Bicycle Counts Using Pneumatic Tubes

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SPR 772

Oregon Department of Transportation

Overview

Background & Methods

Findings

Conclusions & Recommendations

Background & Methods

Goals

Investigate if and under what conditions **existing** continuous and short duration, bicycle and pedestrian count technologies are most accurate

How to cost effectively integrate them into ODOT's current traffic monitoring and signal operations systems

Tube Test Sites

Controlled Environment

- ODOT's Traffic System Services Unit parking lot, Salem

Mixed Traffic

Road Segment

- Historic Columbia River Highway near Corbett

Intersection

- Hall & 99W, Tigard

Pneumatic Tube Counters Tested

Type	Make	Model	Code
Bicycle-specific	Eco-Counter	Bicycle-only Tubes	B1
	Eco-Counter	Bicycle/motor vehicle Tubes	B2
Classification	JAMAR Technologies, Inc.	TRAX Cycles Plus	C1
	TimeMark Corporation	Gamma	C2
	MetroCount	MC5600	C3
Volume	Diamond Traffic Products	TT-6	V1

Ground Truth – Video Cameras

Error Metrics

Overall Error = $\frac{c-m}{m}$

Mean Percent Error (MPE) $= \frac{1}{h}\sum_{i=1}^{h}\frac{c_i-m_i}{m_i}$

Mean Absolute Percent Error (MAPE) $= \frac{1}{h}\sum_{i=1}^{h}\left|\frac{c_i-m_i}{m_i}\right|$

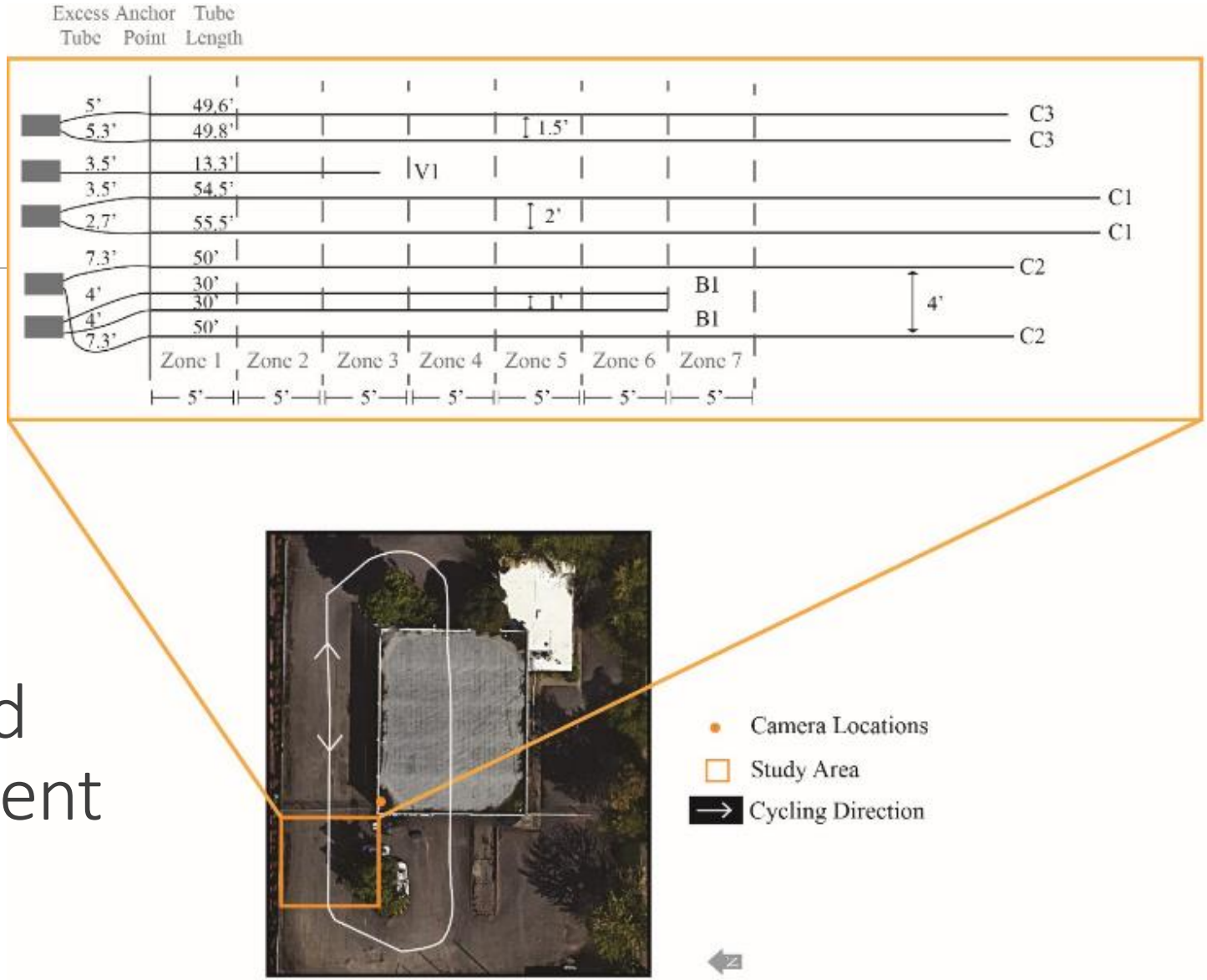
where m = ground truth count for study period

c = tube count for study period

h = total number of bins (hours)

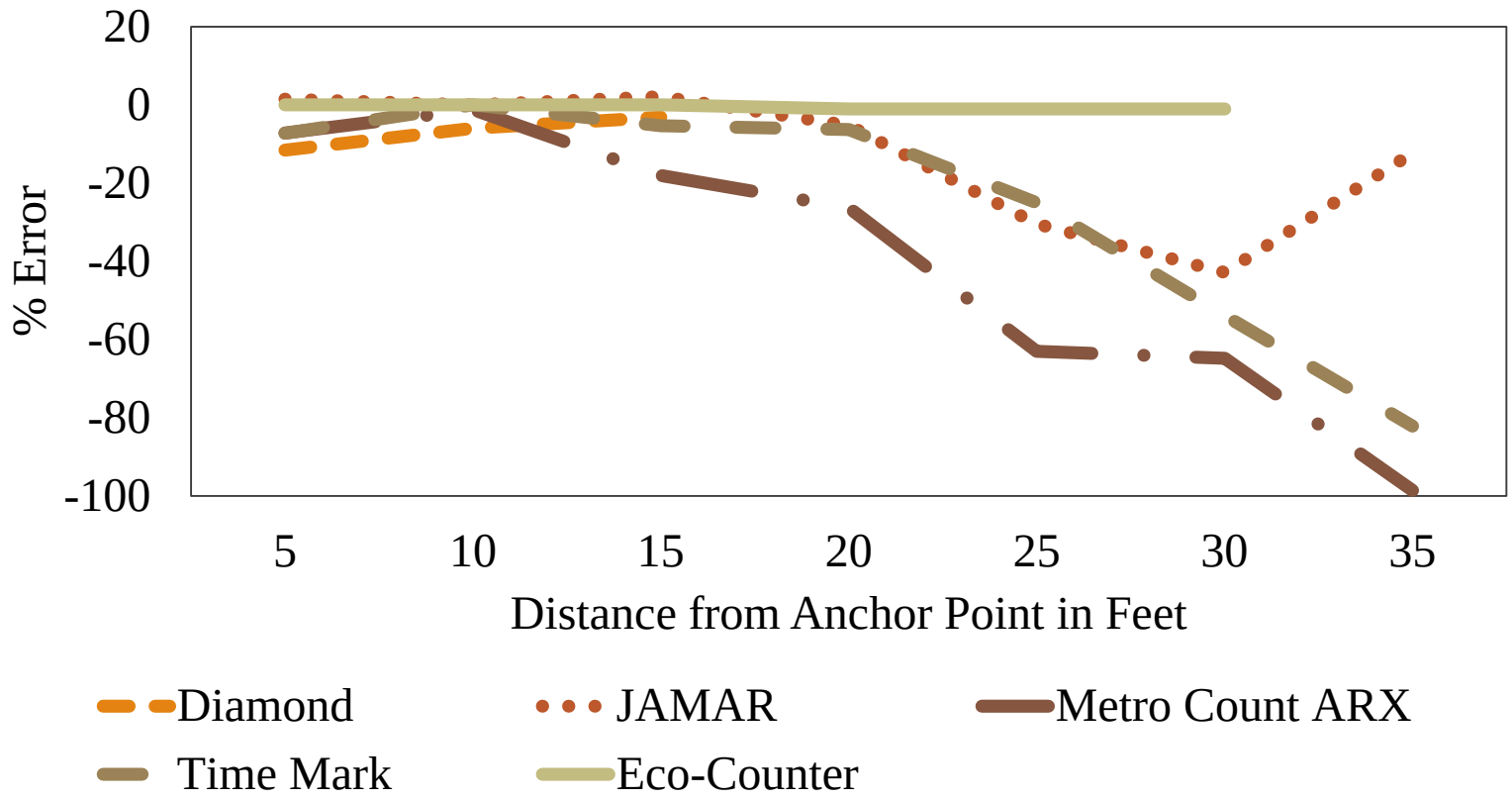
Findings

Controlled Environment Test



Controlled Environment

All had < 10% error within 10 to 15 feet of the count equipment (standard bikes)



