Effectiveness of Pedestrian Crossing Treatments

by

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March 25, 2015
Key Abbreviations

- Ped = pedestrian
- HAWK = former name of PHB
- PHB = pedestrian hybrid beacon
- RFB = rapid flashing beacon
- RRFB = rectangular rapid flashing beacon
- CRFB = circular rapid flashing beacon
- Veh = vehicle
- CW = crosswalk
MUTCD

- Traffic control devices for pedestrian crossings - limited
- Signals (of course)
- Markings, warning signs
- In-roadway warning lights (in 2000 MUTCD)
With Limited Options.... Non-Uniformity

- Lots of different solutions at pedestrian crossings

Photos: Richard Nassi
In the 2009 MUTCD and 2011 MMUTCD as Pedestrian Hybrid Beacon
Staged Pedestrian

- Ensures oncoming drivers receive consistent presentation of approaching pedestrian
- Member of research team wears: gray shirt, blue jeans, non-reflective shoes
- Flags used to indicate stopping distance upstream of site
- 2\textsuperscript{nd} researcher gathers driver yielding / not yielding data
Driver Yielding

Motorist Yielding (%)

Maximum site value
Average of all sites
Minimum site value

Midblock Sig
HAWK Beacon
Half Signal
In Street Sign
Flag
Over, Push
Refuge Island
High Visibility
Over, Active

TCRP/NCHRP Report 112/562 2006
HAWK Safety Effectiveness

- Anecdotal evidence = yes
- FHWA-sponsored research (started 2007)
  - Comprehensive, before-after safety evaluation
  - Safety evaluation: Empirical Bayes method

Photo: Marcus Brewer
HAWK Safety Results

• 21 treatment sites
  • 38% 6 lanes, 62% 4 lanes
  • 52% 40 mph, 43% 35 mph, 5% 30 mph
  • All at stop-controlled intersections/major driveways
• 102 unsignalized intersections for reference group
• Statistical significant changes:
  • 29% reduction in total crashes
  • 69% reduction in pedestrian crashes
Pedestrian Hybrid Beacon (PHB)

- Added to the 2009 MUTCD / 2011 MMUTCD
- Name = Pedestrian Hybrid Beacon (Chapter 4F)

Figure 4F-3. Sequence for a Pedestrian Hybrid Beacon

1. Dark Until Activated
2. Flashing Yellow Upon Activation
3. Steady Yellow
4. Steady Red During Pedestrian Walk Interval
5. Alternating Flashing Red During Pedestrian Change Interval
6. Dark Again Until Activated

Legend:
SY = Steady yellow
FY = Flashing yellow
SR = Steady red
FR = Flashing red

Note: An optional steady red clearance interval may be used after Interval 3 and before Interval 4.
PHBs are Being Used in Michigan

- Ann Arbor
- Detroit
- West Bloomfield
- Ypsilanti
- Macomb County
- Oakland County
- Other??
PHB Anticipated Changes for Next Edition

• NCUTCD (2011) voted to remove following restriction:
  • The pedestrian hybrid beacon should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs

• NCUTCD (2011) voted to add:
  • If a pedestrian hybrid beacon is installed at or immediately adjacent to an intersection with a side road, vehicular traffic on the side road shall be controlled by STOP signs.
In-Roadway Warning Lights

MMUTCD Section 4N
2011 MMUTCD

- “...special types of highway traffic signals installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent...”
- Confined to pedestrian crossing applications
- Height shall not exceed 0.75 inch above surface
- Shall be flashed and not steadily illuminated
In-Roadway Warning Lights at Crosswalks

• Characteristics:
  • Crosswalks with warning signs
  • Pedestrian actuation
  • Entire length of crosswalk on both sides

• Maintenance:
  • Replace bulbs/LEDs
  • Remove snow and road debris

• Yielding: 50-90% (early ‘00s)
Crosswalk Markings

Changes are Coming to the Manual
Concerns

• Minimal attention given to selecting crosswalk marking style (staff turnover can increase this concern)
• MUTCD allows numerous options for flexibility, but perhaps clearer direction is needed
• Need research to show specific benefits of different styles
FHWA Study on Crosswalk Markings

