A Summary of Recent Evaluations of Cycling Facilities in Portland, OR

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Outline

- Bike Boxes at Signalized Intersections
- Cycle Track on SW Broadway
- Buffered Bike Lanes on SW Stark & SW Oak
Bike Boxes in Portland

9 - Green Bike Boxes

3 - Uncolored Bike Boxes
Typical Design

- 24" Stop Bar
- "WAIT HERE" Marking
- Existing Crosswalk
- 30' 16'
- 80'
- Mount sign on new 2B pole
- Hang Sign from existing span wire
- NO TURN ON RED EXCEPT BICYCLES
Our Research Questions

- Do road users (motorists and cyclists) understand the markings?
- Do road users behave as intended?
- Are the markings improving safety?
- Does color (green vs. no color) matter?
Methods: Video Data

- Pre & Post video
  - 10 bike box (7 green, 3 uncolored)
  - 2 control
  - 2 peak and 1 off-peak hours analyzed per location
    - +56 more hours for conflict analysis
  - Before video: Jan to March 2008
  - After video: April to June 2009
Methods: Surveys

- Intercept survey of bicyclists
  - 5 bike box intersections
  - 47% response rate (468 of 997)

- On-line survey of motorists
  - 24% response rate (717 of 3,020)
Do Users Understand the Markings?
Motorist Survey

If you approached an intersection with a red light where should you stop your car?

- 94% 2% in box
- 1% either
- 3% don’t know

- 89% 9% in box
- <1% either
- 1% don’t know
Do Users Behave as Intended?
Comparing Encroachments of Motor Vehicles in Bike Boxes (Post) vs. Crosswalks (Pre)

% of motor vehicles arriving on red signal encroaching

- **All Intersections**
  - Bike Box: 27%
  - Crosswalk: 23%
  - $p = 0.13$

- **Color**
  - Bike Box: 28%
  - Crosswalk: 25%
  - $p = 0.07$

- **No Color**
  - Bike Box: 23%
  - Crosswalk: 18%
  - $p = 0.02$
Location of Stopped Cyclist in Box

73% of cyclists stop ahead of motor vehicle (A or B), though only 9% in front (area A)
Are the markings improving safety?

Video data

Motor vehicle encroachment into crosswalk
Cyclist encroachment into crosswalk
Motor vehicle encroachment into bike lane
Yielding behavior
Conflicts

Survey data

Perceptions of safety (motorists and cyclists)
Motor Vehicle Encroachment in Crosswalk

% of motor vehicles arriving on red signal encroaching in the crosswalk

- **Control**
  - Before: 10%
  - After: 13%
  - $p=0.265$

- **No Color**
  - Before: 6%
  - After: 19%
  - $p=0.000$

- **Color**
  - Before: 6%
  - After: 25%
  - $p=0.000$
Yielding Behavior

Counts

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT. Turning Cars</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Yielding Events

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car to Cyclist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car Fails to Yield</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of vehicles observed

Number of Events

- NE Weidler & NE 7th
- SE Hawthorne & SE 7th
- NW Broadway & NW Hoyt
Conflicts between motor vehicles and bicycles

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Number of Conflicts Before</th>
<th>Number of Conflicts After</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW Bway &amp; Hoyt</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>NW Everett &amp; 16th</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>SE 11th &amp; Hawthorne</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SE 7th &amp; Hawthorne</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SW 3rd &amp; Madison</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SW Bway &amp; Taylor</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>W Burnside &amp; 14th Ave</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

No conflicts before or after at three bike box intersections and both control intersections.

Overall, decrease from 29 to 20 (-31%) conflicts.

+94% bicycle volumes
+15% right turning cars
Does Color Matter?
Motorist Survey

As a driver, do you think one of the pavement marking designs is better than the other?