Special Cases

Tandem Bike

Cargo Bicycle

Carbon Fiber Bike

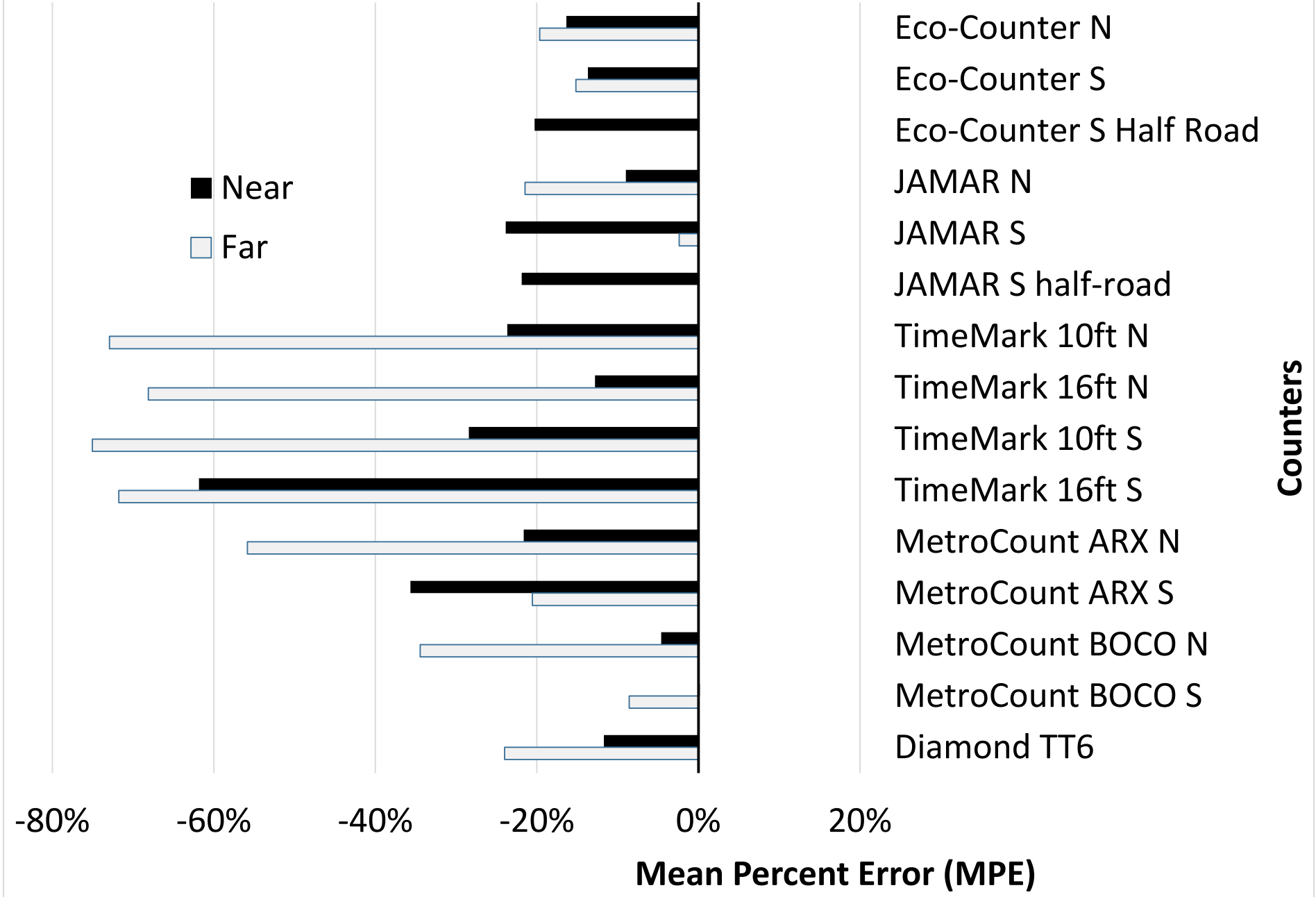
Bike with Trailer

Special Cases Tube Test

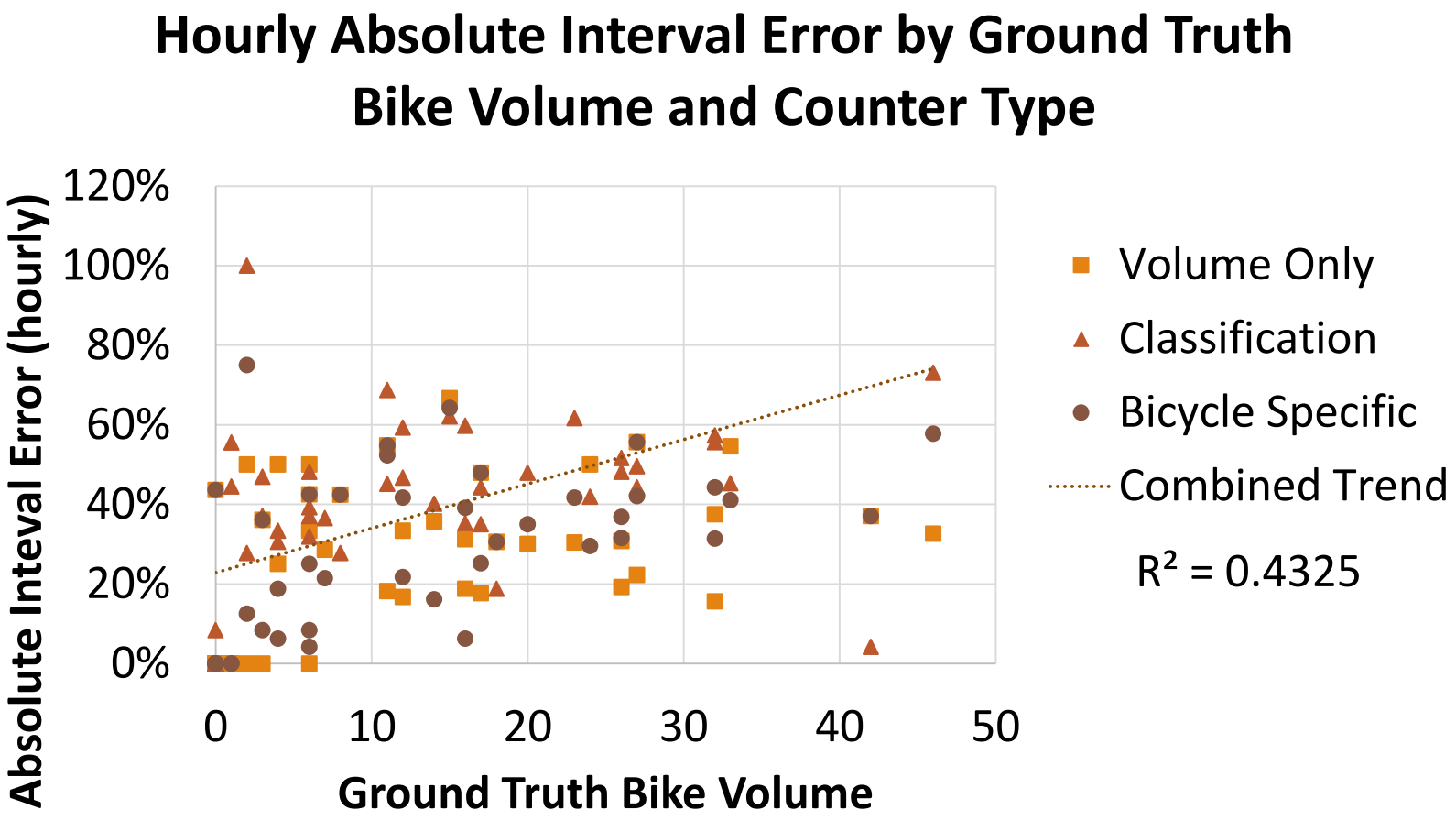
Tube Counter	Tandem, Bike with Trailer	Carbon Fiber, Cargo Bicycle	Standard bicycles: One behind the Other	Standard bicycles: Side by Side
	Overall Error (%)	Overall Error (%)	Overall Error (%)	Overall Error (%)
EcoCounter	-75	-4	-74	-59
Jamar CyclesPlus	-50	-50	-2	-46
TimeMark	-4	-6	-65	-38
MetroCount 5600 - ARXCycle	-96	-56	-95	-57
Daimond TT6	4	-9	-4	-36

Mixed Traffic Test

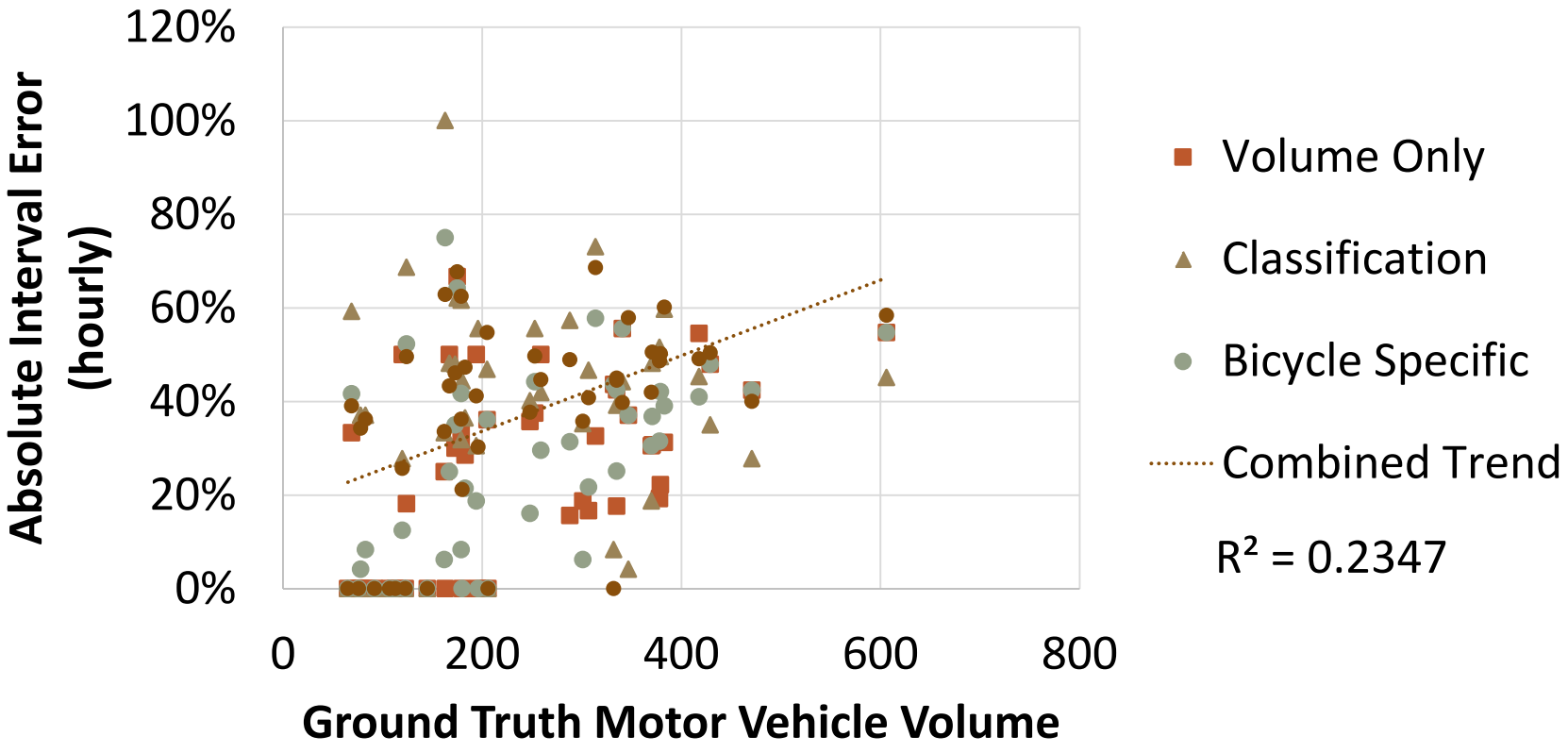
- 28 Tubes
- Low motor vehicle traffic
- 576 bicyclists during study


Near
Far
Eco-Counter N
Eco-Counter S
Eco-Counter S Half Road
JAMAR N
JAMAR S
JAMAR S half-road
TimeMark 10ft N
TimeMark 16ft N
TimeMark 10ft S
TimeMark 16ft S
MetroCount ARX N
MetroCount ARX S
MetroCount BOCO N
MetroCount BOCO S
Diamond TT6
Counters
-80%
-60%
-40%
-20%
0%
20%
Mean Percent Error (MPE)

Mixed Traffic –Tube Error



Mixed Traffic – Tube Error



Causes for Undercounts

Cyclists riding side-by-side

Cars passing cyclists crossing tubes

Bicycle Speed

Equipment	Average Bicycle Speed (mph)		
	Eastbound	Westbound	Combined
Jamar, south side, (total)	13.3	20.3	17.0
Jamar, north side, (total)	12.5	20.5	16.8
Jamar half road, south side, near (EB)	12.1	n/a	n/a
TimeMark, south side, 16ft, (total)	13.8	12.7	13.3
TimeMark, north side, 16ft, (total)	13.2	19.2	18.2
TimeMark, south side, 10ft, (total)	12.6	17.7	13.2
TimeMark, north side, 10ft, (total)	13.2	20.9	20.0
MetroCount, south side BOCO, (total)	13.0	21.6	17.6
MetroCount, north side BOCO, (total)	13.4	21.8	18.7
All Counter Average	12.9	19.4	16.4
Manual (Video)	12.1	21.6	16.7

