Pedestrian Challenges to Traffic Engineers and How They Affect Traffic Signal Operations

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Outline

- Background of Pedestrian Conditions
  - Historic Treatment of Pedestrians in the HCM
  - Recent Research for Considering Pedestrians
  - Manual of Uniform Traffic Control Devices

- Traffic Signal Operations Challenges and Treatments
Ask Engineers the Right Question and You’ll Always Get Another Question

- How can we improve traffic signals for pedestrians?
  - Lower walking speeds accommodates all users, but increases crossing time and increased delay for other users
  - Intersection width impacts crossing distance
  - Crossing distance reductions may result in increased delay for motorists
  - Pedestrians that are also transit riders may want signal priority

- How do we improve traffic signals to achieve our objectives of safe, efficient movement of all users?
  - Measure effects on all users
  - Define priorities and establish policies
  - Improve detection to provide flexibility of traffic signal operation
Historical Treatment of Pedestrians

- 1950 Highway Capacity Manual (HCM) acknowledged pedestrians as having an impact on turning movements
  - impacts were dealt with only indirectly in terms of the intersection location
Historical Treatment of Pedestrians

- 1965 HCM recognized that pedestrians have an effect on exclusive right turn lanes

- 1985 HCM introduced a separate chapter on Pedestrians
  - Pedestrian LOS tables were provided for walkways and queuing areas
  - LOS based on the average area provided per pedestrian; more crowded areas received a lower LOS.
HCM 2000 Methodology

- Pedestrian chapters expanded to include:
  - walkways and sidewalk segments,
  - pedestrian queuing areas,
  - shared off-street paths,
  - pedestrian crosswalks, and
  - pedestrian facilities along urban streets

- Pedestrian LOS for crossing signalized intersections was based on average pedestrian delay, with lower thresholds for unsignalized intersections than for signals.

- Pedestrian LOS for an urban street was based on average travel speed.
Recent Research

- Florida DOT sponsored the development of alternative pedestrian LOS measures
  - reflective of pedestrian and bicycle comfort while using facilities, in comparison to the traditional capacity and speed oriented measures.

- NCHRP 3-70 developed a new multimodal LOS framework that provides a comprehensive set of measures that are more reflective of perceptions of conditions.
  - What’s happening next to them (speed, volume, driveway presence)
Relevant Research
Signal Timing and its Effect on Pedestrians

- Pedestrians are affected by traffic, thus incorporate them in the procedure (Hubbard, Awwad, and Bullock, 2007)
  - Pedestrian delay due to turning vehicles while on the curb
  - Pedestrian evasive maneuvers in response to vehicles

- Signal timing and design strategies can mitigate conflicts
  - Leading pedestrian intervals can provide enhanced visibility
  - Curb extensions may reduce pedestrian crossing requirements
  - Population and therefore waking speeds are changing, how can we improve to balance tradeoffs?
Issues for the HCM 2010

- Pedestrian chapter is seldom used because it is separate from Signalized Intersections Chapter methodology
  - The option of assessing person delay should be incorporated into the signalized intersections chapter to include delay of pedestrians (and other users)
  - A separate chapter may be appropriate, but is not entirely sufficient
MUTCD Signal Warrant Analysis: Basis of Installation

- The selection and use of traffic control signals should be based on an engineering study of roadway, pedestrian, bicyclist, and other conditions, MUTCD Section 4B.02
  - Use of Signal Warrant Analyses to assess location
  - Political issues

- MUTCD stipulates location, design, and meaning of the signal indications, including uniformity in the design features that affect the traffic to be controlled
From the MUTCD: Advantages of Traffic Control Signals

- Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages:
  - They reduce the frequency and severity of certain types of crashes, especially right-angle collisions.
  - They are coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions.
  - They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.
From the MUTCD: Disadvantages of Traffic Control Signals

- Improper or unjustified traffic control signals can result in one or more of the following disadvantages:
  - Excessive delay;
  - Excessive disobedience of the signal indications;
  - Increased use of less adequate routes as road users attempt to avoid the traffic control signals; and
  - Significant increases in the frequency of collisions (especially rear-end collisions).
MUTCD Section 4B.05
Adequate Roadway Capacity

- Delays inherent in the alternating assignment of right-of-way at intersections controlled by traffic control signals can be reduced by widening the major roadway, the minor roadway, or both roadways.

- Widening the minor roadway often benefits the operations on the major roadway, because it reduces the green time that must be assigned to minor-roadway traffic.
Corollary to the MUTCD

- On the other hand, widening the major street increases the pedestrian crossing

- A wider pedestrian crossing will require additional time for pedestrians, thus reducing time for major street traffic
  
  - Major street traffic may include bus or transit operations
Where do we go from here?
Establish Objectives for Signal Timing/Design

- Objectives need to consider policies and local interests
  - Downtown merchants may favor pedestrian traffic over vehicular traffic, reduced speeds
  - Speed control may be an objective for a neighborhood
  - Are facilities in place to accommodate movement (sidewalks, signals, etc)
  - Signal delay may be a transit agency’s concern
Treatments to Improve Pedestrian Conditions

- **Leading Pedestrian Interval Walk**
  - Head start for pedestrians

- **Barnes’ Dance**
  - Exclusive pedestrian phase to eliminate conflicts

- **Right Turn on Red (RTOR) Restriction**
  - Spatial separation

- **Shorter Cycle Lengths, Fewer Phases**
  - Shorter wait times

*May increase cycle lengths and therefore pedestrian delay*
Leading Pedestrian Walk Interval
Leading Pedestrian Walk Interval
Following Interval (All Lanes – Green)
Barnes’ Dance
Shorter Cycle Length, Fewer Phases