6% 89%
Conclusions

- **Findings that support bike boxes**
  - Compliance and understanding is high
  - Pedestrians are benefitting from reduced crosswalk encroachment
  - Conflicts fell
  - Yielding behavior increased
  - Improved perceptions of safety

- **Unclear findings**
  - Increase in bike lane encroachment
  - Benefits of color
Cycle Track and Buffered Bike Lanes

SW Stark Street from West Burnside to SW Naito Parkway & SW Oak Street from SW Naito Parkway to SW10th Avenue

SW Clay to SW Jackson Streets
About 0.34 miles
Evaluation Questions

- What are the perceptions of all users?
- Are the facilities being used as intended?
- Do the users understand the facility?
- Are there any operational issues?
- What additional delay has been introduced for motor vehicles?
## Cycle Track Methods

<table>
<thead>
<tr>
<th>Type</th>
<th>Data</th>
<th>Cycle Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey Responses</td>
<td>Motorists</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Cyclists</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>Pedestrians</td>
<td>198</td>
</tr>
<tr>
<td>Traffic Analysis</td>
<td>Video Data</td>
<td>18 hours</td>
</tr>
<tr>
<td></td>
<td>Analyzed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intersections</td>
<td>SW Broadway at SW Montgomery/Harrison</td>
</tr>
<tr>
<td></td>
<td>Studied</td>
<td>SW Broadway at SW College</td>
</tr>
</tbody>
</table>
## Cyclist Counts and Lane Choice

### Before: SW Broadway at Harrison
6/3/2009 (Weds)

<table>
<thead>
<tr>
<th></th>
<th>Bike Lane</th>
<th>MV Lane</th>
<th>Sidewalk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-8am</td>
<td>36</td>
<td>4</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>8-9am</td>
<td>32</td>
<td>5</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>9-10am</td>
<td>47</td>
<td>7</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td><strong>AM</strong></td>
<td><strong>115</strong></td>
<td><strong>16</strong></td>
<td><strong>1</strong></td>
<td><strong>132</strong></td>
</tr>
<tr>
<td>4-5pm</td>
<td>40</td>
<td>4</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>5-6pm</td>
<td>51</td>
<td>8</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>6-7pm</td>
<td>40</td>
<td>5</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td><strong>PM</strong></td>
<td><strong>131</strong></td>
<td><strong>17</strong></td>
<td><strong>1</strong></td>
<td><strong>149</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>246</strong></td>
<td><strong>33</strong></td>
<td><strong>2</strong></td>
<td><strong>281</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Cycle Track</th>
<th>MV Lane</th>
<th>Sidewalk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>44</td>
<td>1</td>
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<td>0</td>
<td>45</td>
</tr>
<tr>
<td>35</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td><strong>AM</strong></td>
<td><strong>124</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td><strong>127</strong></td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>59</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td><strong>PM</strong></td>
<td><strong>118</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
<td><strong>122</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>242</strong></td>
<td><strong>5</strong></td>
<td><strong>2</strong></td>
<td><strong>249</strong></td>
</tr>
</tbody>
</table>

### After: SW Broadway at Montgomery
8/4/2010 (Weds)

<table>
<thead>
<tr>
<th></th>
<th>Cycle Track</th>
<th>MV Lane</th>
<th>Sidewalk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>44</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>45</td>
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<tr>
<td>35</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td><strong>AM</strong></td>
<td><strong>124</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td><strong>127</strong></td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>59</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td><strong>PM</strong></td>
<td><strong>118</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
<td><strong>122</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>242</strong></td>
<td><strong>5</strong></td>
<td><strong>2</strong></td>
<td><strong>249</strong></td>
</tr>
</tbody>
</table>
I understand how PEDESTRIANS are supposed to cross this section of SW Broadway

MOST pedestrians understand how they are supposed to cross this section of SW Broadway

The cycle track has made this section of SW Broadway SAFER for me as a cyclist.

The cycle track has made this section EASIER for me to use as a cyclist.

The cycle track makes for a better cycling environment in Portland.

Motor vehicle driver behavior on this section of SW Broadway is safer and calmer.

Motor vehicles travel at faster speeds since the cycle track was installed.