Tube Tests

Hall and 99 W, Tigard

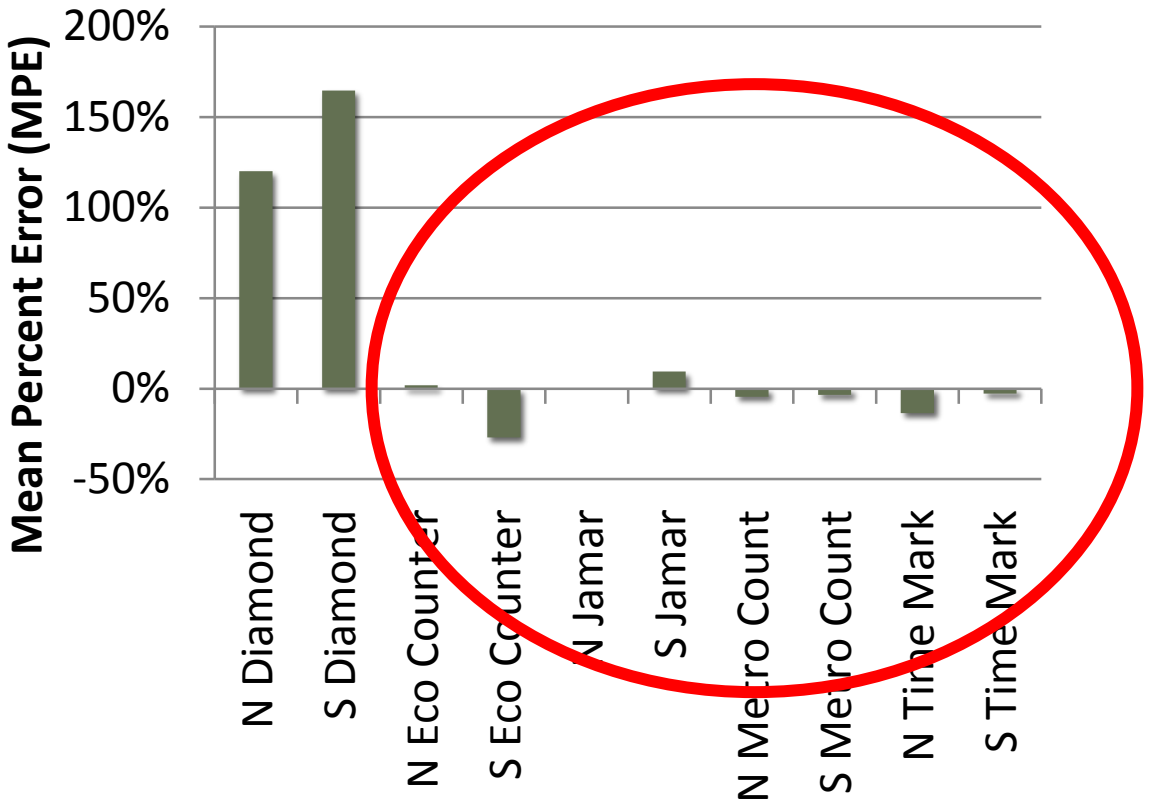
Bike lane
and Sidewalk

Mini-tubes
<20 feet long

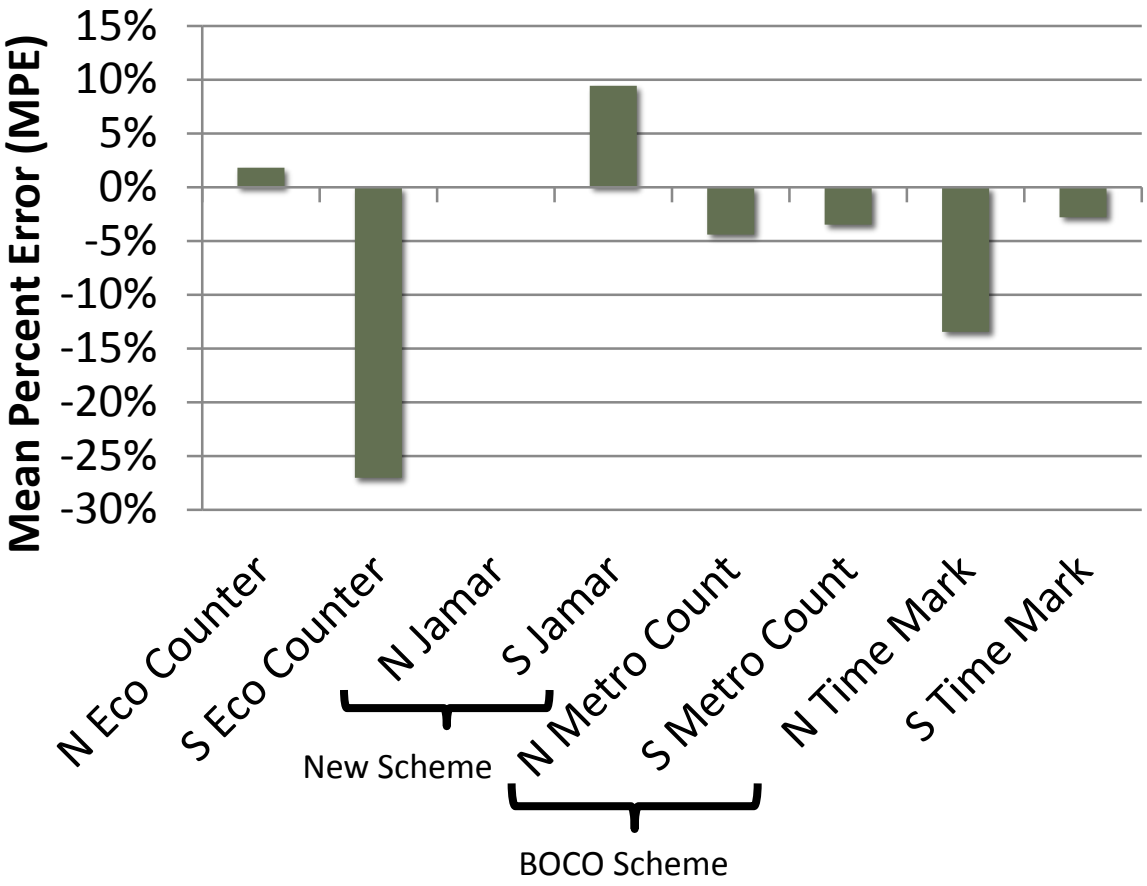
Tubes

Camera Location

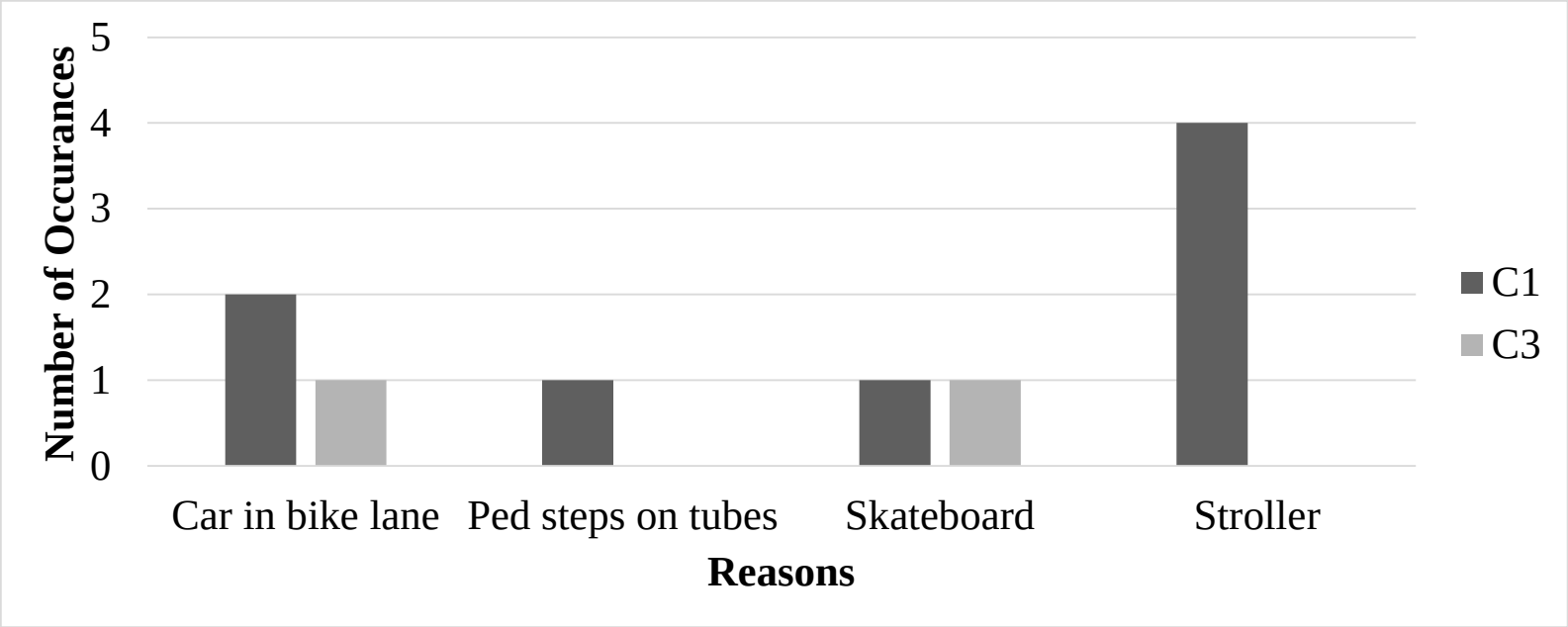
Bike Lane & Sidewalk



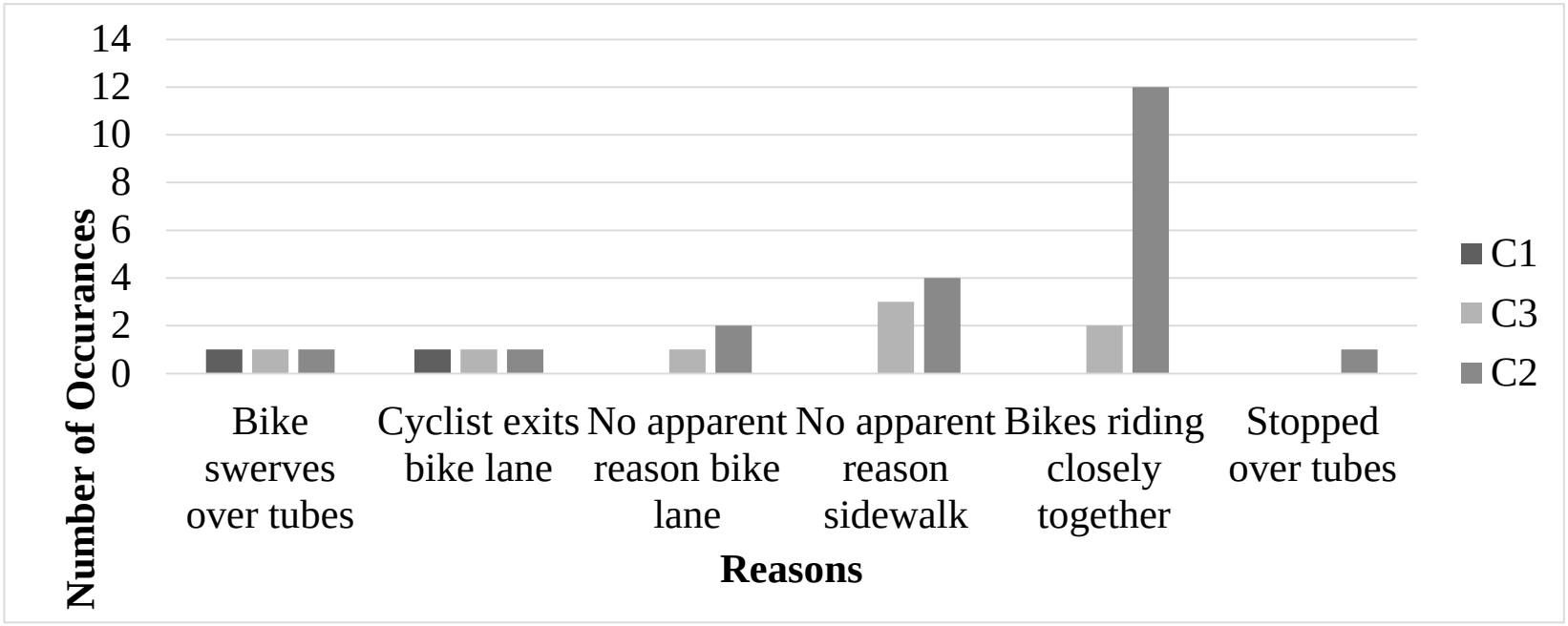
More Accurate Counters



Causes for Overcounting by Classification Tube Counters



Causes for Undercounting by Classification Tube Counters



Conclusions & Recommendations

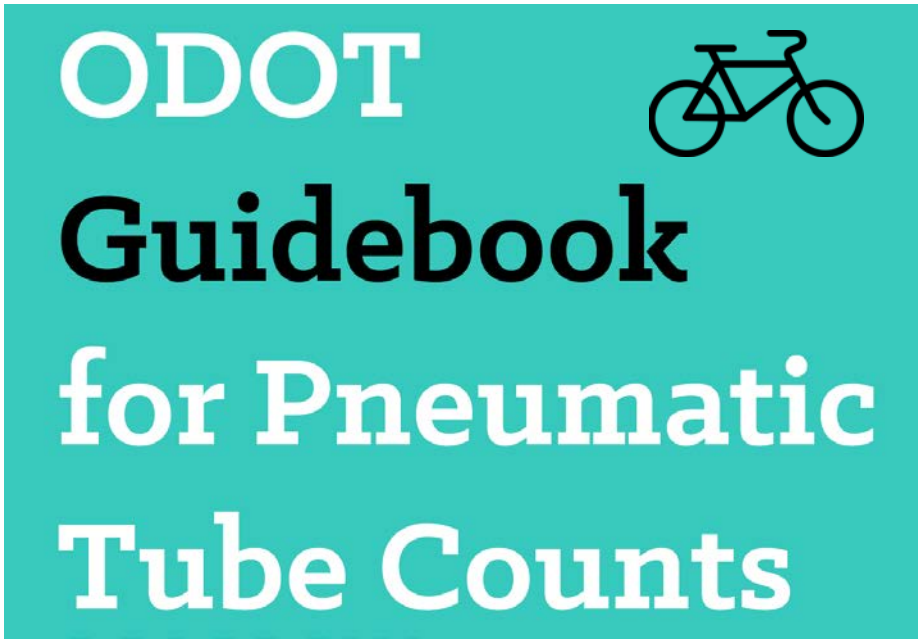
Conclusions

Tube counters can be used for counting bicycles

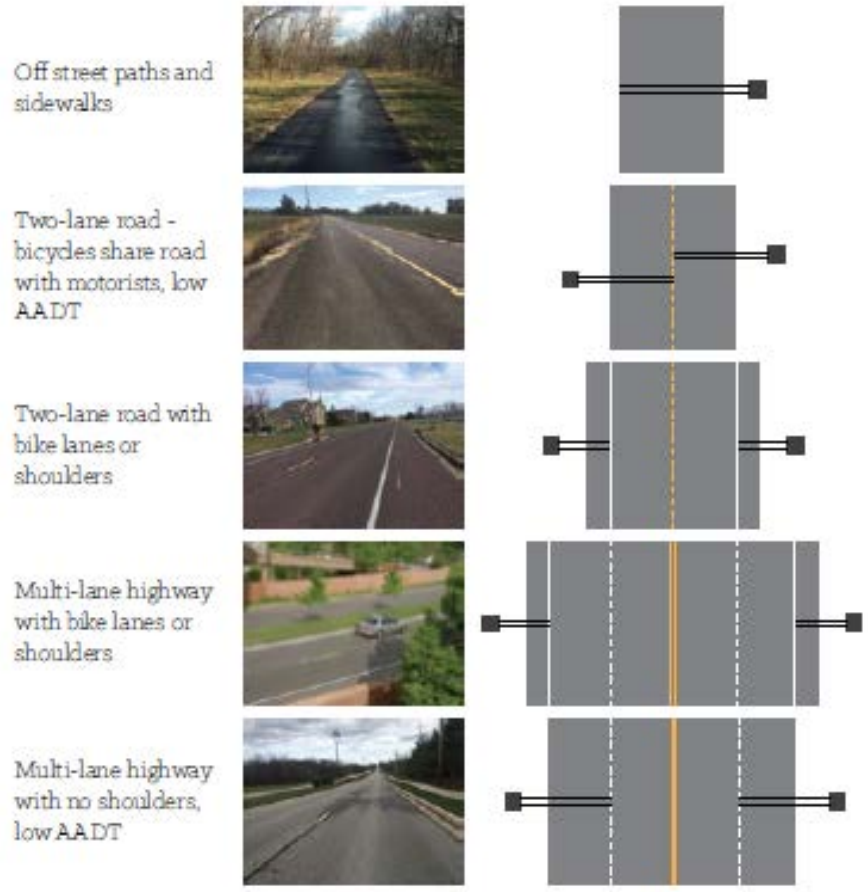
- In low volume mixed traffic, only Eco-Counter, JAMAR Cycles Plus, and MetroCount with BOCO are better (-10% to -40% undercount, overall error).
- In mostly bicycle traffic, TimeMark Gamma* can also be used. Recommend short tubes (<15 feet), 6-foot spacing, mini-tubes used to reduce trip hazard.
- In bicycle-only traffic, Diamond TT6 can also be used.

*TimeMark Gamma with standard tubes (> 50 ft long) and 10 or 16 foot spacing in mixed traffic greatly undercounts bicycles (-66 to -73% error far side, -13% to -64% near side)

Guidebook



Tube Recommendations



TIPS

- Avoid mixed traffic.
- Count on low traffic roads.
- Use bicycle-specific classification schemes.
- Avoid counting bicycles >15 feet tube length from counter.
- Use mini-tubes.

DO NOT

- ~~Use 50 foot long tubes.~~
- ~~Count in high volume mixed traffic.~~

Acknowledgements

Technical Advisory Committee
- Lyn Cornell, former Chair
- Mark Joerger, current Chair
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Hall & 99W Test: Tiffany Slauter, Mike Casper, Tim Damm

Questions

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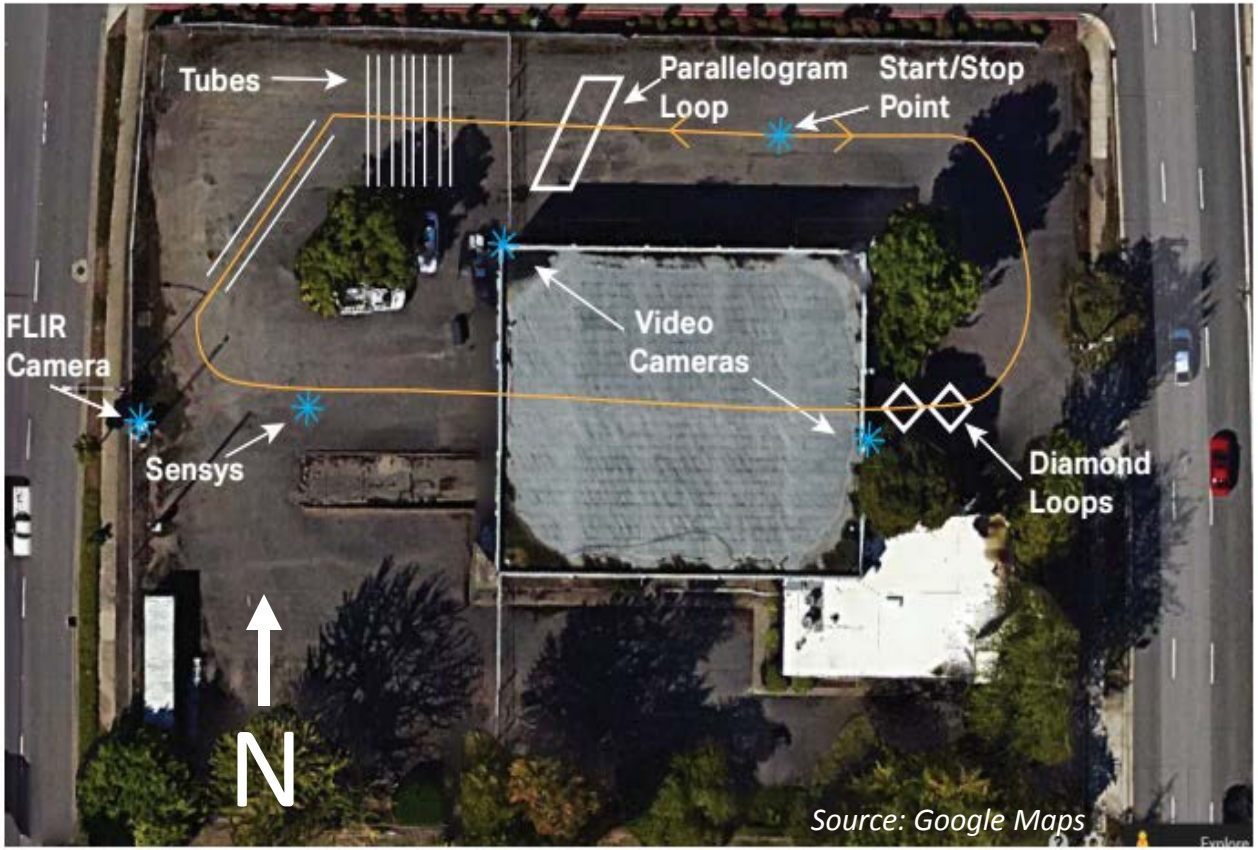
Extra Slides

