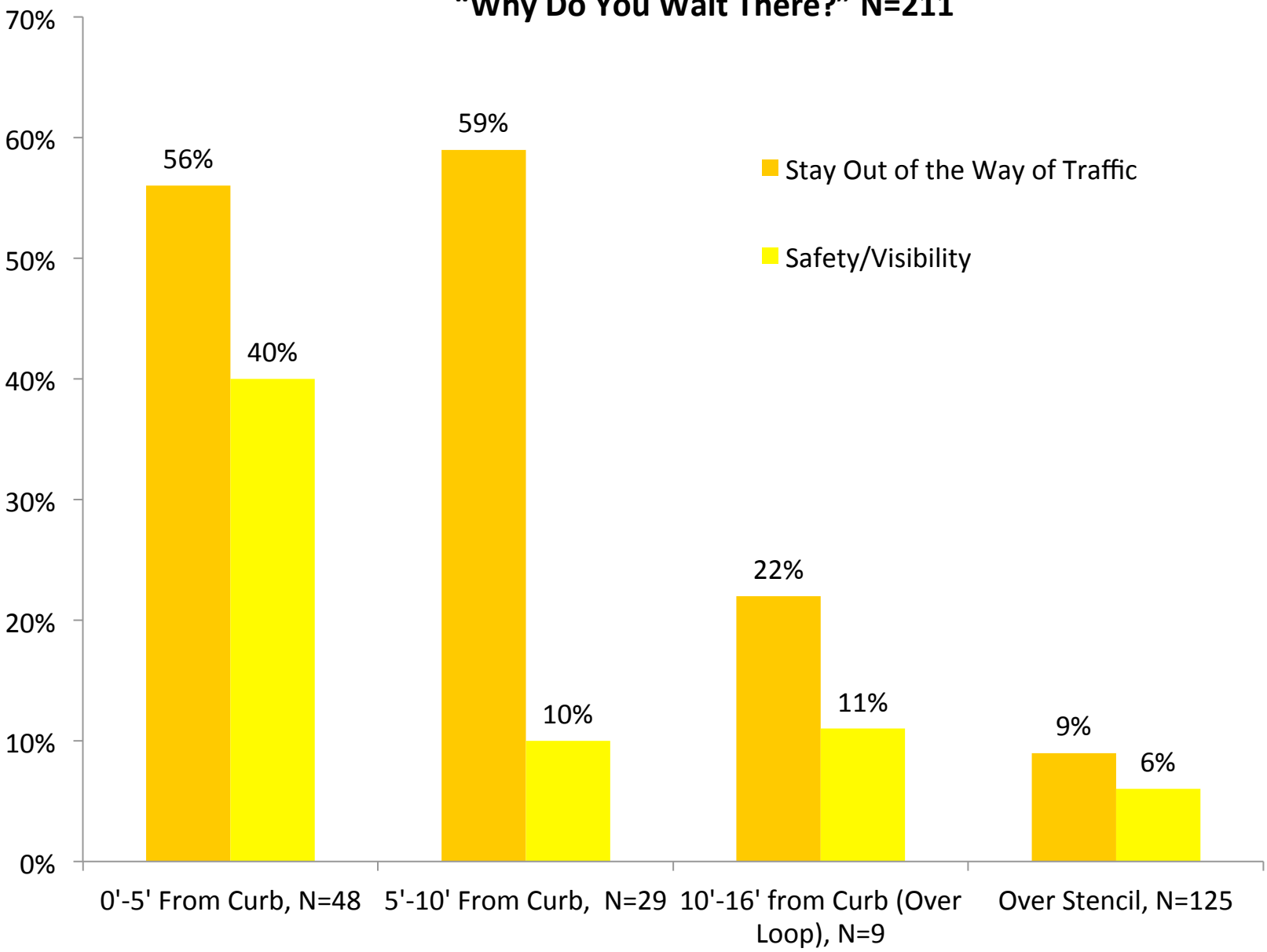