- Is this the delay or the amount of time left for me to Walk?
- Left turn phases will increase delay
- Shorter cycle lengths reduce delay (HCM Equation)
Pedestrian Delay

- HCM Equation for Delay of Pedestrians at Traffic Signals

\[ d = \frac{0.5 \times (C - g)^2}{C} \]

- C = Cycle Length
- g = effective green time

- This is not considered in HCM Signalized Intersection Analyses, no matter how many pedestrians exist
  - Doesn’t reflect mode (coordination or not) and how that affects delay
  - Link between treatments and demand aren’t well defined
### HCM Results and MOEs

<table>
<thead>
<tr>
<th></th>
<th>Leading Ped Phase</th>
<th>Shorter Cycle Length</th>
<th>Barnes Dance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intersection MOE</strong></td>
<td><strong>LOS/Delay/v/c</strong></td>
<td><strong>LOS/Delay/v/c</strong></td>
<td></td>
</tr>
<tr>
<td>(LOS/Delay/v/c)</td>
<td>B / 12.8 / 0.66</td>
<td>B / 11.0 / 0.57</td>
<td>D / 51.5 / 0.99</td>
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<tr>
<td><strong>Arterial Signal Delay</strong></td>
<td>15.8</td>
<td>9.7</td>
<td>33.0</td>
</tr>
<tr>
<td>(sec/veh)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Travel Time (sec)</strong></td>
<td>32.3</td>
<td>30.2</td>
<td>53.5</td>
</tr>
<tr>
<td><strong>Arterial LOS</strong></td>
<td>C</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td><strong>Bandwidth (sec)</strong></td>
<td>39</td>
<td>36</td>
<td>27</td>
</tr>
<tr>
<td><strong>Pedestrian delay</strong></td>
<td>12.2/13.3</td>
<td>9.3/11.4</td>
<td>18.1</td>
</tr>
</tbody>
</table>
Treatments that may Impact Pedestrians

- Two stage gap acceptance
- Large radius intersections
- Coordinated operation
- Pedestrian countdown timers
- RTOR Restrictions
Issues with Pedestrians at Traffic Signals

- Pedestrian Safety & Speed
- Visibility at Intersections
- Detector Applications
- Maintenance Issues
- HAWK Signal
- Other applications

➢ Build it and they will come
Speed Limit - Vehicle speed & safety

Odds of Death in Pedestrian-Vehicle Collision

Speed of Motor Vehicle (mph)

Likelihood of Fatality

Visibility of Pedestrians at Traffic Signals

- Curb extensions improve visibility and reduce walking crossing times which may be beneficial for traffic.

**Figure 10.19** A curb extension bus stop. Source: Kimley-Horn and Associates Inc.

**Figure 10.15** Curb extensions can improve pedestrian visibility and reduce crossing distance. Source: Community, Design + Architecture.
Detector Applications and Potential Innovations

- Detect arrival of all users
  - Areawide detection has had limited effectiveness
  - Pedestrian push buttons
- Serve most users
  - Is this sufficient?
  - Why do pedestrians have to push the button?
- Improve pedestrian detection to use passive approach
- Extend clearance time as necessary for pedestrians
Improved Detection for Pedestrians
Removal of Push Buttons

“Stand in Box for Walk Signal”
Extension of FDW Example

Pedestrian begins on NW corner and detection is critical near SW corner

Detection of slow pedestrian here allows extension and ultimately reduces crossing time needed in most cases.
Pedestrian Safety – Signalized Crossings

- Walking speed – 4 ft./sec. is average speed, not design speed\(^1\)
- 2008 MUTCD will recommend 3.5 ft./sec. per NCHRP 562
- Walking speeds should be supplemented with improved detection?

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Maintenance for Pedestrians

- Existing maintenance practices leave something to be desired
- Traffic Engineers are hesitant to build what they can’t maintain
**HAWK Signal**

- **Pedestrian and Bicycle Crossing Treatment**
  - Takes the place of half signals which are not allowed
HAWK Signal for Motorists
Signalized Crossings Summary

- **Encourage compliance**
  - Use short cycle lengths where possible
  - Don’t make pedestrians wait two cycles to cross the street

- **Provide alternatives**
  - Unsignalized crossings – Hybrid Signals (HAWK)
Summary

- Existing methodologies fall short:
  - including pedestrian experience into traffic signal evaluation
  - Identifying pedestrian safety treatments and crash modification
  - promoting pedestrian innovation/ coupling improvements with traditional measures

- Existing practice seldom links policy with actions

- Signal operations innovations are limited and not advocated for in the pedestrian community and vice versa
Questions
Warning: Practical Application Ahead
Case Study: Downtown Baltimore

- Downtown Ring Road serves vehicles
- Mostly one way street system over the grid (inside ring)
- Our project is to retime the network
- What should our MOEs be?

Vehicles

Light Rail
Case Study: Downtown Baltimore

- Traditional travel time surveys through the City?
  - Increase Speeds?
  - Reduce Delay?

- What’s the Mayor going to say?
  - Previous request for reducing the cycle length in downtown
Case Study: Downtown Baltimore

- Traditional travel time surveys through the City
  - Does not recognize multimodal needs
  - Local issues with property owners
  - May bias retiming to increase speeds
Case Study: Downtown Baltimore

- LRT Corridor
  - LRT delay survey
- Center of the City
  - Speed management
- Vehicular Travel speed
  - Bandwidth
- Bus Corridor
  - Bus signal delay
- Community Planning
  - Neighborhood wants reduced through traffic
Case Study: Downtown Baltimore

- **Speed Management in Center City**
  - Stops and Delay
  - Pedestrian Delay
  - Min, Max, Average Speed

- **LRT Corridor**
  - Let transit conduct a delay survey

- **Vehicular Travel Speed**
  - Bandwidth
  - Stops and Delay