Controlled Environment Test

ODOT Traffic Systems Service Unit in Salem



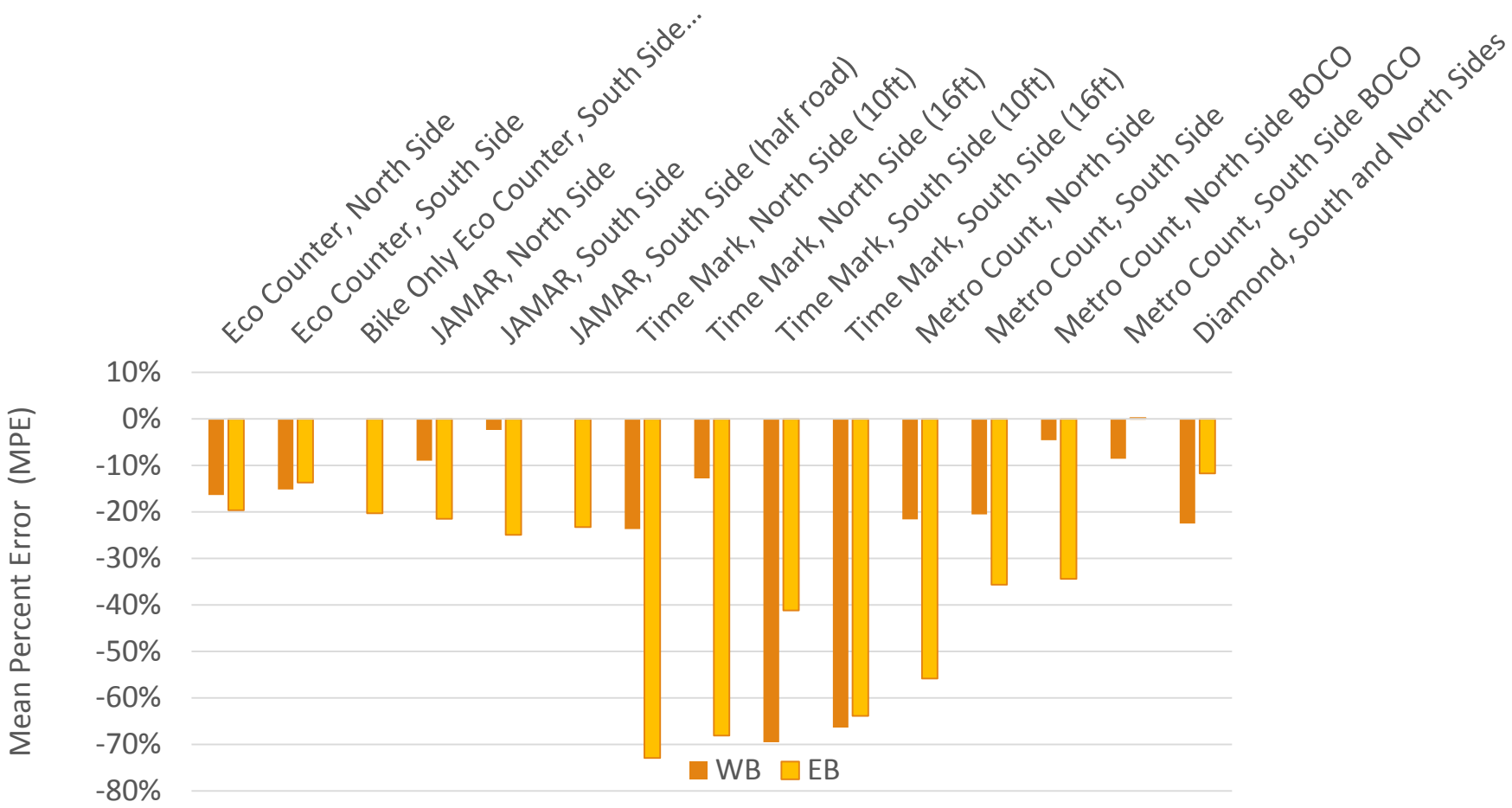
Historic Columbia River Hwy

RESULTS

Pneumatic Tube Counters Tested

Type	Make	Model	Tubes
Bicycle-specific	Eco-Counter	Bicycle-only Tubes	Road Tube
	Eco-Counter	Bicycle/motor vehicle Tubes	Road Tube
Classification	JAMAR Technologies, Inc.	TRAX Cycles Plus	Mini-tube
	Time Mark Corporation	Gamma	Road Tube
	MetroCount	MC5600	Mini-tube
Volume	Diamond Traffic Products	TT-6	Road Tube

Mixed Traffic



TSSU Results

Loops

Data from diamond loops was not useable due to adjustments in settings during test.

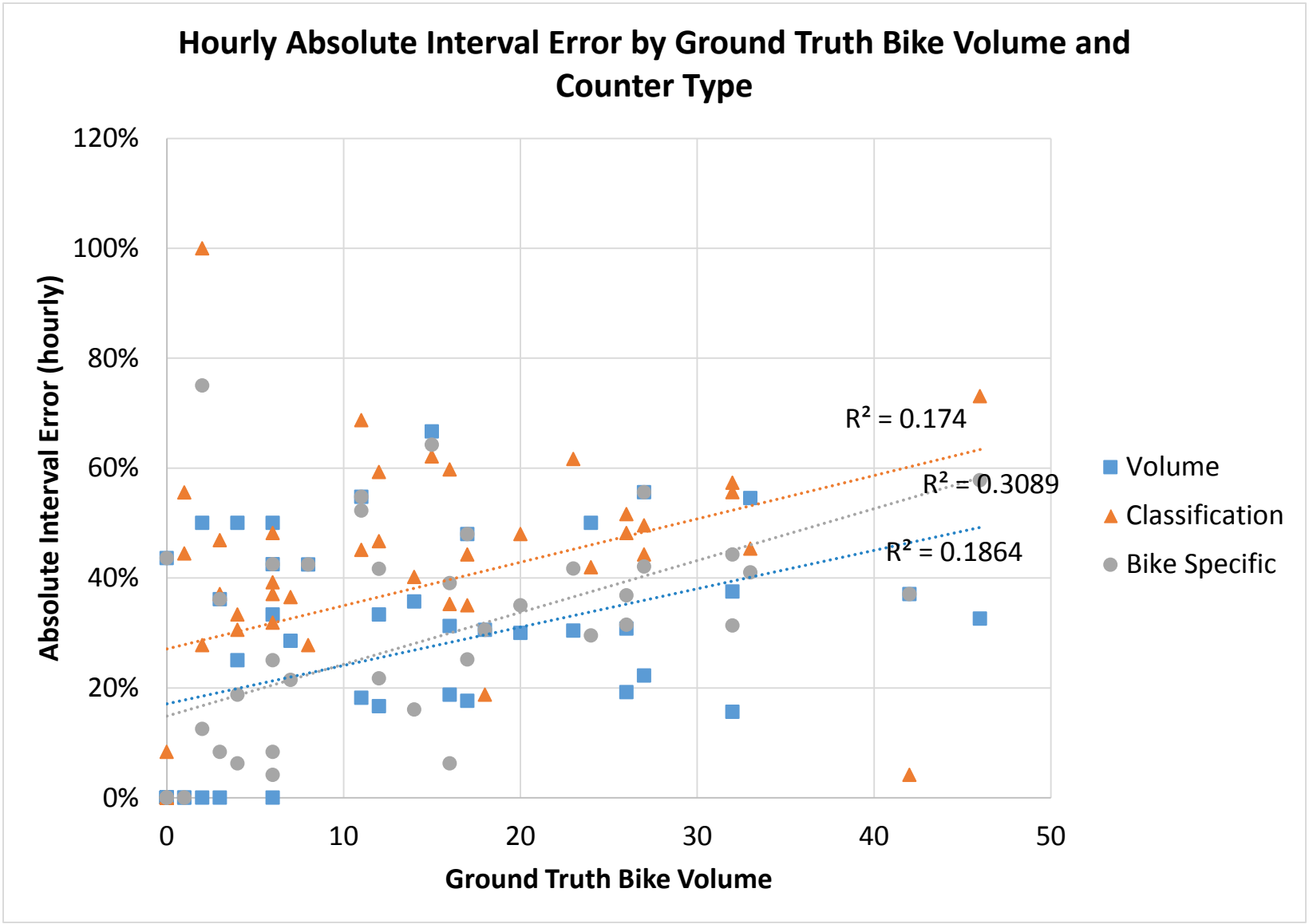
Parallelogram loops tested with two cards:

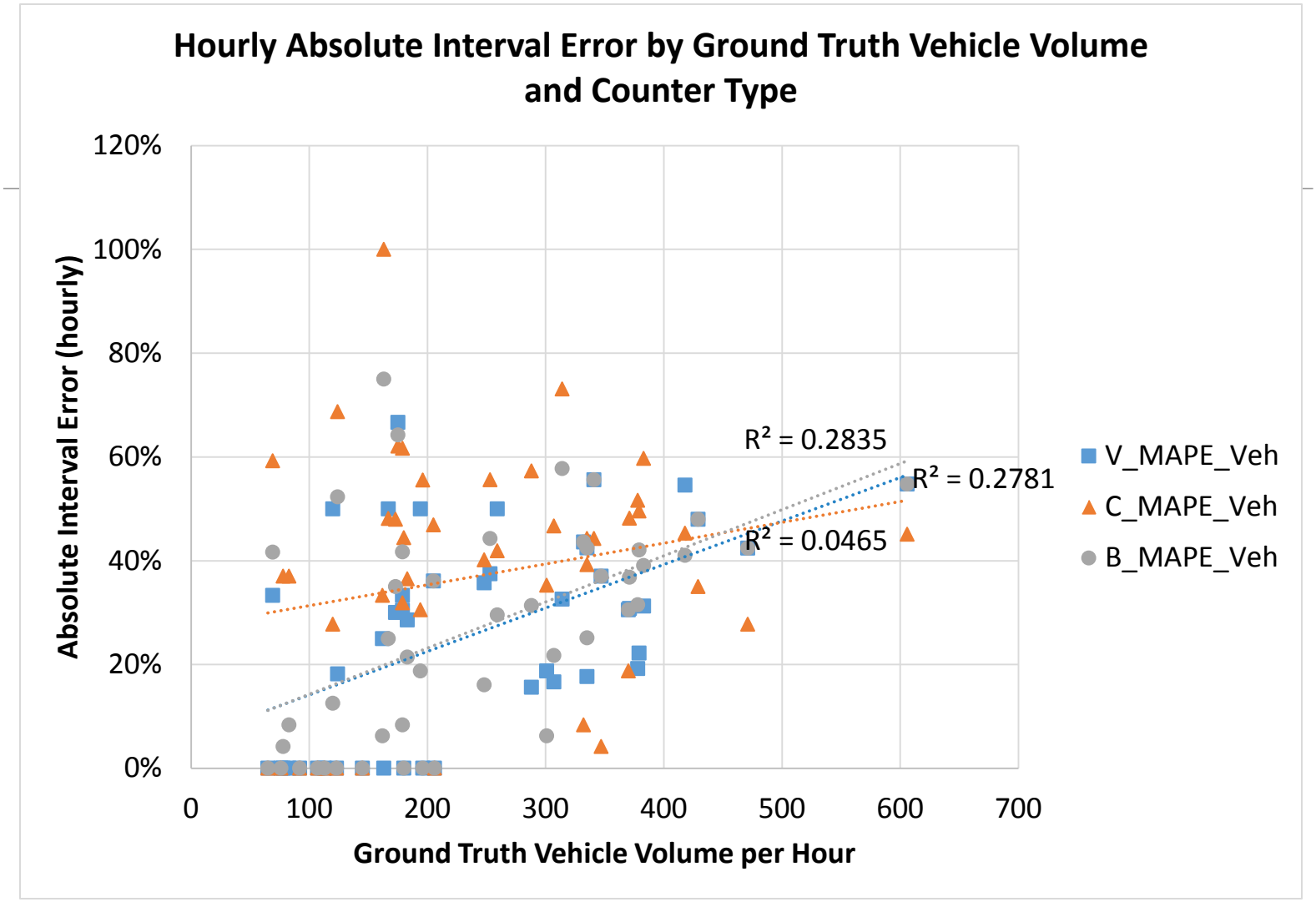
- Reno A&E 1101B
- EDI >50% error in center

TSSU – Tube Test Results

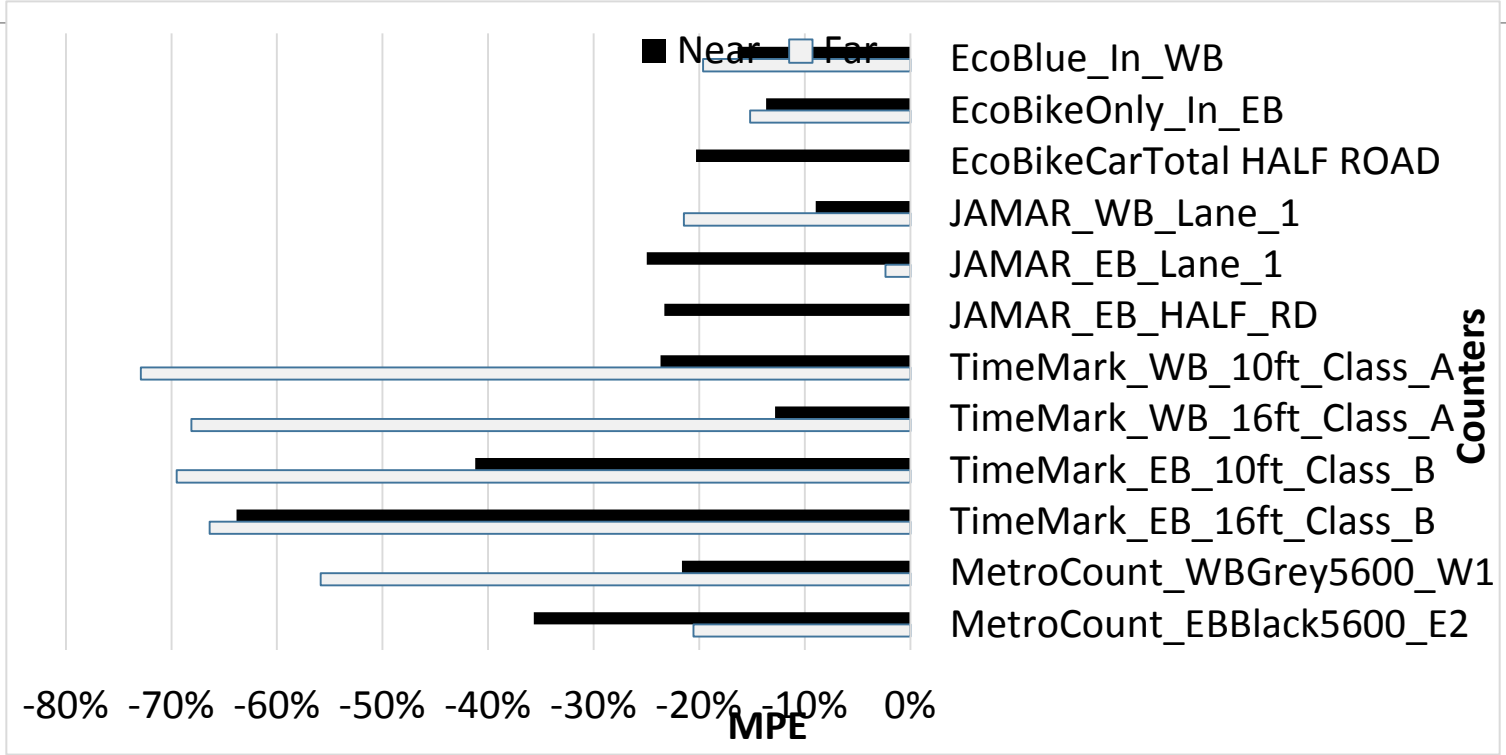
Type	Percent Overall Error by Zone (%)							MPE (%)	MAPE (%)
Zone	1	2	3	4	5	6	7		
n	69	85	92	95	93	90	73		
EcoCounter		0.0			-1.06		N/A	-0.6	1.7
Jamar CyclesPlus	1.5	0.0	0.0	-10.5	-38.0	-49.5	-26.0	-15.7	16.7
TimeMark	-7.3	0.0	-5.3	-6.3	-25.0	-53.9	-82.2	-16.2	16.6
MetroCount 5600 - ARXCycle	-7.3	-1.2	-18.1	-26.3	-63.0	-64.8	-98.6	-30.8	30.8
Daimond TT6	-11.6	6.0	3.2	N/A	N/A	N/A	N/A	-7.6	9.9