- Objective = investigate relative visibility of crosswalk marking patterns (detection distance)
- Approach
  - **Open road** course on TAMU west campus
  - Participant in instrumented vehicle verbally indicating when crosswalk (or speed limit sign or turn arrow) is visible

“Crosswalk”
# Crosswalk Patterns

<table>
<thead>
<tr>
<th>Bar Pairs</th>
<th>Continental</th>
<th>Transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong>&lt;br&gt;45 Rural</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Group 2</strong>&lt;br&gt;30 Mixed</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Group 3</strong>&lt;br&gt;30 Urban</td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Bar**<br>**Con**<br>**Tra**
Crosswalk Detection Distance
Key Finding = Light / Marking

Average Adj. Detection Dis. (ft)

Bar Pair  Continental  Transverse

Day  Night

Texas A&M Transportation Institute
Crosswalk Recommendations
Potential Changes Approved 6-23-11

- High-visibility markings
  - Defined
  - Install at non-intersection locations
- If 35 mph speed limit, 8 ft crosswalk width
Pedestrian Rapid-Flashig Beacon

Being Considered for the Manual
FHWA Interim Approval

• Optional use of rectangular rapid flashing beacons (RRFB)
• Pedestrian and school crosswalks across uncontrolled approaches
• July 16, 2008

Photos: TTI
## Research – RRFB Driver Yielding

<table>
<thead>
<tr>
<th>Study</th>
<th># Sites</th>
<th>Driver Yielding</th>
<th>Unique Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 FHWA</td>
<td>22 (most in St. Pete)</td>
<td>72 to 96% activated</td>
<td>Original study, multiyear (2 yrs+ data)</td>
</tr>
<tr>
<td>2009 FHWA</td>
<td>2 (Miami)</td>
<td>55 to 60% day 66 to 70% night</td>
<td>Day and night</td>
</tr>
<tr>
<td>2009 Florida</td>
<td>1 (St. Pete)</td>
<td>35% overall 54% activated</td>
<td>Trail crossing</td>
</tr>
<tr>
<td>2011 Texas</td>
<td>1 (Garland)</td>
<td>80% activated</td>
<td>School, overhead</td>
</tr>
<tr>
<td>2011 Oregon</td>
<td>2 (Bend)</td>
<td>83% activated</td>
<td>45 mph</td>
</tr>
<tr>
<td>2014 Texas</td>
<td>22 (most in Garland)</td>
<td>34 to 92% activated</td>
<td>Significant: city, PSL, crossing dist, 1/2 way</td>
</tr>
</tbody>
</table>
National Committee on Uniform Traffic Control Devices

- RRFB → Signals Technical Committee (STC)
- STC would like answers to several questions before developing draft language
  - Why rectangular? Would circular be OK? Size?
  - Could the beacons be mounted above? Within?
  - Are there optimal flash rates & flash patterns?
  - What is the proper intensity?
  - What about potential for seizures?
  - Others
Research Studies

• Shape: circular or rectangular (C vs R)
  • Completed

• Flash pattern: 3 tested (Pattern)
  • Completed

• Beacon location: above or below the sign
  • Ongoing
C vs R: Object Detection on Closed Course

• Certain assemblies → shorter object detection distance (i.e., drivers had to be closer to detect object, which is not desirable)
  – Daytime: shorter for R-B compared to C-B12, C-B8, R-A, 155 to 167 ft differences (significant)
  – Nighttime: shorter for R-B compared to C-B12, 37 ft difference (significant)

• Selected R-B and C-B12 for open road
C vs. R: Data Collection

- **Daytime**
  - 40 staged pedestrian crossings minimum
  - All sites

- **Nighttime**
  - Possible due to travel arrangements
  - 40 crossings goal
  - One site per city for both shapes
C vs. R: Sites

• 12 Sites:
  • Austin, TX (2)
  • College Station, TX (2)
  • Flagstaff, AZ (3)
  • Milwaukee, WI (5)

• Speed limit: 30, 35, or 40 mph
• Number of lanes: 2 to 6 lanes
C vs. R: Brightness

Average Intensity (candela)

