Bicycle Counts Using Pneumatic Tubes

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Taylor Phillips
Andrew Schrope
Carson Gorecki

TREC and Civil & Environmental Eng. Dept.
Portland State University
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

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

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

- 28 Tubes
- Low motor vehicle traffic
- 576 bicyclists during study
Mixed Traffic – Tube Error

Hourly Absolute Interval Error by Ground Truth Bike Volume and Counter Type

- Volume Only
- Classification
- Bicycle Specific
- Combined Trend

$R^2 = 0.4325$
Mixed Traffic – Tube Error

![Graph showing Absolute Interval Error vs. Ground Truth Motor Vehicle Volume]

- **Volume Only**
- **Classification**
- **Bicycle Specific**
- **Combined Trend**

\[ R^2 = 0.2347 \]
Causes for Undercounts

Cyclists riding side-by-side
Cars passing cyclists crossing tubes
## Bicycle Speed

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Average Bicycle Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eastbound</td>
</tr>
<tr>
<td>Jamar, south side, (total)</td>
<td>13.3</td>
</tr>
<tr>
<td>Jamar, north side, (total)</td>
<td>12.5</td>
</tr>
<tr>
<td>Jamar half road, south side, near (EB)</td>
<td>12.1</td>
</tr>
<tr>
<td>TimeMark, south side, 16ft, (total)</td>
<td>13.8</td>
</tr>
<tr>
<td>TimeMark, north side, 16ft, (total)</td>
<td>13.2</td>
</tr>
<tr>
<td>TimeMark, south side, 10ft, (total)</td>
<td>12.6</td>
</tr>
<tr>
<td>TimeMark, north side, 10ft, (total)</td>
<td>13.2</td>
</tr>
<tr>
<td>MetroCount, south side BOCO, (total)</td>
<td>13.0</td>
</tr>
<tr>
<td>MetroCount, north side BOCO, (total)</td>
<td>13.4</td>
</tr>
<tr>
<td>All Counter Average</td>
<td>12.9</td>
</tr>
<tr>
<td>Manual (Video)</td>
<td>12.1</td>
</tr>
</tbody>
</table>
Tube Tests

Hall and 99 W, Tigard

Bike lane and Sidewalk

Mini-tubes <20 feet long

Camera Location
Bike Lane & Sidewalk

Mean Percent Error (MPE)

-50% 0% 50% 100% 150% 200%

N Diamond  S Diamond  N Eco Counter  S Eco Counter  N Jamar  S Jamar  N Metro Count  S Metro Count  N Time Mark  S Time Mark
More Accurate Counters

![Chart showing Mean Percent Error (MPE) for different counters. The chart compares 'New Scheme' and 'BOCO Scheme' with 'N Eco Counter', 'S Eco Counter', 'N Jamar', 'S Jamar', 'N Metro Count', 'S Metro Count', 'N Time Mark', and 'S Time Mark'. The chart indicates that 'New Scheme' generally results in lower mean percent error compared to 'BOCO Scheme'.]
Causes for Overcounting by Classification Tube Counters

<table>
<thead>
<tr>
<th>Reasons</th>
<th>C1</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car in bike lane</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ped steps on tubes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skateboard</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Stroller</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Causes for Undercounting by Classification Tube Counters

<table>
<thead>
<tr>
<th>Number of Occurrences</th>
<th>Reason</th>
<th>C1</th>
<th>C3</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Bike swerves over tubes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Cyclist exits bike lane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No apparent reason bike lane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No apparent reason sidewalk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Bikes riding closely together</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Stopped over tubes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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)
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

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- Lyn Cornell, former Chair
- Mark Joerger, current Chair
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- Dave Hirsch
- Don Crownover
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Tube Test: Dara Gayler, Will Adams, Phillip Armand, and Rick Hindle and all the vendors.

Hall & 99W Test: Tiffany Slauter, Mike Casper, Tim Damm
Questions

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Sirisha Kothuri, skothuri@pdx.edu
Taylor Phillips, tphill2@pdx.edu
Controlled Environment Test

ODOT Traffic Systems Service Unit in Salem

Source: Google Maps

Diagram:
- Tubes
- Parallelogram Loop
- Start/Stop Point
- FLIR Camera
- Sensys
- Video Cameras
- Diamond Loops
Historic Columbia River Hwy

RESULTS
# Pneumatic Tube Counters Tested

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

Mean Percent Error (MPE)