Analysis on Columbia River Hwy


Hourly Absolute Interval Error by Ground Truth Bike Volume and Counter Type
Absolute Interval Error (hourly)
120%
100%
80%
60%
40%
20%
0%
0
10
20
30
40
50
Ground Truth Bike Volume
R² = 0.174
R² = 0.3089
R² = 0.1864
Volume
Classification
Bike Specific


Hourly Absolute Interval Error by Ground Truth Vehicle Volume and Counter Type
Absolute Interval Error (hourly)
120%
100%
80%
60%
40%
20%
0%
0
100
200
300
400
500
600
700
Ground Truth Vehicle Volume per Hour
R² = 0.2835
R² = 0.2781
R² = 0.0465
V_MAPE_Veh
C_MAPE_Veh
B_MAPE_Veh

Error for Pneumatic Tube Counters in Mixed Traffic

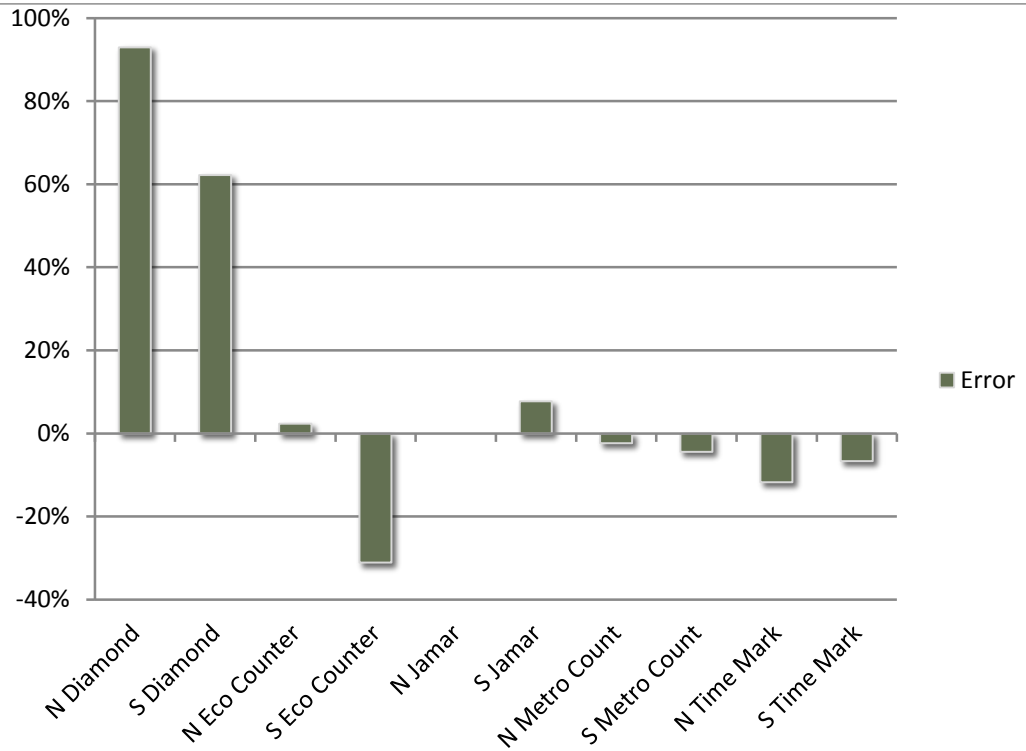


Summary of Error for Mixed Traffic Tube Test

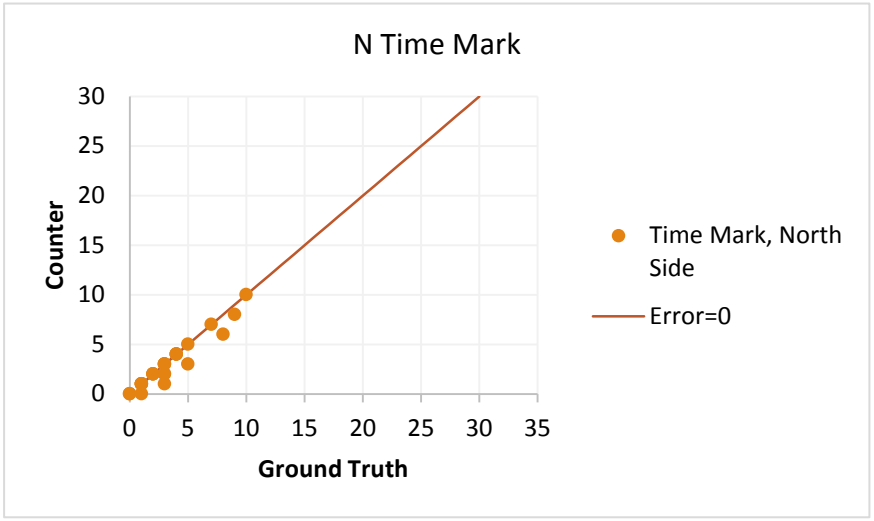
Counter Name	n	Bicycles Counted	Overall Error (%)	MPE (%)	MAPE (%)	Total Hourly Over Counts
Eco Counter, North Side	576	361	-37	-23	26	2
Eco Counter, South Side	576	378	-34	-20	23	3
Bike Only Eco Counter, South Side (half road)	300	183	-39	-20	26	2
JAMAR, North Side	576	409	-29	-18	22	9
JAMAR, South Side	576	400	-31	-13	31	15
JAMAR, South Side (half road)	300	185	-38	-23	24	1
Time Mark, North Side (10ft)	576	170	-70	-50	55	3
Time Mark, North Side (16ft)	576	200	-65	-44	50	12
Time Mark, South Side (10ft)	576	142	-75	-60	60	1
Time Mark, South Side (16ft)	576	79	-86	-73	73	3
Metro Count, North Side	576	236	-59	-43	43	0
Metro Count, South Side	576	288	-50	-32	32	0
Metro Count, North Side BOCO	576	380	-34	-28	29	1
Metro Count, South Side BOCO	576	495	-14	-10	10	1
Diamond, South and North Sides	576	425	-26	-20	27	20

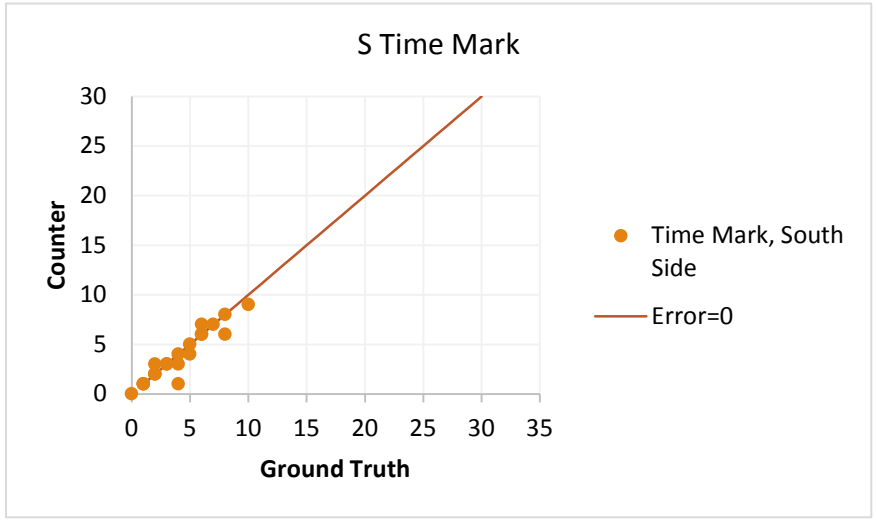
Analysis on Hall & 99W

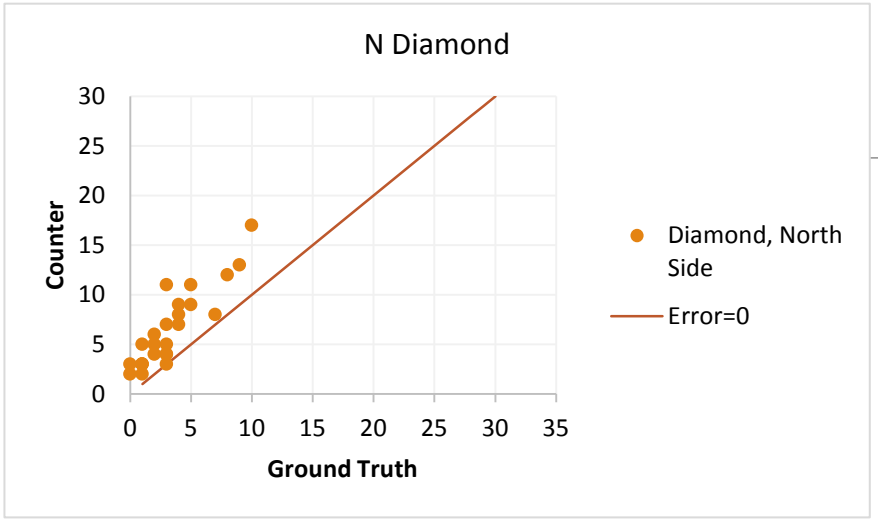
Error, All Tube Counters

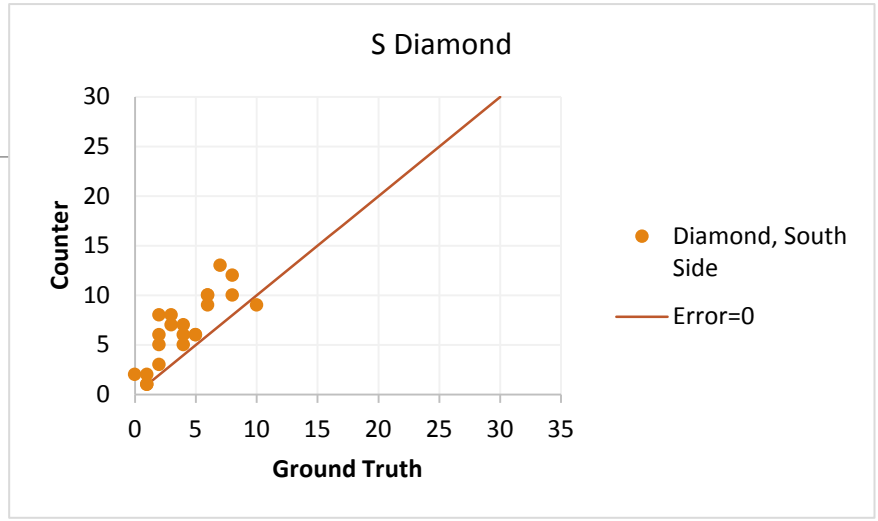


Hall & 99 Tube Results






N Diamond
Counter
Ground Truth
0
5
10
15
20
25
30
35
Diamond, North Side
Error=0


S Diamond
Counter
Ground Truth
0
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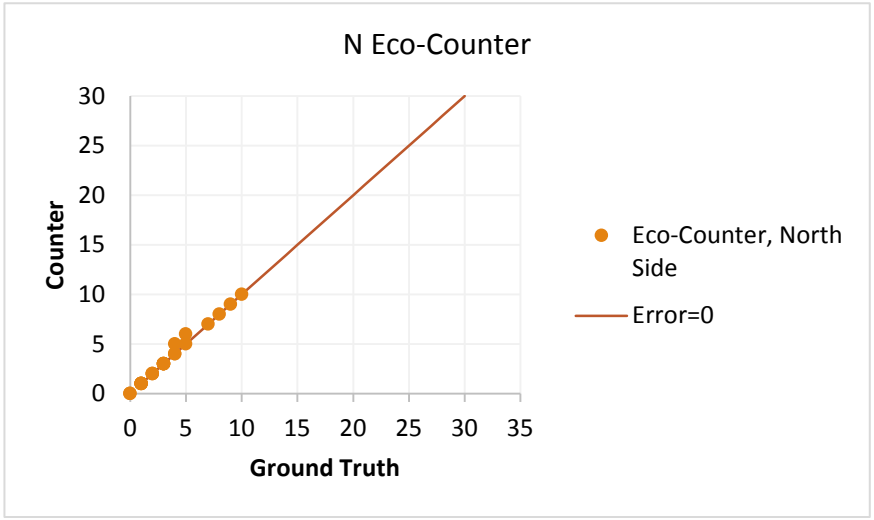
35
Diamond, South Side
Error=0


N Eco-Counter
Counter
Ground Truth
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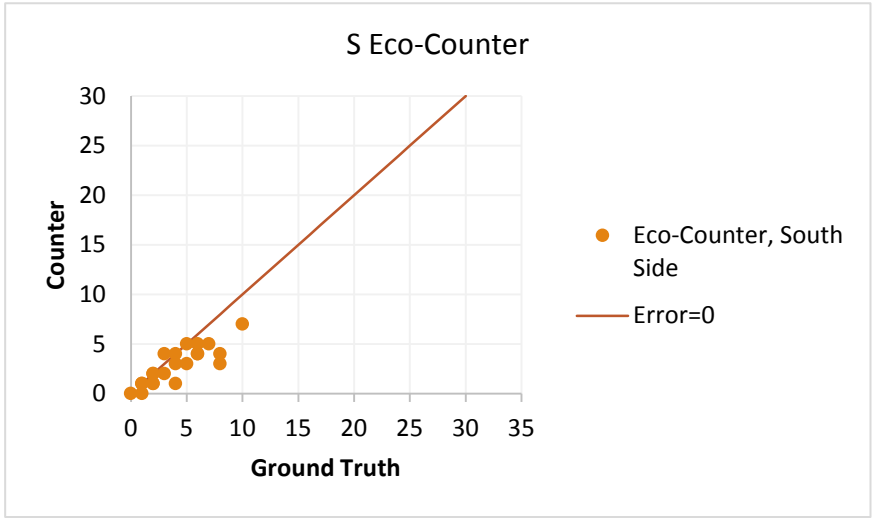
Eco-Counter, North Side
Error=0


S Eco-Counter
Counter
Ground Truth
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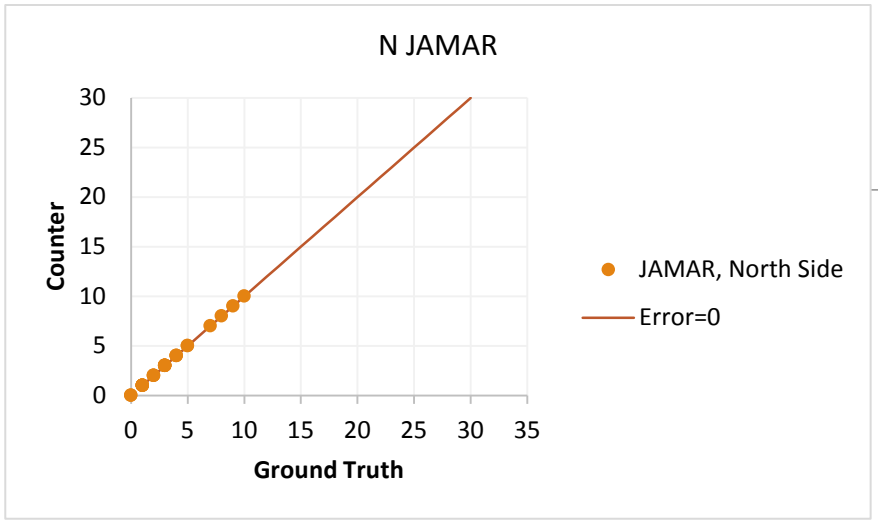
Eco-Counter, South Side
Error=0