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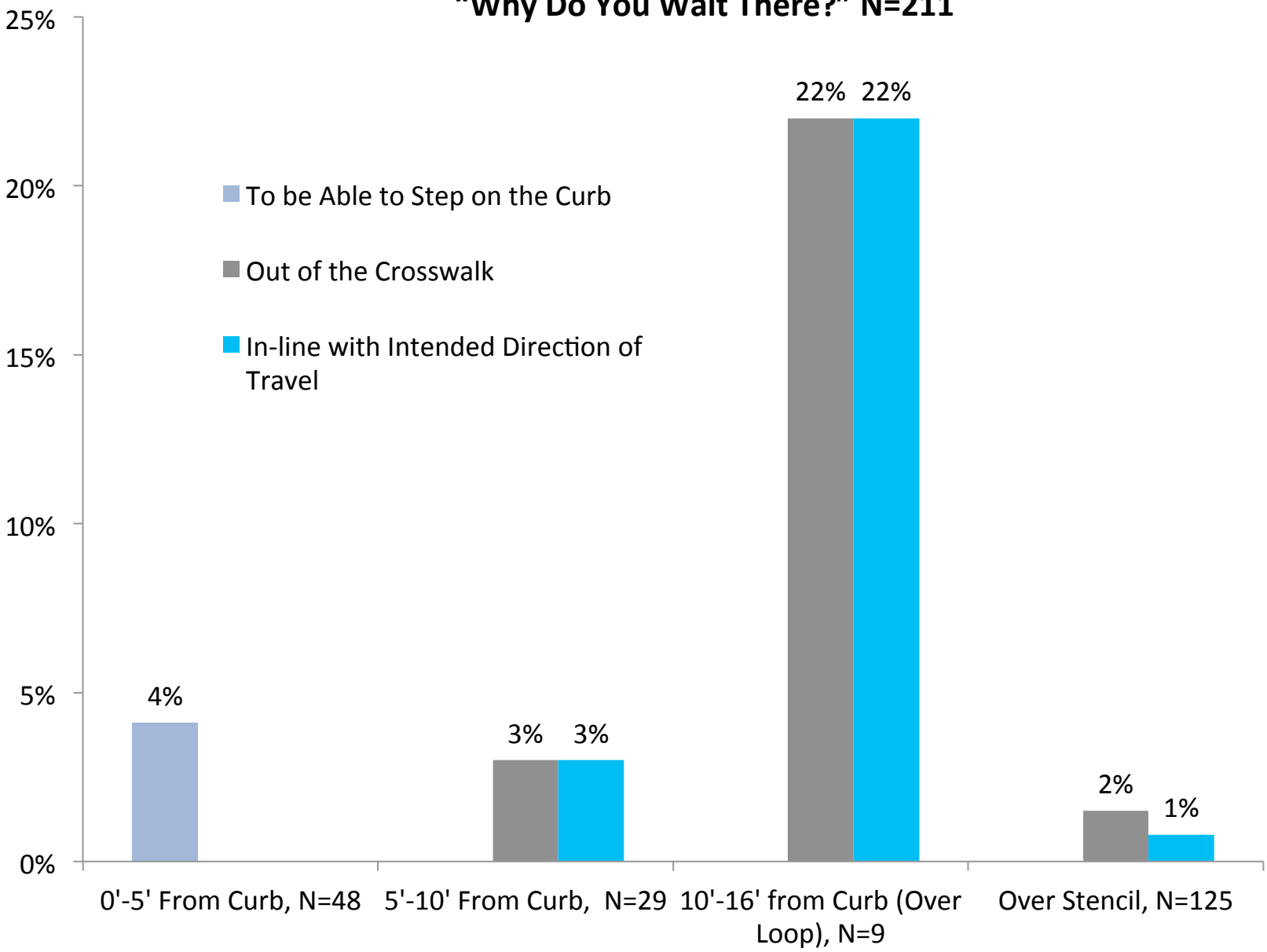