While riding IN THE CYCLE TRACK, I have to pay a lot of attention to avoid being “doored”

while riding IN A STANDARD BIKE LANE next to parking, I have to pay a lot of attention to avoid...
View of traffic signals
Cyclist compliance with red signal

- **Before**
  - 55 cyclists arrive on red, 41% violated the red signal indication

- **After**
  - Of 113 cyclists arriving on red, 44% violated the red signal
  - 63% stated that they were required to STOP
Cyclist left-turn movements

<table>
<thead>
<tr>
<th></th>
<th>Stated</th>
<th>Observed (24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33%</td>
<td>29%</td>
</tr>
<tr>
<td>2</td>
<td>7.5%</td>
<td>29% + 29%*</td>
</tr>
<tr>
<td>3</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>* Waited next to in the cycle track</td>
</tr>
</tbody>
</table>
Motor vehicle delay is low

- Motor vehicle delay is still low after removing one travel lane
- LOS A < 10 sec/veh
<table>
<thead>
<tr>
<th>Statement</th>
<th>Non Cyclist</th>
<th>Cyclist</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cycle track has made driving safer</td>
<td><img src="chart1" alt="Bar Chart" /></td>
<td><img src="chart2" alt="Bar Chart" /></td>
</tr>
<tr>
<td>The cycle track has made driving less convenient</td>
<td><img src="chart3" alt="Bar Chart" /></td>
<td><img src="chart4" alt="Bar Chart" /></td>
</tr>
<tr>
<td>I like that bikes and cars are more separated</td>
<td><img src="chart5" alt="Bar Chart" /></td>
<td><img src="chart6" alt="Bar Chart" /></td>
</tr>
<tr>
<td>Parking is more stressful and challenging</td>
<td><img src="chart7" alt="Bar Chart" /></td>
<td><img src="chart8" alt="Bar Chart" /></td>
</tr>
<tr>
<td>I have changed how I drive</td>
<td><img src="chart9" alt="Bar Chart" /></td>
<td><img src="chart10" alt="Bar Chart" /></td>
</tr>
<tr>
<td>Traffic has gotten worse since the cycle track</td>
<td><img src="chart11" alt="Bar Chart" /></td>
<td><img src="chart12" alt="Bar Chart" /></td>
</tr>
<tr>
<td>Driver behavior is safer and calmer</td>
<td><img src="chart13" alt="Bar Chart" /></td>
<td><img src="chart14" alt="Bar Chart" /></td>
</tr>
<tr>
<td>It takes longer to drive this section of SW Broadway</td>
<td><img src="chart15" alt="Bar Chart" /></td>
<td><img src="chart16" alt="Bar Chart" /></td>
</tr>
</tbody>
</table>

Motorists’ opinions

- Strongly Disagree
- Somewhat Disagree
- Neither Agree nor Disagree
- Somewhat Agree
- Strongly Agree
Interactions with pedestrians

- **Survey**
  - 12% (24/197) peds stated that they had been involved in near collision with cyclist
  - 24% (48/197) peds had witnessed a near collision
  - 31% of cyclist stated they had encountered a pedestrian in the cycle track during green

- **Video**
  - 113/407 cyclists passed within 15’ of ped
  - Noted 10/113 (9%) interactions (5 minor, 4 evasive, 1 emergency)
Other issues

- Parking does not seem to be a problem any more.
- Loss of curb access presents a challenge to physically handicapped persons.
  - Note TriMet #68 buses enter cycle track to disembark passengers in AM peak.
Recommendations

- **Bicycle-pedestrian interactions**
  - Bike signal in cycle track
  - Additional striping, signing (crosswalk in cycle track).

- **Left-turns**
  - Additional channelization
  - Bike signals on far or near side

- **ADA/Curb issues**
  - Install raised concrete curb
  - Create landing pad by raising cycle track to curb height.
SW Stark and Oak Buffered Bike Lanes

Before

After

Proposed Buffered Bike Lane: SW Oak - Stark
## Methods and Data Collection

<table>
<thead>
<tr>
<th>Type</th>
<th>Data</th>
<th>Buffered Bike Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey Responses</td>
<td>Motorists</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Cyclists</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Pedestrians</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>Businesses</td>
<td>35</td>
</tr>
<tr>
<td>Traffic Analysis</td>
<td>Video Data Analyzed</td>
<td>18 hours</td>
</tr>
<tr>
<td></td>
<td>Intersections Studied</td>
<td>SW Stark at SW 3rd and SW 5th</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SW Oak at SW 6th and 4thd</td>
</tr>
</tbody>
</table>
Cyclists perceptions

Riding on SW Oak and SW Stark is SAFER for me as a cyclist.