-80% -70% -60% -50% -40% -30% -20% -10% 0% 10%

WB EB

Eco Counter, North Side
Eco Counter, South Side
Bike Only Eco Counter, South Side
JAMAR, North Side
JAMAR, South Side
Time Mark, North Side
Time Mark, South Side (half road)
Time Mark, South Side (10ft)
Time Mark, South Side (16ft)
Time Mark, North Side (10ft)
Time Mark, North Side (16ft)
Metro Count, North Side
Metro Count, South Side
Metro Count, North Side BOCO
Metro Count, South Side BOCO
Diamond, South and North Sides
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Percent Overall Error by Zone (%)</th>
<th>MPE (%)</th>
<th>MAPE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Zone n</td>
<td></td>
<td>69</td>
<td>85</td>
</tr>
<tr>
<td>EcoCounter</td>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Jamar CyclesPlus</td>
<td></td>
<td>1.5</td>
<td>0.0</td>
</tr>
<tr>
<td>TimeMark</td>
<td></td>
<td>-7.3</td>
<td>0.0</td>
</tr>
<tr>
<td>MetroCount 5600 - ARX Cycle</td>
<td></td>
<td>-7.3</td>
<td>-1.2</td>
</tr>
<tr>
<td>Daimond TT6</td>
<td></td>
<td>-11.6</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Analysis on Columbia River Hwy
Hourly Absolute Interval Error by Ground Truth Bike Volume and Counter Type

![Graph showing scatter plot with Ground Truth Bike Volume on the x-axis and Absolute Interval Error (hourly) on the y-axis. Different markers represent Volume, Classification, and Bike Specific counter types. The graph includes R² values: R² = 0.174, R² = 0.3089, and R² = 0.1864.](image)
Hourly Absolute Interval Error by Ground Truth Vehicle Volume and Counter Type

Absolute Interval Error (hourly)

Ground Truth Vehicle Volume per Hour

- $R^2 = 0.2781$
- $R^2 = 0.0465$
- $R^2 = 0.2835$
Error for Pneumatic Tube Counters in Mixed Traffic

-80% -70% -60% -50% -40% -30% -20% -10% 0%

EcoBlue_In_WB
EcoBikeOnly_In_EB
EcoBikeCarTotal HALF ROAD
JAMAR_WB_Lane_1
JAMAR_EB_Lane_1
JAMAR_EB_HALF_RD
TimeMark_WB_10ft_Class_A
TimeMark_WB_16ft_Class_A
TimeMark_EB_10ft_Class_B
TimeMark_EB_16ft_Class_B
MetroCount_WBGrey5600_W1
MetroCount_EBBlack5600_E2
## Summary of Error for Mixed Traffic Tube Test

<table>
<thead>
<tr>
<th>Counter Name</th>
<th>n</th>
<th>Bicycles Counted</th>
<th>Overall Error (%)</th>
<th>MPE (%)</th>
<th>MAPE (%)</th>
<th>Total Hourly Over Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco Counter, North Side</td>
<td>576</td>
<td>361</td>
<td>-37</td>
<td>-23</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>Eco Counter, South Side</td>
<td>576</td>
<td>378</td>
<td>-34</td>
<td>-20</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Bike Only Eco Counter, South Side (half road)</td>
<td>300</td>
<td>183</td>
<td>-39</td>
<td>-20</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>JAMAR, North Side</td>
<td>576</td>
<td>409</td>
<td>-29</td>
<td>-18</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>JAMAR, South Side</td>
<td>576</td>
<td>400</td>
<td>-31</td>
<td>-13</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td>JAMAR, South Side (half road)</td>
<td>300</td>
<td>185</td>
<td>-38</td>
<td>-23</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Time Mark, North Side (10ft)</td>
<td>576</td>
<td>170</td>
<td>-70</td>
<td>-50</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td>Time Mark, North Side (16ft)</td>
<td>576</td>
<td>200</td>
<td>-65</td>
<td>-44</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Time Mark, South Side (10ft)</td>
<td>576</td>
<td>142</td>
<td>-75</td>
<td>-60</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>Time Mark, South Side (16ft)</td>
<td>576</td>
<td>79</td>
<td>-86</td>
<td>-73</td>
<td>73</td>
<td>3</td>
</tr>
<tr>
<td>Metro Count, North Side</td>
<td>576</td>
<td>236</td>
<td>-59</td>
<td>-43</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>Metro Count, South Side</td>
<td>576</td>
<td>288</td>
<td>-50</td>
<td>-32</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Metro Count, North Side BOCO</td>
<td>576</td>
<td>380</td>
<td>-34</td>
<td>-28</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>Metro Count, South Side BOCO</td>
<td>576</td>
<td>495</td>
<td>-14</td>
<td>-10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Diamond, South and North Sides</td>
<td>576</td>
<td>425</td>
<td>-26</td>
<td>-20</td>
<td>27</td>
<td>20</td>
</tr>
</tbody>
</table>
Analysis on Hall & 99W
Error, All Tube Counters

[Bar chart showing error percentages for different tube counters]
Hall & 99 Tube Results

N Time Mark

S Time Mark

Counter

Ground Truth

Counter

Ground Truth

Time Mark, North Side

Time Mark, South Side

Error=0

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
Combined Bicycle and Pedestrian Continuous Counter

Source: Pam Johnson, ODOT
Combined Bicycle and Pedestrian Continuous Counter

EcoCounter
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
Data Collection Pilot Project

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

ODOT TAC Meeting
November 4, 2013
Automated Bicycle Counts - Portland

- Inductive loops are most common

- 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

N Wheeler Ave., N. Williams Ave and N. Winning Way 3-leg intersection
## Portland Inductive Loops