- RRFB.MK-08
- RRFB.MK-07
- RRFB.FG-03
- RRFB.CS-01
- RRFB.AU-02
- CRFB.MK-06
- CRFB.MK-05
- CRFB.MK-04
- CRFB.FG-02
- CRFB.FG-01
- CRFB.CS-02
- CRFB.AU-01
C vs. R: Preliminary Findings

<table>
<thead>
<tr>
<th>Device</th>
<th>Day – Number of Staged Ped</th>
<th>Day – Driver Yielding</th>
<th>Night – Number of Staged Ped</th>
<th>Night – Driver Yielding</th>
</tr>
</thead>
<tbody>
<tr>
<td>RRFB</td>
<td>774</td>
<td>59%</td>
<td>180</td>
<td>72%</td>
</tr>
<tr>
<td>CRFB</td>
<td>753</td>
<td>63%</td>
<td>152 (171)*</td>
<td>68% (49%)*</td>
</tr>
</tbody>
</table>

*includes site with lowest brightness
C vs. R: Results

- All staged ped data, brightness not included
  - No difference between beacon shapes (circular and rectangular)
  - No difference day/night
- Crossing data when brightness is available
  - Statistically significant:
    - Night / Day
    - Intensity at night
Pattern: Objective

- To compare driver yielding behavior to selected flash patterns
- Are there patterns that are simpler or have greater dark periods that are as effective as the 2-5 pattern?
Pattern: Equipment

• 8 sites in College Station or Garland, TX
• Temporary light bar and controller – key elements
Pattern: Driver Yielding

• Staged pedestrian crossings
• 40 crossings for each flash pattern
• All 3 flash patterns tested at each site
• Flash pattern presentation order randomized

Photo: TTI
Pattern: Conclusions

- Average driving yielding for each pattern (across all 8 sites):
  - WW+S: 80%
  - Blocks: 80%
  - 2-5: 78%

- Data for each crossing used in analysis
- After controlling for crossing distance, city, and site, there is no evidence of a difference between Flash Patterns
## Pattern: Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Blocks</th>
<th>WW+S</th>
<th>2-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left (L) or Right (R)</strong></td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td><strong>On time (ms)</strong></td>
<td>300</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td><strong>Percent of cycle for a given beacon with the beacon on</strong></td>
<td>38%</td>
<td>25%</td>
<td>31%</td>
</tr>
<tr>
<td><strong>Off ratio = percent of cycle where both beacons are dark</strong></td>
<td>44%</td>
<td>63%</td>
<td>31%</td>
</tr>
</tbody>
</table>
RRFB: Conclusions

• RRFB = more effective than no treatment or continuously flashing yellow beacon(s)
• Findings from 6 studies + several ongoing FHWA studies → driver yielding range from 22 to 98%
  • Large range an indication that other variables affect driver yielding results!
• Variables found to influence yielding: crossing distance, one-way or two-way, City, brightness
• Variables that may influence yielding: posted speed limit, time since installation, volume
RRFB: Conclusions & Action

• Shape (circular or rectangular) $\rightarrow$ similar driver yielding results (open road study)

• Pattern $\rightarrow$ similar driver yielding results for 3 patterns tested
  • Therefore, use pattern with more dark time (WW+S)

• Actions on C vs R findings:
  • STC of NCUTCD $\rightarrow$ motion to allow either circular or rectangular beacons with pedestrian treatments with rapid flash patterns
RRFB: Conclusions & Action

• Shape (circular or rectangular) $\rightarrow$ similar driver yielding results (open road study)

• Pattern $\rightarrow$ similar driver yielding results for 3 patterns tested (open road study)
  • Therefore, use pattern with more dark time (WW+S)

• NCUTCD STC (June 2014) $\rightarrow$ motions to support using either circular or rectangular and to support using other patterns
FHWA Action

- FHWA (July 25, 2014) Official Interpretation
  - Permit use of either 2-5 or WW+S
  - Favors WW+S
    - Greater percent of dark time (easier to read sign and see waiting pedestrians)
    - Less total on time (more energy efficient)
RFB Questions Being Asked

• Closed course indicates benefits for location beacons above sign
  • TTI currently collecting data to investigate
• Several combinations
  • Flash rate, flash pattern, brightness, shape and size of beacons/LEDs, placement (within, top, bottom, etc.)
    • What is optimal?
    • What about glare?
QUESTIONS

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