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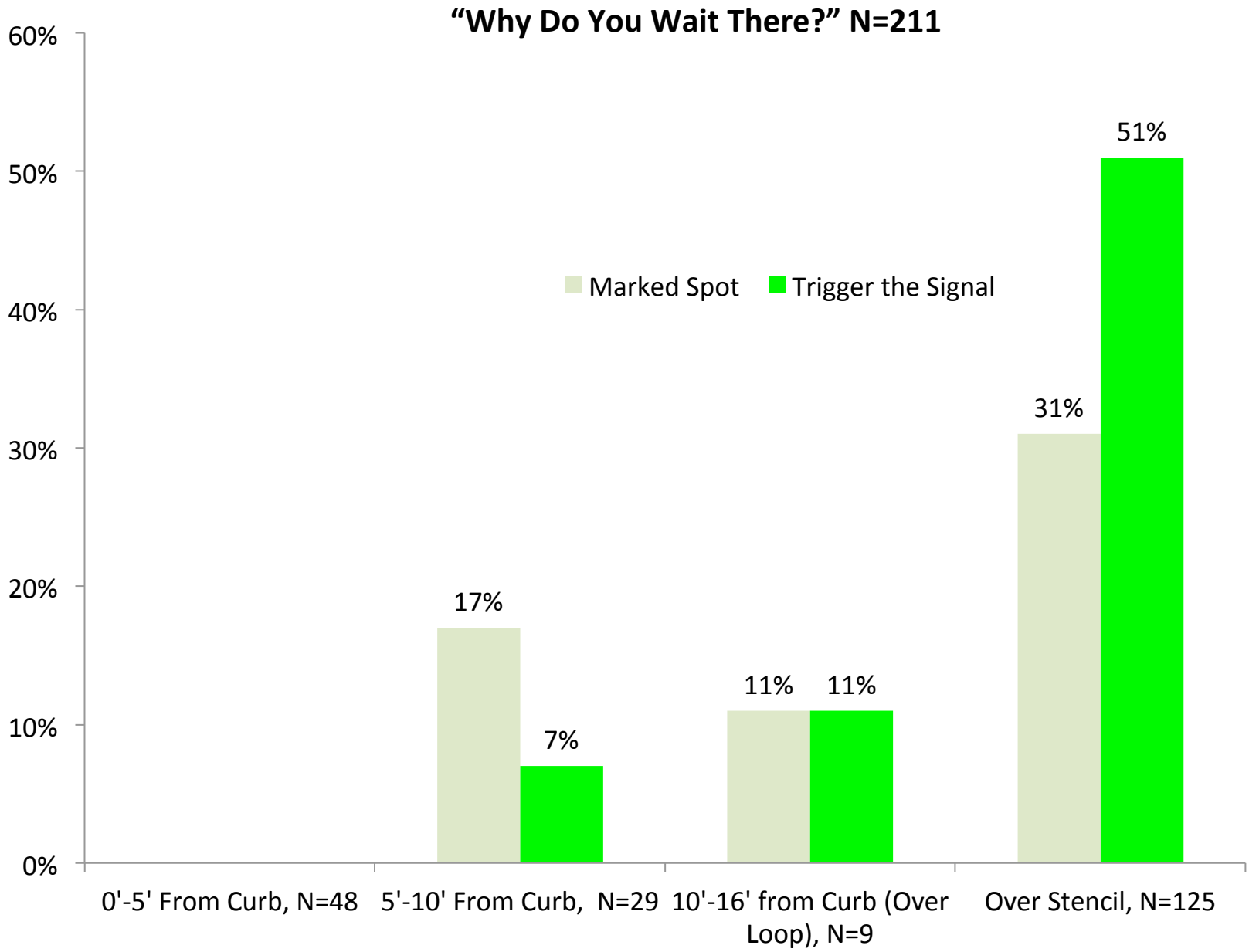