<table>
<thead>
<tr>
<th>Location</th>
<th>% Bike Counted</th>
<th>Mean Absolute Percent Error (MAPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Wheeler Ave., N. Williams Ave and N.</td>
<td>97%, 87%</td>
<td>17%, 18%</td>
</tr>
<tr>
<td>Winning Way Kothuri 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lovejoy at NW 9th Ave Lindsey 2014</td>
<td>98%</td>
<td>1%</td>
</tr>
<tr>
<td>Couch &amp; Grand Lindsey 2014</td>
<td>83%</td>
<td>18%</td>
</tr>
<tr>
<td>Broadway &amp; Williams Lindsey 2014</td>
<td>104%</td>
<td>8%</td>
</tr>
<tr>
<td>Weidler &amp; 2nd Lindsey 2014</td>
<td>103%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>95%</strong></td>
<td><strong>12%</strong></td>
</tr>
</tbody>
</table>
Pneumatic Tubes
Preliminary Site Prep

ODOT Tube Configurations

(Not to scale)
Analysis - Bicycle Tubes

% Errors for counters

North

Hall Boulevard

(Not to scale)
Alex Hyde-Wright, Bicycle Planner/Employee
Transportation Coordinator

Brian Graham, Flood Recovery Coordinator

beta Test-Attachment Methods and Counters Studied

MetroCount: clear vinyl sleeve

Eco-Counter: metal bracket
Distance from Counter vs. Accuracy

- **Eco**
- **BOCO**
- **ARX**

Accuracy

- 0.00%
- 10.00%
- 20.00%
- 30.00%
- 40.00%
- 50.00%
- 60.00%
- 70.00%
- 80.00%
- 90.00%
- 100.00%

Distance from counter (ft.)

- close side
- no shoulders
- shoulders

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
Guide to Bicycle & Pedestrian Count Programs

Interested in understanding bicycle and pedestrian traffic in your area? This site is for you! While there are many ways to quantify bicycling and walking, this site focuses on bicycle and pedestrian count programs. Counting provides information on the level of intersections, paths, and roadways, a dataset already available for motor vehicles, but lacking for non-motorized travelers. Agencies who show clear evidence of use are more likely to receive funding for projects.
Technologies Tested

- **Pneumatic tubes**
- **Inductive loops**
  - Diamond
  - Parallelogram
- **Thermal camera**
- **Pedestrian pushbutton**
- **Passive infrared**
## Recommendation Matrix for Short Duration Counts from Testing

<table>
<thead>
<tr>
<th>Facility</th>
<th>Bicycles</th>
<th>Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Only Facilities (sidewalks, trails)</td>
<td>N/A</td>
<td>Infrared (most accurate for low pedestrian traffic sites)</td>
</tr>
<tr>
<td>Bicycle Only Facilities (cycle tracks, separated bike lanes)</td>
<td>Tubes –All types</td>
<td>N/A</td>
</tr>
<tr>
<td>Bike-Ped Paths &amp; Sidewalks</td>
<td>Tubes – bike specific and classification</td>
<td>Passive infrared (reference)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combine with tubes to distinguish bicycles.</td>
</tr>
<tr>
<td>Shoulders and Bike Lanes</td>
<td>Tubes – bike specific and classification</td>
<td>N/A</td>
</tr>
<tr>
<td>Roadways (mixed traffic)</td>
<td>Tubes – classification</td>
<td>N/A</td>
</tr>
<tr>
<td>(low volume)</td>
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<tr>
<td>Roadways (mixed traffic)</td>
<td>None recommended</td>
<td>N/A</td>
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<tr>
<td>(medium to high volume)</td>
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<td></td>
</tr>
<tr>
<td>Intersections</td>
<td>-</td>
<td>Pushbutton for ped activity</td>
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Historic Columbia River Highway
Tube Test
Historic Columbia River Highway Test
Hall & 99 W in Tigard
## Special Cases Tube Test

<table>
<thead>
<tr>
<th>Tube Counter</th>
<th>Tandem, Bike with Trailer</th>
<th>Carbon Fiber, Cargo Bicycle</th>
<th>Standard bicycles: One behind the Other</th>
<th>Standard bicycles: Side by Side</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Overall Error (%)</td>
<td>n</td>
<td>Overall Error (%)</td>
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<td>EcoCounter</td>
<td>24</td>
<td>-75</td>
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<td>-4</td>
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<td>Jamar CyclesPlus</td>
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<td>-50</td>
<td>54</td>
<td>-50</td>
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<td>TimeMark</td>
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<td>-4</td>
<td>54</td>
<td>-6</td>
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<tr>
<td>MetroCount 5600 - ARXCycle</td>
<td>46</td>
<td>-96</td>
<td>54</td>
<td>-56</td>
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<tr>
<td>Daimond TT6</td>
<td>46</td>
<td>4</td>
<td>54</td>
<td>-9</td>
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