N JAMAR
Counter
Ground Truth
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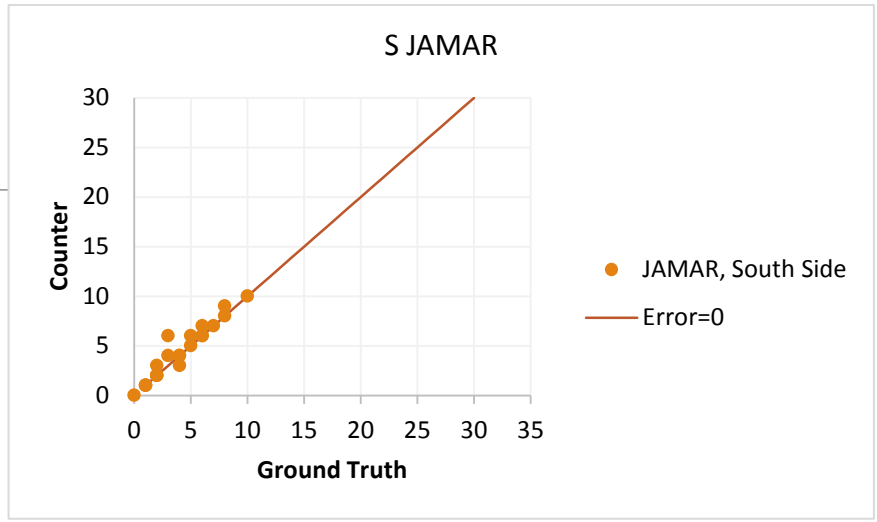
JAMAR, North Side
Error=0


S JAMAR
Counter
Ground Truth
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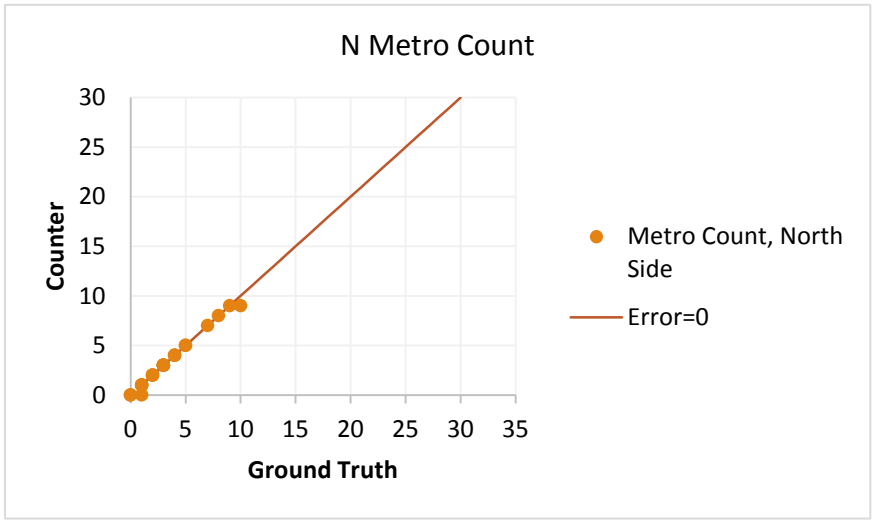
JAMAR, South Side
Error=0


N Metro Count
Counter
Ground Truth
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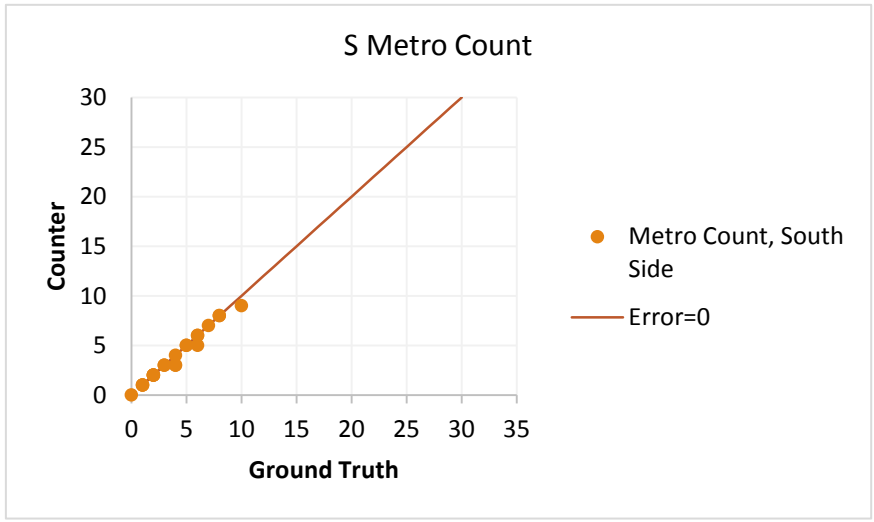
Metro Count, North Side
Error=0


S Metro Count
Counter
Ground Truth
0
5
10
15
20
25
30
35
Metro Count, South Side
Error=0

Criteria

GENERAL CONSIDERATIONS

- **Distance from Portland**
- Traffic volume (AADT): A high volume and a low volume location are desired.
- Location of poles for mounting cameras or infrared (away from sources of heat)
- Availability of inputs in controller for adding detection in parallel
- Surrounding land use – More urban is better
- Already has a video camera for data collection
- Sidewalks
- Six phases or fewer

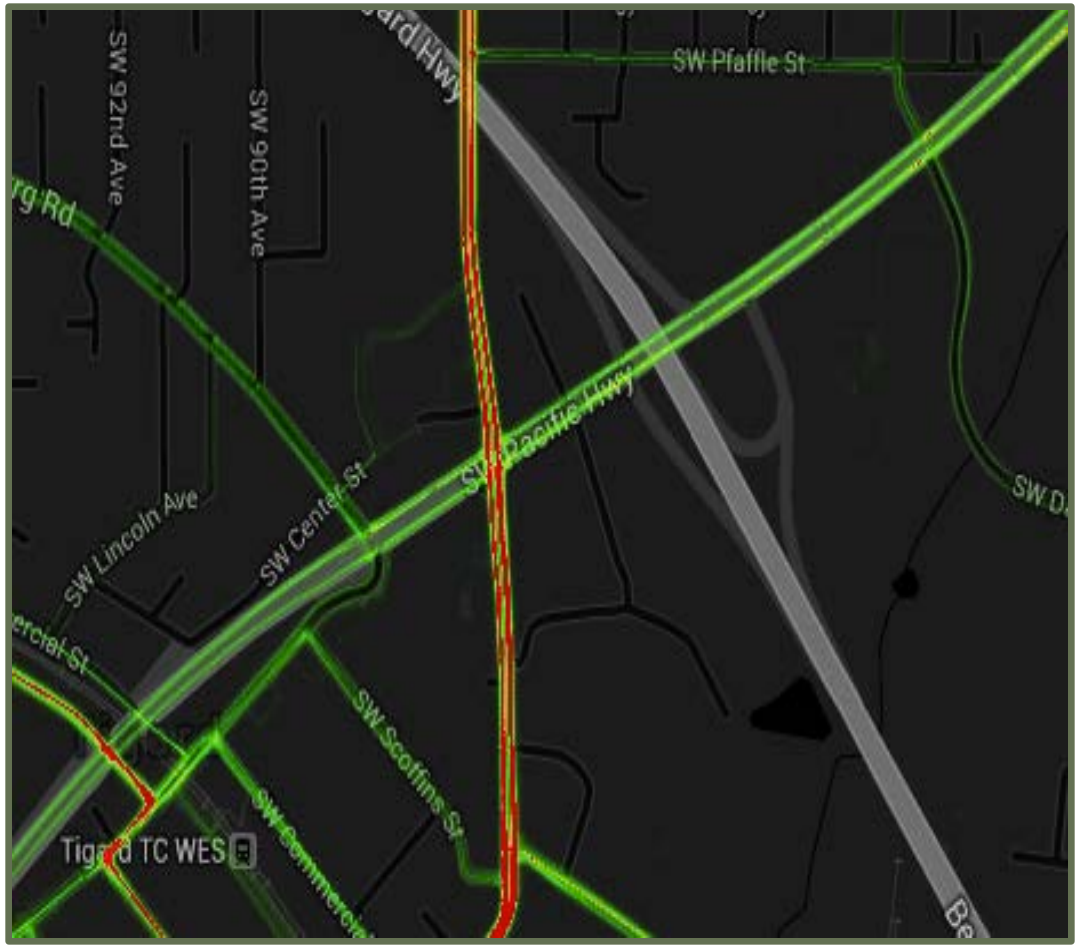
FOR BICYCLES

- **Bicycle traffic volume - Higher is better (100/day minimum ideally)**
- **Presence of bicycle lane**
- **Existing inductive loops for bicycle detection**
- Presence of FLIR camera or possibility of adding one
- Volume of right turning traffic (low is good)

FOR PEDS

- **Availability of push buttons**
- Pedestrian volume – Higher is better
- Presence of bus stops
- Crosswalks

99W and Hall Blvd., Tigard



Pilot test
Preliminary Results


ODOT
TRAFFIC SYSTEMS
SERVICES UNIT
2445 LIBERTY ST NE

Combined Bicycle and Pedestrian Continuous Counter

Source: Pam Johnson, ODOT

Combined Bicycle and Pedestrian Continuous Counter

EcoCounter

Introduction

Portland State UNIVERSITY

ODOT PROJECT SPR 754

Design And Implementation Of Pedestrian and Bicycle-specific Data Collection Methods In Oregon

Dr. Miguel Figliozzi
Dr. Christopher Monsere
Dr. Krista Nordback
Pam Johnson
Bryan Blanc

56

Design and Implementation of Pedestrian and Bicycle Specific Data Collection Methods in Oregon

Data Collection Pilot Project

ODOT TAC Meeting

November 4, 2013

Portland State UNIVERSITY

Automated Bicycle Counts - Portland

- Inductive loops are most common

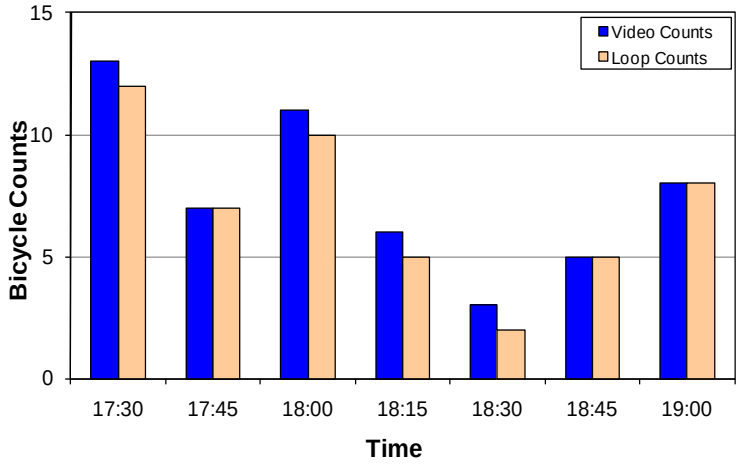
Stop Bar Loop

Advance Loop

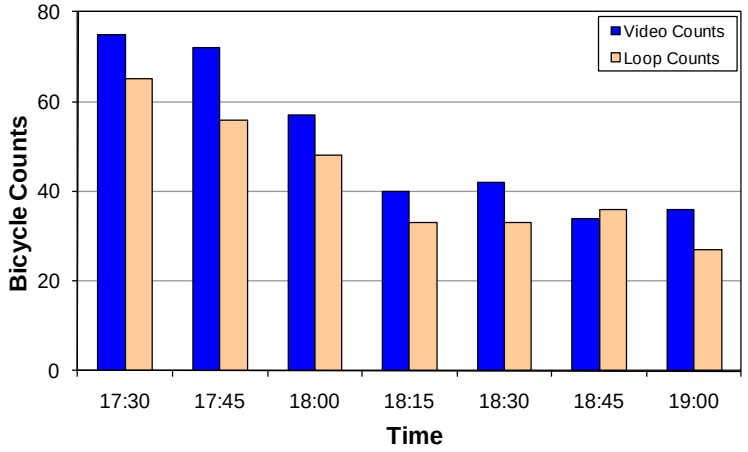
- Conditions that have to be met
  - Presence of bicycle lane
  - Presence of advance loop in bike lane
  - Presence of individual loop wire

Verification of Bicycle Counts

- Verification is needed to ensure accuracy
  - Undercounting bicycles
  - %Bikes Counted 97%, 87%
  - Error (MAPE) 17%, 18%