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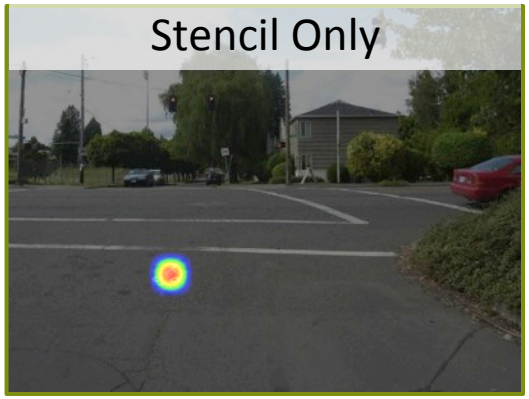
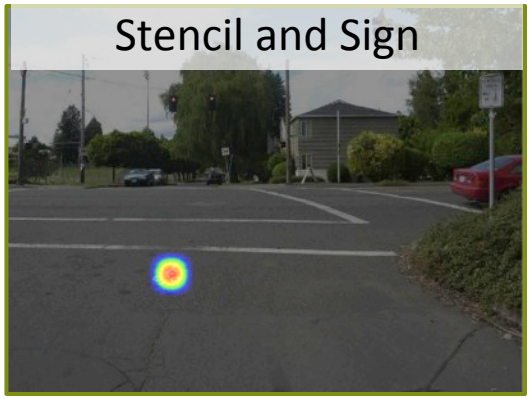
Survey – Results

53.2%



58.7%



58.3%

No significant difference in queuing position between three test cases

Survey – Results

45.4% - Wait Here to Trigger the Signal

33.9% - Bike Lane/Bike Route

11.5% - Recommended Waiting Location

6.5% - Don't Know or No Answer

1.8% - Bikes Allowed Here

0.9% - Other

"As a cyclist, what does the symbol in the above picture mean?"

Video – Results

Analysis excludes observations in which:

- A vehicle arrives immediately after the cyclist
- The cyclist is riding with one or more other cyclists
- The cyclist violates the red indication
- The cyclist is riding on the sidewalk
- Other unusual circumstances

Example of an Excluded Observation

Video – Results

Table 1: Percent of Cyclists Waiting Over Loop Detector Before and After Marking(s) Installed

	Stencil N_B= 51, N_A= 51	Stencil and Sign N_B= 92, N_A= 112	"Green Backed" Stencil N_B= 157, N_A= 225
% Stopping Over Loop Before	27.5%	16.3%	46.5%
% Stopping Over Loop After	37.3%	44.6%	58.2%
X^2	3.71	67.37	15.28
Degrees of Freedom	2	2	2
α	0.157	0.000	0.0005

N_B= Observations Before

N_A= Observations After

Video – Results

Table 2: Percent of Cyclists Waiting Over Stencil Region Before and After Marking(s) Installed

(Only Includes Observations of Cyclists who Waited Over the Loop)

	Stencil, N_B= 14, N_A= 19	Stencil and Sign N_B= 15, N_A= 50	"Green Backed" Stencil, N_B= 73, N_A= 131
% Stopping Over Stencil Region Before	42.9%	40.0%	50.7%
% Stopping Over Stencil Region After	62.3%	78.0%	83.2%
X^2	3.20	30.08	55.43
Degrees of Freedom	1	1	1
α	0.074	0.000	0.000

N_B= Observations Before

N_A= Observations After

Survey Results vs. Video Results

Survey Results

- Self reported preferences
- May represent a best case for stencil use
- Highlight the importance placed on safety

Video Results

Stencil with R10-22 sign and "Green Backed" stencil produce a significant effect

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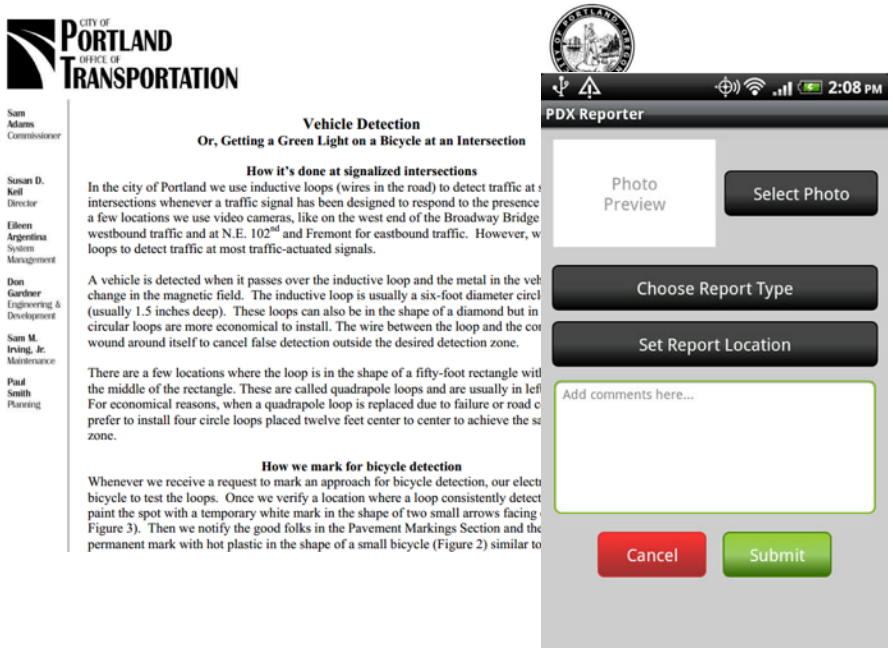
Limitations of Study

