Signalized Intersections

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Learning Outcomes

⇒ At the end of this module, you will be able to:

⇒ Explain why traffic signals don’t “guarantee” safety: they assign the right of way

⇒ Identify major conflicts: concurrent turn movements

⇒ Select protected turns to improve ped safety

⇒ Identify signal timing techniques that favor ped crossings
Signalized Intersections Can Be Improved For Pedestrians By:

1. Using good geometric design
2. Placing islands to break up complex crossings
3. Placing crosswalks in logical locations
4. Providing pedestrian signal heads
5. Placing push-buttons in convenient locations
6. Timing signals to minimize ped delay & conflicts

- 1, 2 & 3 addressed in earlier module
Traffic signals assign the right of way, regulate the flow of traffic and create gaps

Traffic signals do not guarantee safety – in fact, signalized intersections have more crashes than non-signalized
Turn movements often result in conflicts
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Traffic signals don’t ensure protection

Peds routinely ignore the light (usually quite safely)
Traffic signals don’t ensure protection

Pedestrians will cross where it’s convenient
Traffic signals don’t ensure protection

Red-light running

Concurrent left turns on Green

Pedestrians are at risk when crossing with the light
Pedestrian Signals at Signalized Intersections (AKA Ped Heads/Pedestrian Indicators) Need and Placement
Pedestrian signals should be provided, Otherwise pedestrians don’t know when to cross
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Lack of pedestrian signals on one way street:
The pedestrian may not notice the signal
Ped head should be placed here.

Lack of pedestrian signals on one way street: The pedestrian may not notice the signal
Ped head placement: close to crosswalk, visible to pedestrians, especially with long crosswalk

- **Poor example**
  - Place ped head here

- **Good example**
  - Height: 7’ – 10’
Two-step signals: ensure pedestrians don’t see conflicting signals

These pedestrians kept walking, against light.
Old System

1. Ped symbol or WALK
2. Flashing Hand or DON’T WALK
3. Steady Hand or DON’T WALK

1/2 of Americans don’t understand it;
Is there a better system?

* Flashing orange hand/DON’T WALK is ped clearance interval: very counterintuitive
Problem with old system: People not sure if they can start during flashing hand / DON’T WALK
Countdown pedestrian signal tells pedestrians how much crossing time is left
Countdown pedestrian signal research results:

1. Pedestrians understand how it works
2. More people start crossing during clearance phase, but...
3. Fewer people initiate walk late in clearance phase
4. No pedestrians left in crosswalk in steady don’t walk
5. Drivers don’t take a cue and accelerate to beat the light
What about crash reduction?

Results from San Francisco study are promising:

CRF = 25% after countdown signals installed
Change included in 2009 MUTCD

🧶 Countdown displays required for new pedestrian signals (except the rare situation where the change interval is 7 seconds or less)

🧶 Why? Significant reductions in pedestrian-vehicle crashes, as well as all types of crashes
Discussion:

What are your policies & practices regarding the provision of pedestrian indicators and countdown signals?
Placing Push-buttons In Convenient Locations
Proper Push-button Placement

MUTCD Recommendations:

- In line with crosswalk;
- Buttons at least 10’ apart;
- Between 1.5’ and 6’ from curb
- Button face parallel to xwalk

This button for this crosswalk
Proper Push-button Placement

→ The MUTCD recommends these dimensions
Poor Push-button Placement

Inconspicuous

Too far from ramp
Poor Push-button Placement

Behind guardrail

Behind vegetation
Poor Push-button Placement

At back of pole

In front of pole
Poor Push-button Placement

All of the Above?
Proper Push-button Placement

On side of pole

At top of ramp
Communicate With Pedestrians

LED tells peds the button works and the signal has received the call (*like an elevator*)

Tactile arrow gives direction to blind and sighted pedestrians
New Requirement in the 2009 MUTCD

- Positioning of pedestrian pushbuttons and legends on pushbutton signs shall clearly indicate which crosswalk signal is activated by each pushbutton.
Signal Timing & Walking Speeds
Pedestrian Walking Speeds

2003 MUTCD requirements:

- 7 sec steady walk (peds may enter crosswalk); 4 sec “option”
- Pedestrian clearance time calculated at 4’/sec curb-to-curb
- 60’ crosswalk requires 15 sec
- 15 + 7 = 22 sec absolute minimum walk plus clearance
Pedestrian Walking Speeds

2009 MUTCD:

- 7 sec walk, 4 sec option (no change)
- Ped clearance time calculated at 3.5'/sec curb-to-curb.
- 60’ crosswalk requires 17 sec
  - 7 + 17 = 24 sec total
- Additional test for walk plus clearance time: Calculate travel time from push button (or 6’ feet from curb if no button) to curb on other side at 3'/sec
  - 60’ crosswalk + 6’ = 66’
  - 66’ requires 22 sec
  - 24 sec > 22 sec; passes test.
Guidance for walk plus clearance: Calculate time from pushbutton (or 6’ from curb) to curb on other side at 3’/sec

60’ crosswalk + 6’ = 66’ total; @ 3’/sec = 22 sec walk plus ped clearance

Note: pushbutton is considered the departure point for older pedestrians and people in wheelchairs.
Reducing Pedestrian & Left-Turning Vehicle Conflicts
Protected Vs. Permissive Left Turns

At signals, turning movements account for most ped crashes; Left/right turn ratio is roughly 2:1

* CRF 70% (all crashes) converting permissive left turns to protected only left turns
Permissive Left Turns

Pedestrians cross at same time as left-turning car; Drivers turning left on a green ball don’t look for pedestrians.
Permissive Left Turns
Permissive Left Turns
Protected Left Turns

