Effects of Island & RRFB Placement on Midblock Driver Yielding on Three-Lane Roads

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Professor and Chair
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Outline

• Objective
  – Explore driver yielding and pedestrian crossing behavior differences between median-mounted and far-side mounted RRFB displays on three-lane roadways.

• Background and RRFB Installation Policies

• Sites and Data Summary

• Yielding Analysis Results

• Conclusions
## Driver Yielding at RRFB Enhanced Locations

<table>
<thead>
<tr>
<th>Study</th>
<th>Before %</th>
<th>After %</th>
<th># Sites</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Houten, Ellis, &amp; Marmolejo (2008)</td>
<td>0</td>
<td>65</td>
<td>1</td>
<td>Miami-Dade County, Florida</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>92</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pecheux, Bauer &amp; McLeod (2009)</td>
<td>2</td>
<td>35</td>
<td>2</td>
<td>Miami, FL</td>
</tr>
<tr>
<td>Hua, J., et al. (2004)</td>
<td>70</td>
<td>80</td>
<td>1</td>
<td>San Francisco, CA</td>
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<tr>
<td>Hunter, W. W., R. Srinivasan and C. A. Martell. (2009)</td>
<td>2</td>
<td>54</td>
<td>1</td>
<td>St. Petersburg, FL</td>
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<tr>
<td>Shurbutt and Van Houten (2011)</td>
<td>4</td>
<td>84</td>
<td>22</td>
<td>St. Petersburg, FL Washington, D.C. Mundelein, IL</td>
</tr>
<tr>
<td>Ross, Serpico &amp; Lewis (2011)</td>
<td>23-25</td>
<td>83</td>
<td>2</td>
<td>Bend, OR</td>
</tr>
<tr>
<td>Fitzpatrick et al. (2014)</td>
<td>n.a.</td>
<td>34 to 92</td>
<td>22</td>
<td>Texas</td>
</tr>
<tr>
<td>Foster, Monsere &amp; Carlos (2014)</td>
<td>n.a.</td>
<td>91 to 92</td>
<td>2</td>
<td>Portland, OR</td>
</tr>
</tbody>
</table>

Source: Appendix H, NCHRP 841, Effects of Pedestrian Treatments at Unsignalized Crossings: A Summary of Available Research
### CROSSWALK DESIGN BY ROADWAY TYPE

*All crossings must be scoped by an engineer to ensure recommended treatment is appropriate and ADA ramps and illumination are in place.*

<table>
<thead>
<tr>
<th>VEHICLE ADT</th>
<th>≤30 MPI</th>
<th>35 MPI</th>
<th>40+ MPI</th>
<th>≤30 MPI</th>
<th>35 MPI</th>
<th>40+ MPI</th>
<th>≤30 MPI</th>
<th>35 MPI</th>
<th>40+ MPI</th>
<th>≤30 MPI</th>
<th>35 MPI</th>
<th>40+ MPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 4,000 - 9,000</td>
<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Orange" /></td>
</tr>
<tr>
<td>&gt; 9,000 - 12,000</td>
<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="Orange" /></td>
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<tr>
<td>&gt; 15,000</td>
<td><img src="#" alt="Gray" /></td>
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<td><img src="#" alt="Gray" /></td>
<td><img src="#" alt="Orange" /></td>
</tr>
</tbody>
</table>

- **Marked Crosswalk**
- **Marked Crosswalk, island or curb extensions, enhanced signing and striping**
- **Marked Crosswalk and enhanced/active warning (islands and RRFB’s)**
- **Marked Crosswalk and pedestrian hybrid or full signal**
City of Boulder, CO

*RECOMMENDATION BASED ON CITY OF BOULDER SAFETY EVALUATIONS AT EXISTING RRFB SITES AND OBSERVED IMPACTS TO VEHICULAR TRAFFIC OPERATIONS*
**Table: Post Speed Limit and AADT**

<table>
<thead>
<tr>
<th>Roadway Configuration</th>
<th>Vehicle AADT &lt;9,000</th>
<th>Vehicle AADT 9,000–15,000</th>
<th>Vehicle AADT &gt;15,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 lanes (1 lane in each direction)</td>
<td>&lt;30 mph</td>
<td>35 mph</td>
<td>≥40 mph</td>
</tr>
<tr>
<td></td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
<td>1 4 5 6</td>
</tr>
<tr>
<td>3 lanes with raised median (1 lane in each direction)</td>
<td>2 3 4 5</td>
<td>2 3 4 5</td>
<td>2 3 4 5</td>
</tr>
<tr>
<td>3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)</td>
<td>2 3 4 5</td>
<td>2 3 4 5</td>
<td>2 3 4 5</td>
</tr>
<tr>
<td>4+ lanes with raised median (2 or more lanes in each direction)</td>
<td>5 6 7 8 9</td>
<td>5 6 7 8 9</td>
<td>5 6 7 8 9</td>
</tr>
<tr>
<td>4+ lanes w/o raised median (2 or more lanes in each direction)</td>
<td>5 6 7 8 9</td>
<td>5 6 7 8 9</td>
<td>5 6 7 8 9</td>
</tr>
</tbody>
</table>

Given the set of conditions in a call:

- * Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

*Refer to Chapter 4, “Using Table 1 and Table 2 to Select Countermeasures,” for more information about using multiple countermeasures.

