Billgeville’s new pedestrian monkey bars not only reduced accidents but also whipped people into great shape.
Learning Outcomes

- At the end of this module, you will be able to:
  - Identify which crossing technique is appropriate
  - Ensure oft-requested solutions (crosswalks, signals, pedestrian bridges) are effective:
    - Concerned citizens and elected officials often respond to a tragic pedestrian crash asking for an immediate solution, which may or may not be appropriate.
    - This module explains why some countermeasures work, and why others don’t.
Basic Street Crossing Techniques

- Crosswalks
- Illumination
- Signs
- Striping
- Medians/pedestrian islands
- Signals
- Over/undercrossings
Crosswalks

Crosswalk FAQ’s:

- Why are they marked?
- Where should they be marked?
- Do marked crosswalks increase safety, or provide a “false sense of security?”
1. Why are crosswalks markings provided?

- To indicate to pedestrians where to cross
- To indicate to drivers where to expect pedestrians
- At mid-block locations, crosswalk markings legally establish the crosswalk.
2. How to determine where to mark a crosswalk?

- Crosswalk markings are commonly used to guide pedestrians and alert other road users of pedestrians at signalized locations and approaches controlled by STOP or YIELD signs.

- An engineering study should be performed before crosswalk markings are installed at locations away from traffic signals or STOP signs. (MUTCD Section 3B.18)
2. How to determine where to mark a crosswalk?

Consider origins and destinations

In this case, apartments across from bus stop & stores
Not Suitable Location for a Marked Crosswalk
- Not a good location for a marked crosswalk:
- No consistent place where pedestrians cross
Not a good location for a marked crosswalk:

- Poor sight distance
Suitable Locations for a Marked Crosswalk
Suitable location for a marked crosswalk:

- Two-lane, high use, driver expectancy
Suitable location for a marked crosswalk:
Slow speed, high use, driver expectancy
3. Looking or Not Looking?

Do marked crosswalks increase safety, or encourage people to cross without looking?
Results of Most Recent Study (Zegeer et al 2005)

- Marked vs. Unmarked Analysis
- Speeds ≤ to 40 mph
  - Two-lane roads: No significant difference in crash rate
  - Multilane roads (3 or more lanes)
    - Under 12,000 ADT: no significant difference in crash rate
    - Over 12,000 ADT w/ no median: crashes marked > crashes unmarked
    - Over 15,000 ADT & w/ median: crashes marked > crashes unmarked
Study Results

- Median reduces crashes by 40%  
- Pedestrians over 65 are over-represented in crosswalk crashes  
- Pedestrians are not less vigilant in marked crosswalks:  
  - Looking behavior increased after crosswalks installed
Study Results

- Crashes correlate with ADT & number of travel lanes.
- Other studies have shown similar results.
One explanation of higher crash rate at marked crosswalks: multiple-threat crash

1st car stops too close, masks visibility for driver in 2nd lane

Solution: advance stop bar (comes later...)
New marked crosswalks alone, **without other measures designed to reduce traffic speeds**, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph or either:

- Has 4 or more lanes without a raised median or island and ADT of 12,000 or more, or
- 4 or more lanes with raised median island and ADT of 15,000 or more

(2009 MUTCD Section 3B.18)
Increase Effectiveness Of Crosswalks

With:

- Proper location
- High Visibility Markings
- Illumination
- Signing
- Advance Stop Bars
- Median Islands
- Curb Extensions
- Signals
“When considering marked crosswalks at uncontrolled locations, the question should not be simply, “Should I provide a marked crosswalk or not?”…”

“Regardless of whether marked crosswalks are used, there remains the fundamental obligation to get pedestrians safely across the street. In most cases, marked crosswalks are best used in combination with other treatments (e.g., curb extensions, raised crossing islands, traffic signals, roadway narrowing, enhanced overhead lighting, traffic calming measures)…."

“In all cases, the final design must accomplish the goal of getting pedestrians across the road safely…."