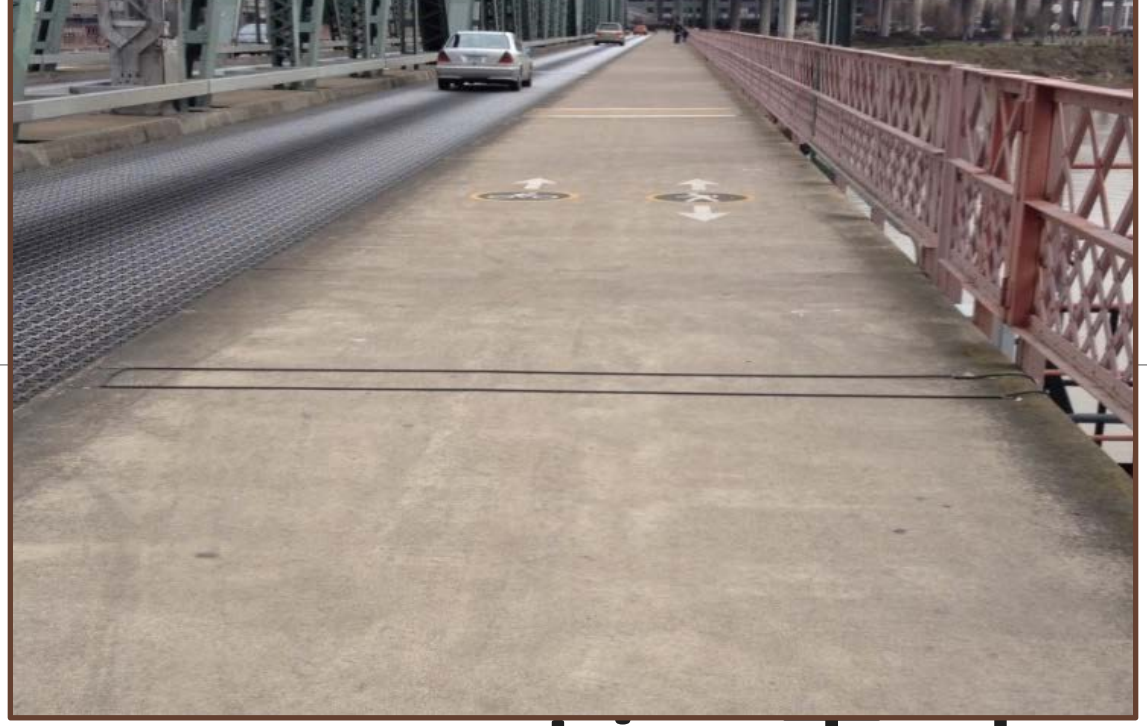
Inbound Bicycle Counts



Outbound Bicycle Counts

Portland Inductive Loops

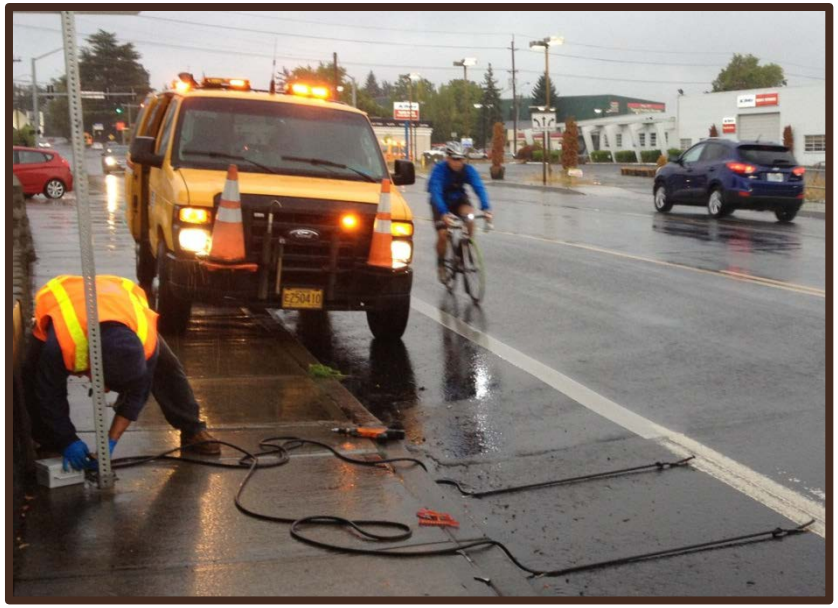
Location	% Bike Counted	Mean Absolute Percent Error (MAPE)
N Wheeler Ave., N. Williams Ave and N. Winning Way Kothuri 2012	97%, 87%	17%, 18%
Lovejoy at NW 9th Ave Lindsey 2014	98%	1%
Couch & Grand Lindsey 2014	83%	18%
Broadway & Williams Lindsey 2014	104%	8%
Weidler & 2nd Lindsey 2014	103%	7%
Average	**95%**	**12%**

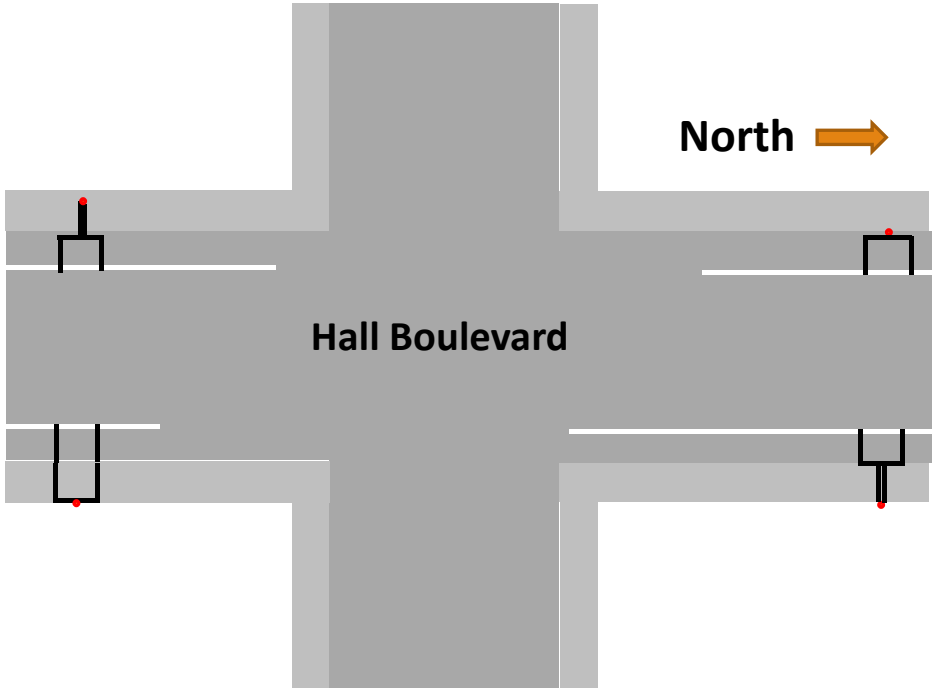


Pneumatic Tubes

Preliminary Site Prep

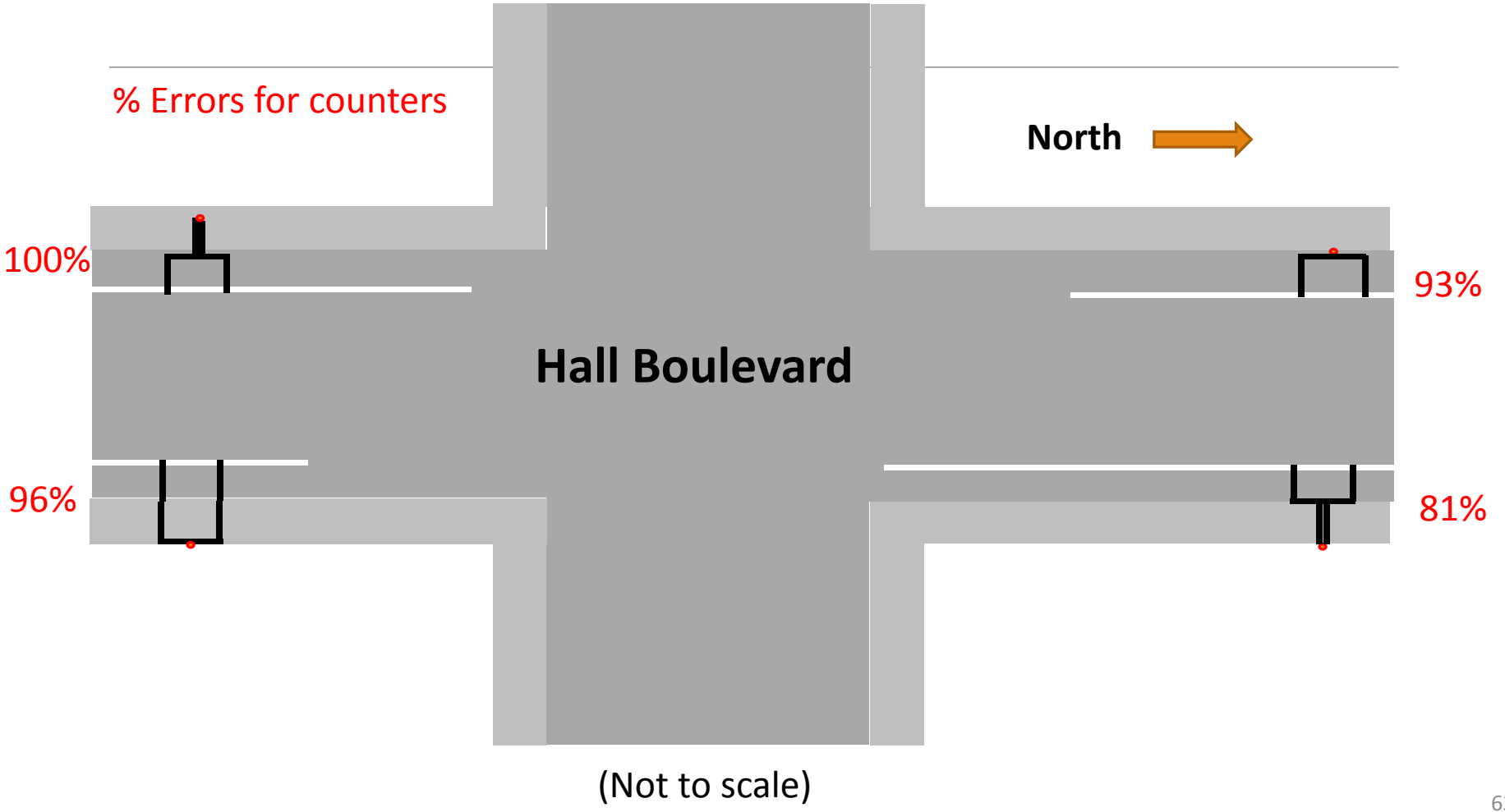
ODOT Tube Configurations





(Not to scale)

Analysis- Bicycle Tubes

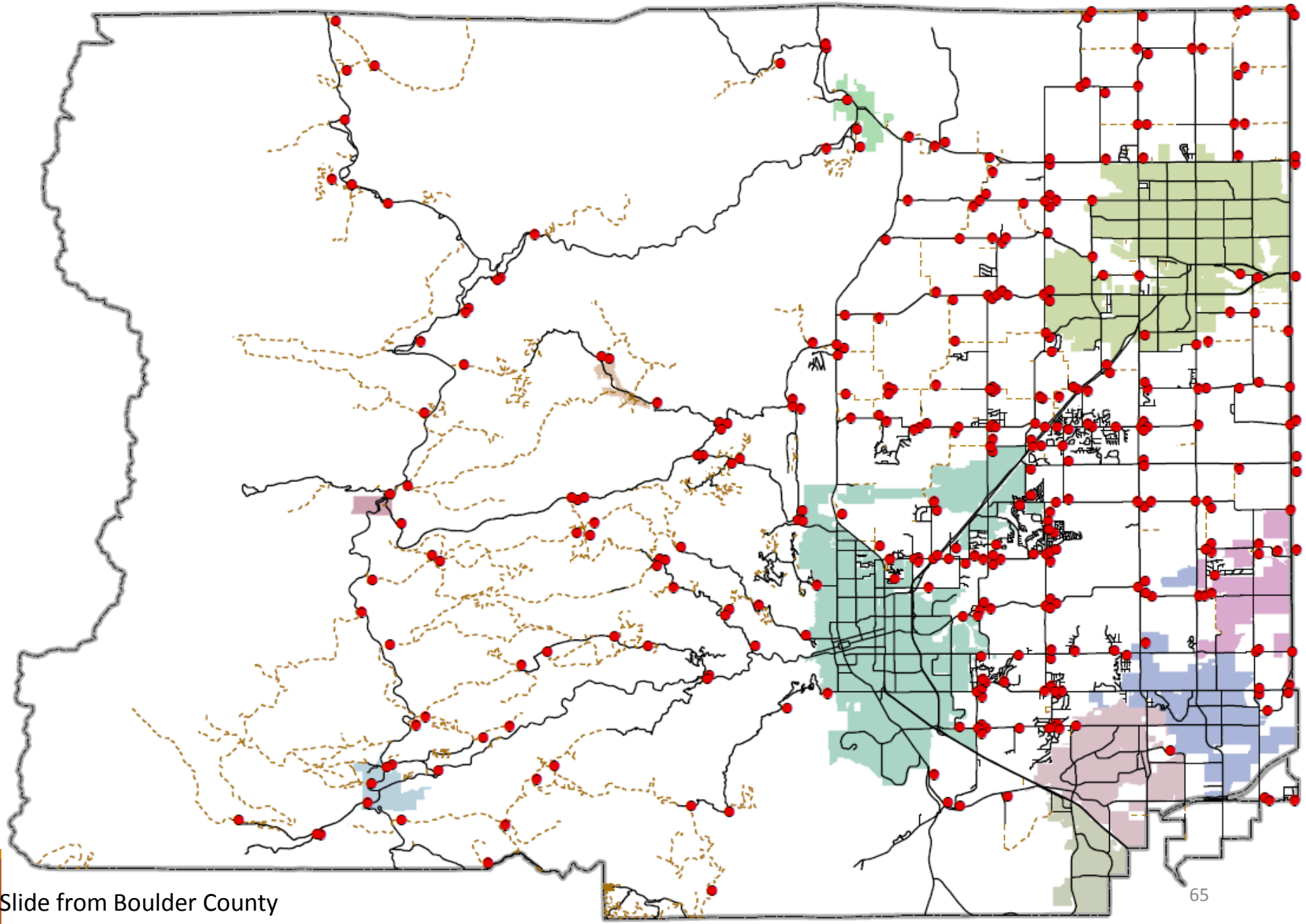


Boulder County Colorado

ALEX HYDE-WRIGHT, BICYCLE PLANNER/EMPLOYEE TRANSPORTATION COORDINATOR

BRIAN GRAHAM, FLOOD RECOVERY COORDINATOR

Boulder County Traffic Stations



Slide from Boulder County

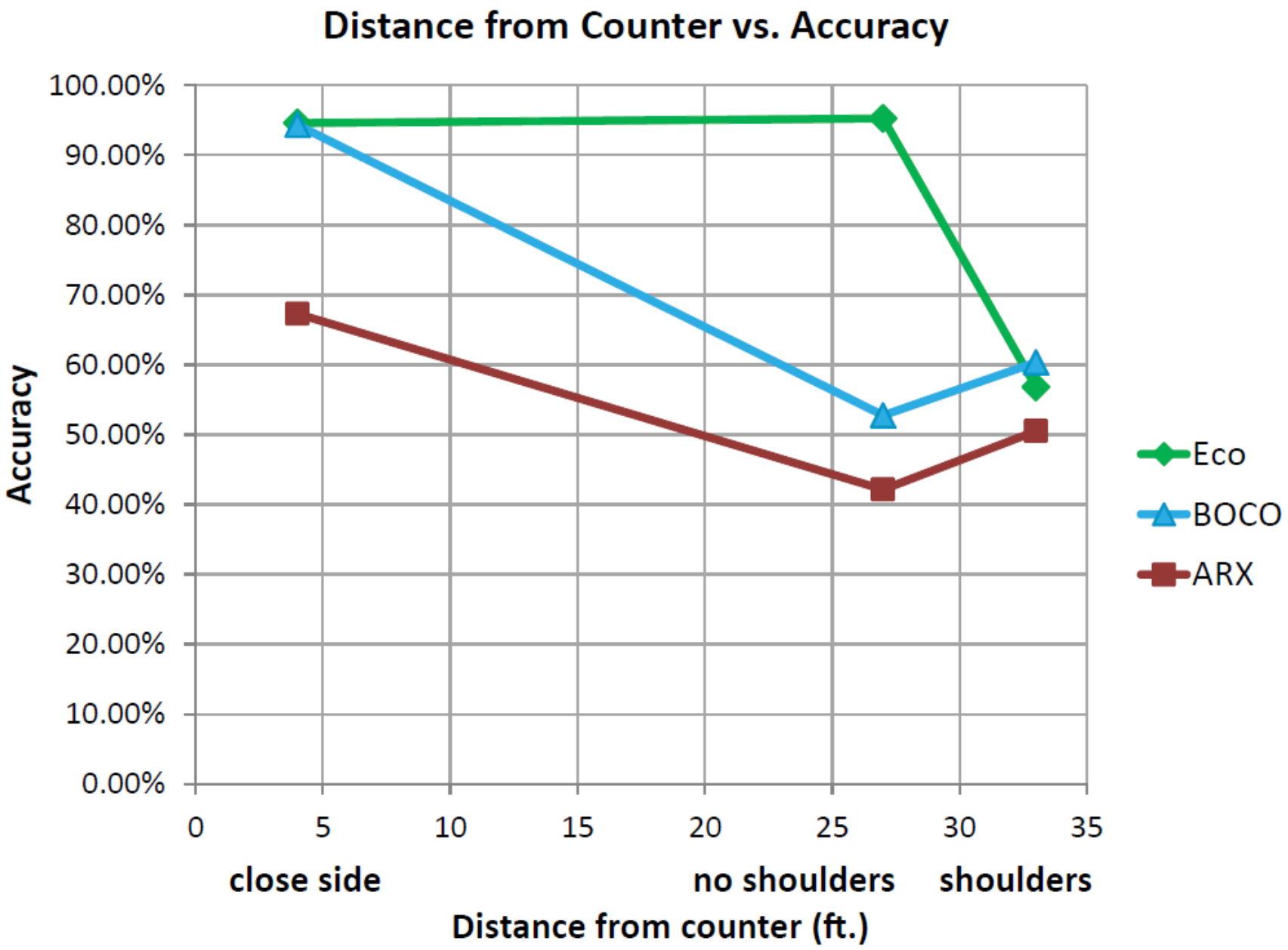
beta Test-
Attachment Methods and Counters Studied