Designed
"Green Backed"
Stencil

Installed
"Green Backed"
Stencil

- Only one field test for each case
- Intersections not uniform in stripping configuration
- "Green Backed" stencil installed in field did not match original design
- High number of regular cyclist in Portland may skew results

What You Can Do



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Sam Adams, Commissioner
Susan D. Keil, Director
Eileen Argentina, System Management
Don Gardner, Engineering & Development
Sam M. Irving, Jr., Maintenance
Paul Smith, Planning

Vehicle Detection
Or, Getting a Green Light on a Bicycle at an Intersection

How it's done at signalized intersections

In the city of Portland we use inductive loops (wires in the road) to detect traffic at s
intersections whenever a traffic signal has been designed to respond to the presence
a few locations we use video cameras, like on the west end of the Broadway Bridge
westbound traffic and at N.E. 102nd and Fremont for eastbound traffic. However, w
loops to detect traffic at most traffic-actuated signals.

A vehicle is detected when it passes over the inductive loop and the metal in the veh
change in the magnetic field. The inductive loop is usually a six-foot diameter circl
(usually 1.5 inches deep). These loops can also be in the shape of a diamond but in
circular loops are more economical to install. The wire between the loop and the co
wound around itself to cancel false detection outside the desired detection zone.

There are a few locations where the loop is in the shape of a fifty-foot rectangle wit
the middle of the rectangle. These are called quadrapole loops and are usually in lef
For economical reasons, when a quadrapole loop is replaced due to failure or road c
prefer to install four circle loops placed twelve feet center to center to achieve the s
zone.

How we mark for bicycle detection

Whenever we receive a request to mark an approach for bicycle detection, our electr
bicycle to test the loops. Once we verify a location where a loop consistently detect
paint the spot with a temporary white mark in the shape of two small arrows facing
Figure 3). Then we notify the good folks in the Pavement Markings Section and the
permanent mark with hot plastic in the shape of a small bicycle (Figure 2) similar to

- Read about the City of Portland's Policy on bikes and detection: http://www.portlandoregon.gov/transportation/article/145110
- Call 503-823-SAFE or 823-CYCL
- Use the PDX Reporter App: http://www.portlandoregon.gov/bts/article/419527
- Share your knowledge!

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Acknowledgements

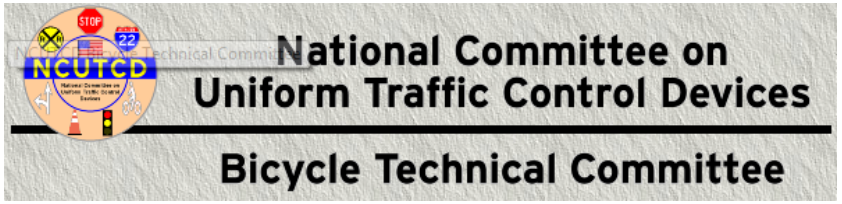
Rob Burchfield

Rodger Geller

Mark Haines

Steve Cohn

Ron Van Houten



Richard Moeur

Questions?