** should be noted that the PHB and RRFB are not both installed at the same crossing location.

Data Collection Procedures

• Staged interaction following methodology suggested by Fitzpatrick et al.
• Video recordings at each site
• Metrics
  ➢ Ped Delay at Start = Time Ped Start Crossing – Time Ped Arrived at Crosswalk
  ➢ Ped Crossing Time = Time Ped Finished Crossing – Time Ped Start Crossing
  ➢ Yielding Rate = \( \frac{\text{Total number of vehicles yielding}}{\text{(Total number of vehicles yielding} + \text{Total number of vehicles not yielding})} \)
1 - NMR-OO No Median Refuge Outside-Mounted Beacons

NE 12th Ave and NE Glisan St, Portland, Oregon

Source: Google Maps
2-MR-OO Median Refuge Outside-Mounted Beacons

Waverly and 22\textsuperscript{nd}, Albany, Oregon

Source: Google Maps
3-MR-IO Median Refuge and Island and Outside Mounted Beacons

NE Glisan St and NE 65th Ave, Portland, Oregon

Source: Google Maps
RRFB Locations - Statewide
## RRFB Locations by Category and ADT

<table>
<thead>
<tr>
<th>Roadway Type (Median Type)</th>
<th>Vehicle ADT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 9,000</td>
</tr>
<tr>
<td></td>
<td>30 mph</td>
</tr>
<tr>
<td>1-NMR-OO</td>
<td>3</td>
</tr>
<tr>
<td>2-MR-OO</td>
<td>-</td>
</tr>
<tr>
<td>3-MR-IO</td>
<td>1</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
</tr>
</tbody>
</table>

**Portland State University**
Data Summary

• 23 locations statewide

• 1,556 crossing events (1,621 pedestrians)
  – 1,338 of the crossings were staged (86%)
  – 218 were naturalistic crossings (14%)

• 48 did not activate RRFBs
  – Low = 25 crossings
  – High = 104 crossings
  – Average = 67 crossings
Yielding Rates by Site

Geary & Heritage
Dalles-California Hwy, near...
US 101 between 33rd & 34th St
Waverly Dr
Lincoln City US 101
Cottage Grove
West Union & Rock Creek Trail
Sandy Blvd.
Olympic St & Winco
Barrows & Walnut
60th & Willow St
Kaiser Rd
NE Glisan & 65th
US 20 & Samaritan Hospital
NE Science Park Drive
NW Laidlaw Rd
Benson & 12th
Oregon St & NW 8th
Main & Bear Creek
17th & Pershing
Walker Road
Kildeer & Costco
NE Wilkins Rd

Near Side
Far Side
### Difference in Base Yielding Rates by Category and ADT

<table>
<thead>
<tr>
<th>Cat.</th>
<th>ADT</th>
<th>Near Side</th>
<th>Near Side</th>
<th>Far Side</th>
<th>Far Side</th>
<th>Near Side</th>
<th>Near Side</th>
<th>Far Side</th>
<th>Far Side</th>
<th>Near Side</th>
<th>Far Side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;9,000</td>
<td>-2.23</td>
<td>**</td>
<td>-0.56</td>
<td>**</td>
<td>4.76</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>**</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>9,000 to 12,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>12,000 - 15,000</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>&gt; 15,000</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near Side</td>
<td>**</td>
<td>-8.16</td>
<td>1.56</td>
<td>2.53</td>
<td>4.25</td>
<td>**</td>
<td>1.64</td>
<td>1.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Far Side</td>
<td>-2.34</td>
<td>0.69</td>
<td>-6.21</td>
<td>1.56</td>
<td>4.05</td>
<td>4.76</td>
<td>1.64</td>
<td>1.64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Yielding Rates by Posted Speed

- 1-NMR-OO
- 2-MR-OO
- 3-MR-IO

locations:
- US 20 & Samaritan Hospital
- NE Glisan & 65th
Yielding Rates by 1-min Volume

Near Side

Yielding Rate

Avg 1-min vehicle volume

Far Side

Yielding Rate

Avg 1-min vehicle volume
# Statistical Analysis: Effect of Median + Beacon

<table>
<thead>
<tr>
<th>ADT</th>
<th>Near Side</th>
<th>Far Side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-NMR-OO</td>
<td>3-MR-IO</td>
</tr>
<tr>
<td></td>
<td>Yielding</td>
<td>Not Yielding</td>
</tr>
<tr>
<td>&lt;9,000</td>
<td>196</td>
<td>4</td>
</tr>
<tr>
<td>9,000-12,000</td>
<td>187</td>
<td>3</td>
</tr>
<tr>
<td>12,000-15,000</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>&gt;15,000</td>
<td>173</td>
<td>3</td>
</tr>
</tbody>
</table>
Conclusions

• RRFB is a useful tool for alerting drivers about pedestrian presence
• High yielding rates observed at all locations
• Yielding rates generally increase with the addition of median beacons, although increases are small

• Limitations
  – Sample was collected during daylight hours and good weather
  – Crossings mostly staged and during non-peak hours
Guidance for Three-Lane Roadways

• Median refuge
  – Optional for less than 12,000 ADT
  – Recommended for more than 12,000 ADT, based on the evidence of increased yielding

• Median beacons
  – Considered whenever the median refuge is installed based on site specific conditions, especially on roadways with a posted speed limit of 35 mph and higher

• Important note
  – Other reasons, primarily for pedestrian comfort and safety, to add a median refuge that should be considered.
Acknowledgements

• Research funded by Oregon DOT, SPR 814
  – Link to final report
• Sirisha Kothuri
• Jason Anderson
• Frank Apiah
• ODOT TAC Members