MetroCount: clear vinyl sleeve

Eco-Counter: metal bracket

Slide from Boulder County

Slide from Boulder County



Slide from Boulder County

Ingredients for Success

Use thinner walled “bicycle” tubes

Avoid pinching tube with securing strap

Use “BOCO Classification Scheme” instead of ARX Cycle (available for free)

http://www.pdx.edu/ibpi/short-duration-count-program

Or contact:

Alex Hyde-Wright
Transportation Engineering Assistant
Boulder County Transportation Department
303.441.4910
ahyde-wright@bouldercounty.org

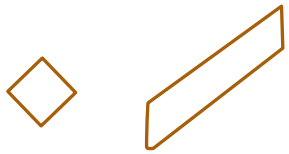
On-line Guide

www.pdx.edu/ibpi/count

Technologies Tested

Pneumatic tubes

Inductive loops
- Diamond
- Parallelogram



Thermal camera

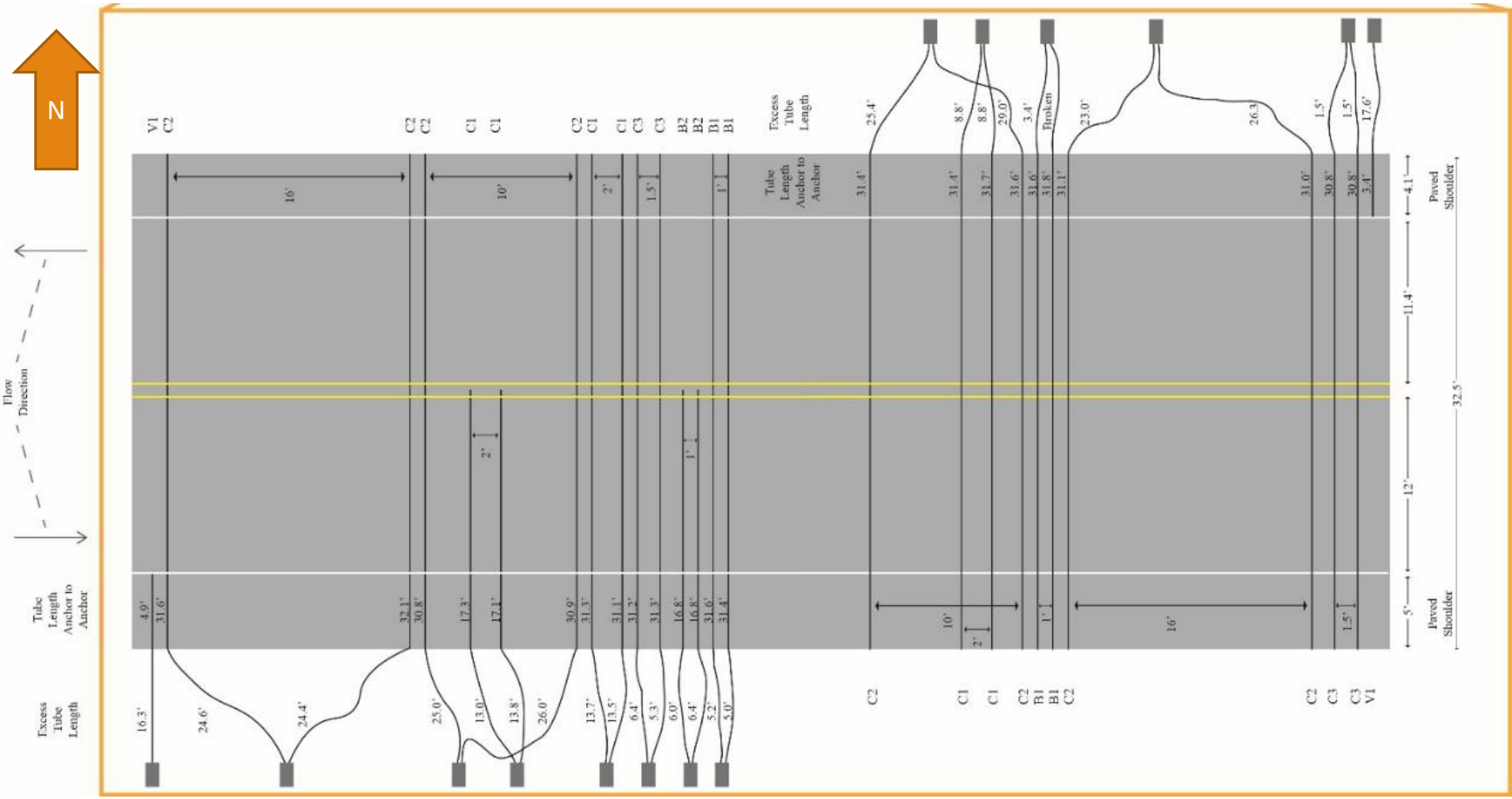
Pedestrian pushbutton

Passive infrared

Recommendation Matrix for Short Duration Counts from Testing

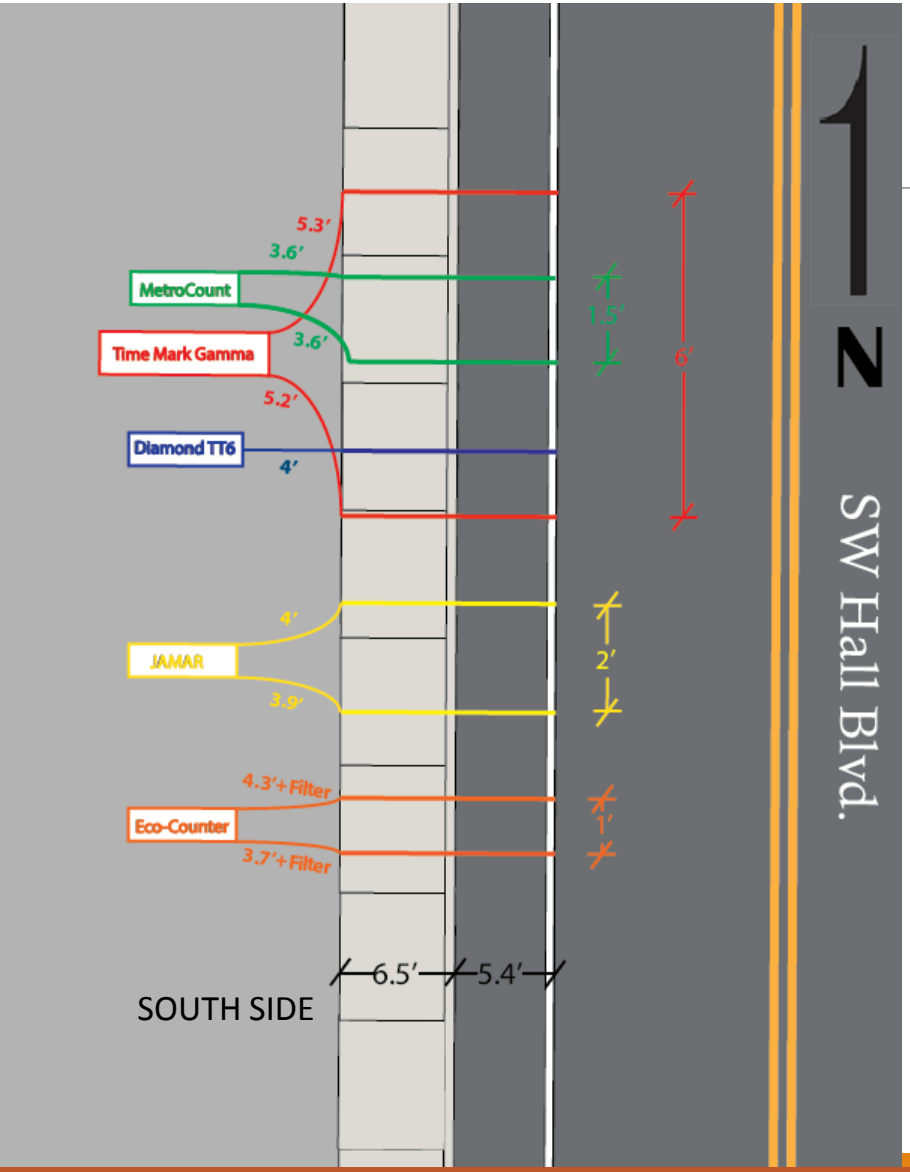
Facility	Bicycles	Pedestrian
Pedestrian Only Facilities (sidewalks, trails)	N/A	Infrared (most accurate for low pedestrian traffic sites)
Bicycle Only Facilities (cycle tracks, separated bike lanes)	Tubes –All types	N/A
Bike-Ped Paths & Sidewalks	Tubes – bike specific and classification	Passive infrared (reference) Combine with tubes to distinguish bicycles.
Shoulders and Bike Lanes	Tubes – bike specific and classification	N/A
Roadways (mixed traffic) low volume	Tubes – classification counters low volume roads	N/A
Roadways (mixed traffic) medium to high volume	None recommended	N/A
Intersections	-	Pushbutton for ped activity

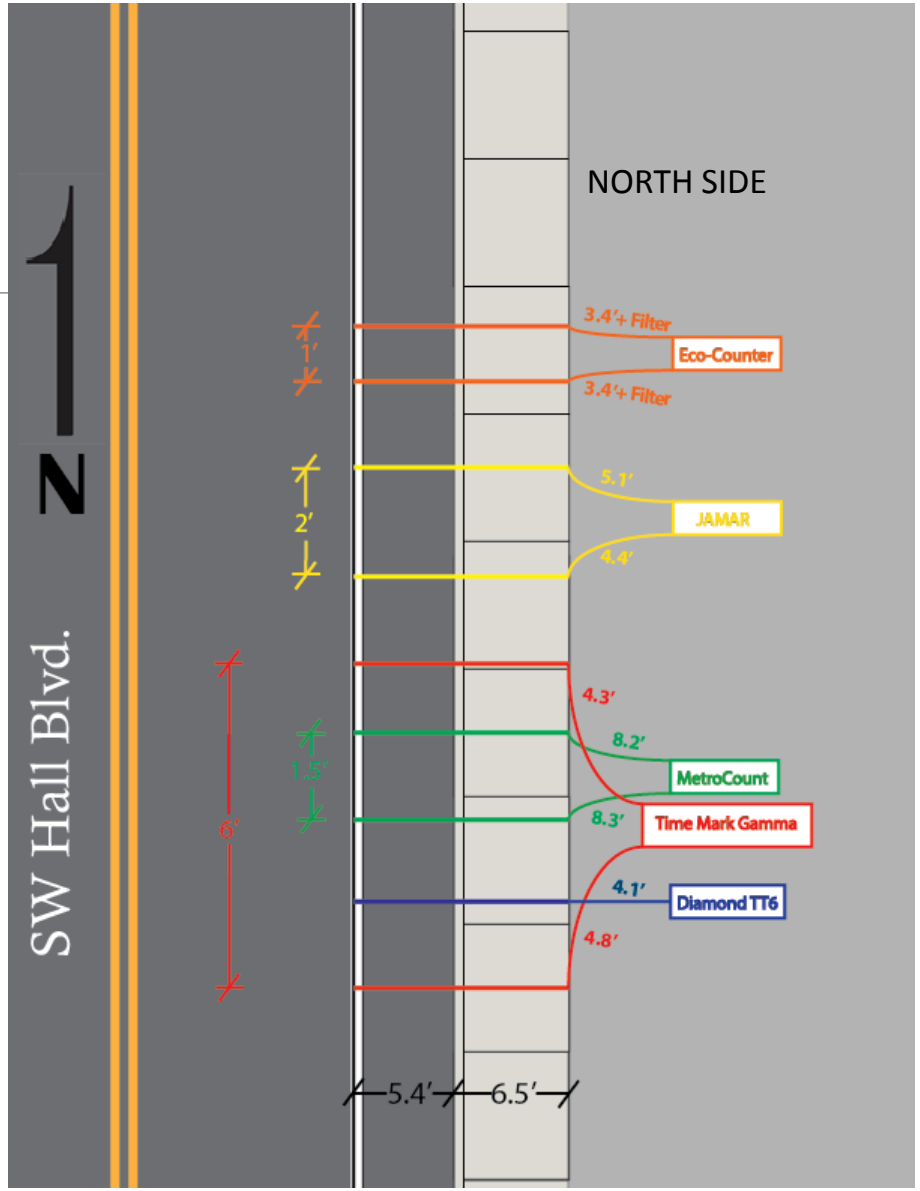
Historic Columbia River Highway Tube Test



Historic Columbia River Highway Test

Hall & 99 W in Tigard


SW Hall Blvd.
N
5.3′
3.6′
MetroCount
3.6′
Time Mark Gamma
5.2′
Diamond TT6
4′
4′
JAMAR
3.9′
4.3′+ Filter
Eco-Counter
3.7′+ Filter
1.5′
6′
2′
1′
6.5′
5.4′
SOUTH SIDE


SW Hall Blvd.
N
NORTH SIDE
1′
3.4′+ Filter
Eco-Counter
3.4′+ Filter
2′
5.1′
JAMAR
4.4′
6′
1.5′
4.3′
8.2′
MetroCount
8.3′
Time Mark Gamma
4.1′
Diamond TT6
4.8′
5.4′
6.5′

Special Cases Tube Test

Tube Counter	Tandem, Bike with Trailer		Carbon Fiber, Cargo Bicycle		Standard bicycles: One behind the Other		Standard bicycles: Side by Side	
	n	Overall Error (%)	n	Overall Error (%)	n	Overall Error (%)	n	Overall Error (%)
EcoCounter	24	-75	24	-4	68	-74	70	-59
Jamar CyclesPlus	46	-50	54	-50	116	-2	118	-46
TimeMark	46	-4	54	-6	116	-65	118	-38
MetroCount 5600 - ARXCycle	46	-96	54	-56	116	-95	118	-57
Daimond TT6	46	4	54	-9	116	-4	118	-36