Supplemental Slide – Installed Sign and Stencil

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Supplemental Slide – Installed “Green Backed” Stencil

Supplemental Slide – Site Selection

Quadrant	Intersection	Approach	Comments	Edge of Loop to Curb (estimated)	Thru Lane
N	Prescott St and MLK Blvd	WB	No stencil, loops visible. T intersection		10
NE	47th Ave and Sandy Blvd	NB	Stencil illegible and badly worn. Loops are visible.		10
N	Ainsworth St and MLK Blvd	WB	No stencil, loops visible		10
N	Vancouver Ave and Columbia Blvd	SB	No stencil, loops visible. Bike lane has no loop but extends to the stop bar.		10
SW	30th Ave and B-H Hwy	SB	No stencil, loops visible		10
~~N~~	~~Vancouver Ave and Rosa Parks Way~~	~~SB~~	~~No stencil, loops visible, bike lane with no loop. Push button nearby, no bike sign.~~		~~11~~
~~NE~~	~~47th Ave and Sandy Blvd~~	~~SB~~	~~No stencil, loops visible~~		~~11~~
~~SE~~	~~30th Ave and Hawthorne Blvd~~	~~NB~~	~~No stencil, loops visible~~		~~13~~
SE	27th Ave and Hawthorne Blvd	NB	No stencil, loops visible. Stencil on SB approach		13
SW	Sunset and Capitol Hwy	EB	No stencil, loops visible		13
SE	69th Ave and Powell Blvd	NB	No stencil, loops visible.		14
SE	69th Ave and Powell Blvd	SB	No stencil, loops visible.		14
N	Killingsworth St and MLK Blvd	WB	No stencil, loops visible	6	14
SE	52nd Ave and Powell Blvd	NB	No stencil, loops visible.	6	14
SE	112th Ave and Division St	NB	No stencil, loops visible	6	14
SE	52nd Ave and Flavel St	WB	No stencil, loops visible. T intersection		15
~~SE~~	~~30th Ave and Hawthorne Blvd~~	~~SB~~	~~No stencil, no loops visible~~		~~16~~
~~SW~~	~~35th Ave and Multnomah Blvd~~	~~NB~~	~~No stencil, loops visible. Stencil on SB approach~~	~~8~~	~~16~~

Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - 33rd and Grant (Alternative Stencil)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
1+2	65	65	28.9%	41.4%	93.2	8.51
3	131	73	58.2%	46.5%	104.6	6.65
4+5+6	29	19	12.9%	12.1%	27.2	0.12
	225	157	100.0%	100.0%		
					Total Chi Squared Value	15.28
					α, df=2	0.0005

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - 33rd and Grant (Alternative Stencil)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
3.1	109	37	83.2%	50.7%	66.40	27.34
3.2+3.3	22	36	16.8%	49.3%	64.60	28.09
	131	73	100.0%	100.0%		
					Total Chi Squared Value	55.43
					α, df=1	0.00000

Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - Ainsworth and MLK (Stencil and Sign)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
1	51	68	45.5%	73.9%	82.8	12.20
2	50	15	44.6%	16.3%	18.3	55.17
4+5	11	9	9.8%	9.8%	11.0	0.00
	112	92	100.0%	100.0%		
					Total Chi Squared Value	67.37
					α, df=2	0.0000

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - Ainsworth and MLK (Stencil and Sign)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
2.1	39	6	78.0%	40.0%	20.00	18.05
2.2+2.3	11	9	22.0%	60.0%	30.00	12.03
	50	15	100.0%	100.0%		
					Total Chi Squared Value	30.08
					α, df=1	4.13873E-08

Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - Dekum and MLK (Stencil Only)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
1+2	24	24	47.1%	47.1%	24.0	0.00
3	19	14	37.3%	27.5%	14.0	1.79
4+5+6	8	13	15.7%	25.5%	13.0	1.92
	51	51	100.0%	100.0%		
					Total Chi Squared Value	3.71
					α, df=2	0.157

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - Dekum and MLK (Stencil Only)						
Zone	**Observations After**	**Observations Before**	**Percent of Observations After**	**Percent of Observations Before**	**Expected Value After**	**Chi Squared Value**
3.1	12	6	63.2%	42.9%	8.14	1.83
3.2+3.3	7	8	36.8%	57.1%	10.86	1.37
	19	14	100.0%	100.0%		
					Total Chi Squared Value	3.20
					α, df=1	0.074