Riding on SW Oak and SW Stark is EASIER for me as a cyclist

While riding in the BUFFERED BIKE LANES, I have to pay a lot of attention to avoid being “doored”

While riding in STANDARD BIKE LANES, I have to pay a lot of attention to avoid being “doored”

I prefer a BUFFERED BIKE LANE over a STANDARD BIKE LANE
<table>
<thead>
<tr>
<th>Street</th>
<th>Before (9/09)</th>
<th>After (8/10)</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW Oak (AM)</td>
<td>74</td>
<td>275</td>
<td>275%</td>
</tr>
<tr>
<td>SW Stark (PM)</td>
<td>191</td>
<td>339</td>
<td>77%</td>
</tr>
</tbody>
</table>
Some confusion about use

- When can cars be in the buffered bike lane?
## Observed right-turning actions

<table>
<thead>
<tr>
<th>Turning Action</th>
<th>Stark/5&lt;sup&gt;th&lt;/sup&gt; 8/10/10</th>
<th>Stark/5&lt;sup&gt;th&lt;/sup&gt; 8/11/10</th>
<th>Oak /4&lt;sup&gt;th&lt;/sup&gt; 8/17/10</th>
<th>Oak /4&lt;sup&gt;th&lt;/sup&gt; 8/18/10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right turn from the motor vehicle lane</td>
<td>35</td>
<td>30</td>
<td>49</td>
<td>52</td>
<td>166</td>
</tr>
<tr>
<td>Right turn from the buffered bike lane</td>
<td>37</td>
<td>27</td>
<td>21</td>
<td>22</td>
<td>107</td>
</tr>
<tr>
<td>Right turn from parking lane/area</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>61</td>
<td>78</td>
<td>77</td>
<td>291</td>
</tr>
</tbody>
</table>
### Motorists' opinions

<table>
<thead>
<tr>
<th>Statement</th>
<th>Non Cyclist</th>
<th>Cyclist</th>
</tr>
</thead>
<tbody>
<tr>
<td>The buffered bike lanes have made driving safer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The buffered bike lanes have made driving less convenient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like that bikes and cars are more separated</td>
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<tr>
<td>Parking is more stressful and challenging</td>
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<tr>
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<tr>
<td>Traffic has gotten worse since the buffered bike lanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver behavior is safer and calmer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It takes longer to drive these sections of SW Oak and Stark</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Strongly Disagree**: Red
- **Somewhat Disagree**: Orange
- **Neither Agree nor Disagree**: Black
- **Somewhat Agree**: Green
- **Strongly Agree**: Dark Green
Motor vehicle delay

Average Control Delay per Vehicle

0.0 10.0 20.0 30.0 40.0 50.0 60.0

4:00-4:14:59
4:15-4:29:59
4:30-4:44:59
4:45-4:59:59
5:00-5:14:59
5:15-5:29:59
5:30-5:44:59
5:45-6:00

SW4th and Oak, 8/17
SW4th and Oak, 8/18
SW5th and Stark, 8/10
SW5th and Stark, 8/10
Conclusions

- Both facilities appear to be working well though some improvements identified.
- SW Broadway cycle track is unique
  - Pedestrian issue is “worst case” on the SW Broadway (issues existed prior to cycle track) but best case for right-turn conflicts
Acknowledgements

- City of Portland
  - Rob Burchfield
  - Tom Jensen
  - Matthew Machado
  - Roger Geller

- Student Research Assistants
  - Nathan McNeil
  - Bob Kellett
  - Will Farley

- OTREC
Questions?

Find full final reports at http://www.ibpi.usp.pdx.edu/research.php

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