Pedestrians cross after left-turning car, with thru-traffic; Pedestrian and car not in conflict
Protected Left Turns
Protected Left Turns
Protected Left Turns
Protected Left Turns

[Diagram showing a protected left turn at a signalized intersection]
Pedestrians cross after most left-turning cars (protected phase); Pedestrian and remaining cars are in conflict (permissive phase)
Protected/permissive Left Turns
Protected/permissive Left Turns
Protected/permissive Left Turns
Protected/permissive Left Turns
Protected/permissive Left Turns: Solutions

1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed

2. Flashing Yellow Arrow (details on the next slide)
Protected/permissive Left Turns: Solutions

Flashing left yellow arrow during steady green ball warns drivers: yield to pedestrians and oncoming traffic.
Protected/permissive Left Turns: Solutions

1. Green Turn Arrows
Protected/permissive Left Turns: Solutions

2. Steady Yellow Turn Arrows
Protected/permissive Left Turns: Solutions

3. Steady Yellow Ball
4. Steady Red Ball & Turn Arrows
Protected/permissive Left Turns: Solutions

5. Steady Green Ball
Protected/permissive Left Turns: Solutions

6. Flashing Yellow Turn Arrow
Protected/permissive Left Turns: Solutions

7. Steady Yellow Ball & Arrow
Protected/permissive Left Turns: Solutions

8. Steady Red Ball & Arrow
Discussion

- What are your traffic signal timing policies?
- Do you use protected left turns to protect pedestrians from turning vehicles?
- Do you use protected/permissive phasing?
- If so, have you considered flashing left yellow arrow during the steady green ball?
Signal Timing To Minimize Pedestrian Delay & Conflicts
Use Short Signal Cycle Length

Long wait causes stacking: pedestrians wait in street, or don’t wait and cross against the signal
At high-use crosswalks, pedestrians should get a signal at every cycle.
Set pedestrian signals to recall to WALK when major street is set to recall to green.

Peds shouldn’t have to push a button to cross the minor street.
LPI

⇔ LPI = Lead Pedestrian Interval
⇔ LPI gives pedestrians a head start
⇔ Looks like a regular signal to drivers
Looks like a regular signal to drivers: green-yellow-red
LPI: WALK comes on at least 3 seconds prior to the green signal; pedestrians enter crosswalk before turning vehicles arrive there.
LPI Sequence - without:
Pedestrian starts crossing at same time as RT-turning car;
Pedestrian and car on collision course
LPI Sequence - *with*: Pedestrian starts crossing before RT-turning car; Pedestrian gets head start and driver sees ped before entering crosswalk.
LPI Sequence - *with*: Pedestrian starts crossing before RT-turning car; Pedestrian gets head start and driver sees ped before entering crosswalk.
Where do the extra 3-5 seconds come from?

- Peds need 30 seconds to cross
- Vehicle queue needs less time to clear
Where do the extra 3-5 seconds come from?

Walk Signal
Where do the extra 3-5 seconds come from?

Car waits to turn
Where do the extra 3-5 seconds come from?
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Car waits to turn
Where do the extra 3-5 seconds come from?
These peds waited 3 cycles before turning drivers let them cross as legally required. LPI would give them a head start.

CRF: 5%
Simple & Innovative Ideas To Minimize Pedestrian Conflicts
Signs: Remind Turning Drivers to Yield to Peds

Older local variations, using MUTCD-approved lettering and symbols:

Leesburg, FL

Juneau, AK

Orlando, FL
Signs: Remind Turning Drivers to Yield to Peds

Old MUTCD R10-15

R10-15 in 2009 MUTCD
Restricting Turns on Red

→ Consider No Turn on Red signs where there is:

- Poor sight distance between vehicles and peds;
- An unusual number of ped conflicts with turns on red (compared to turns on green);
- An exclusive pedestrian phase; or
- A leading pedestrian interval
Restricting Turns on Red

1. At all times
Restricting Turns on Red

2. When pedestrians are present
   - Difficult to enforce
Restricting Turns on Red

3. By time of day
   - Limits most turns on red
Restricting Turns on Red

4. Changeable message sign – can be activated when ped pushes button or as set by controller

- Note: An on-demand NTOR sign can be used to improve the effectiveness of a Lead Pedestrian Interval
Exclusive Pedestrian Phase (Barnes Dance)

Popular because all traffic stops and pedestrians can cross in any direction (must ban turns on red)
Pedestrians pay a price in delay: Pedestrians wait for traffic in one direction
Pedestrians wait for traffic in other direction
Reward: pedestrians can cross in any direction

- Exclusive pedestrian phase increases safety *(CRF 34%)* but decreases efficiency of intersection
- Use where there are high ped volumes and many turning vehicles
Using ITS to Help Pedestrians
In this example a high-tech signal was used to help slower pedestrians cross the street with minimal delay to traffic.

A slower crossing speed would delay traffic significantly.
Microwave sensors are aimed at the crosswalks to track peds
Pedestrian clearance is timed @ 4 ft/sec

The sensor tracks ped as they cross the street
The controller adds 4 seconds crossing time if pedestrian hasn’t finished crossing (8 seconds maximum).

In this case, the walk phase was prolonged in 20% of crossings, reducing unnecessary traffic delay the other 80% of crossings.
Learning Outcomes

You should now be able to:

1. Explain why traffic signals don’t “guarantee” safety; they assign the right of way
2. Identify major conflicts: concurrent turn movements
3. Select protected turns to improve pedestrian safety
4. Identify signal timing techniques that favor pedestrian crossing
Questions?

→ For more information see archived TRB Webinar:

Accommodating Pedestrians at Signalized Intersections

https://www1.gotomeeting.com/register/622595628