“The design question is, “How can this task [getting pedestrians across the road safely] best be accomplished?”
Discussion:

What are your policies & practices regarding marked crosswalks?
Marked crosswalk must be visible to the DRIVER

What the pedestrian sees
Marked crosswalk must be visible to the DRIVER

What the driver sees (same crosswalk)
Crosswalk Visibility

Crosswalk Marking Types
Crosswalk Visibility

Longitudinal markings are more visible to driver from afar
Longitudinal markings with transverse markings – very visible
Place longitudinal markings to avoid wheel tracks, reducing wear & tear & maintenance.
Staggered markings improve visibility from afar
Textured crosswalks: How effective are they?

In theory, more visible. Reality?
What the pedestrian sees
What the driver sees
- Brick crosswalks: prone to failure
- Difficult for wheelchair users
Mitigation Measures For Colored Crosswalks
Supplement textured crosswalks with white lines to increase visibility.
Brick street with (asphalt-coated) concrete crosswalk
Checkerboard pattern created by alternating brushed concrete with exposed aggregate (use fine rock)
Idea: imbed white crosswalk within contrasting color
Driver perspective: crosswalks show up well
Raised Crosswalks

- FHWA Study “The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior” - 2001
- Increase pedestrian visibility & likelihood the driver yields to pedestrians especially when combined with an overhead flashing light
- Most appropriate on low speed local or neighborhood streets
- Should not be used on emergency routes, bus routes, or high speed streets
- Drainage of storm water runoff and snow plowing considerations may also be a concern with raised crosswalks

Figure 6. Raised crosswalk and overhead flasher, Towerview Drive, Durham, North Carolina.
Table 8. Comparison of Vehicle Speeds at the Treatment and Control Sites.

<table>
<thead>
<tr>
<th>CITY AND TREATMENT</th>
<th>50TH PERCENTILE SPEED TREATMENT SITE</th>
<th>50TH PERCENTILE SPEED CONTROL SITE</th>
<th>DIFFERENCE IN SPEEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham, NC – Research Drive Raised crosswalk</td>
<td>33.3 km/h (20.7 mi/h)</td>
<td>39.8 km/h (24.7 mi/h)</td>
<td>6.5 km/h (4.0 mi/h) lower at treatment site SIGNIFICANT1</td>
</tr>
<tr>
<td>Durham, NC – Towerview Drive Raised crosswalk &amp; overhead flasher</td>
<td>18.5 km/h (11.5 mi/h)</td>
<td>38.4 km/h (23.9 mi/h)</td>
<td>19.3 km/h (12.4 mi/h) lower at treatment site SIGNIFICANT</td>
</tr>
<tr>
<td>Montgomery County, MD2 Raised Crosswalk</td>
<td>34.6 km/h (21.5 mi/h)</td>
<td>38.6 km/h (24.0 mi/h)</td>
<td>4.0 km/h (2.5 mi/h) lower at treatment site NOT SIGNIFICANT</td>
</tr>
</tbody>
</table>

1. Significant at the 0.05 level or better, using a two-tailed test.
2. Vehicle speeds in Montgomery County were measured only when the staged pedestrian was present.


<table>
<thead>
<tr>
<th>SITE AND TREATMENT</th>
<th>TREATMENT SITE</th>
<th>CONTROL SITE</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham, NC — Towerview Dr Raised crosswalk and overhead flasher</td>
<td>79.2% (159)*</td>
<td>31.4% (35)</td>
<td>* (0.000)</td>
</tr>
<tr>
<td>Montgomery County, MD Raised crosswalk</td>
<td>1.2% (169)</td>
<td>1.0% (198)</td>
<td>N</td>
</tr>
</tbody>
</table>
Illumination – Essential For Any Crossing

- Marked crosswalk?
  - Light it
- Up to 50% of pedestrian crashes occur at night
Lighting reduces the odds of pedestrian fatalities:
- by 42% at midblock locations
- by 54% at intersections
Ped shows up well in well-lit crosswalk
Informational Report on Lighting Design for Midblock Crosswalks

- FHWA-HRT-08-053
- April 2008
Sample Illustrations from FHWA Report

Fig 11. Traditional midblock crosswalk lighting layout

Fig 12. New design for midblock crosswalk lighting layout

Recommended lighting level: 20 lux at 5’ above pavement
Fig 13. Traditional intersection lighting layout

Fig 14. New design for intersection lighting layout for crosswalks.

Fig 15. New design for wide roadway intersection lighting layout for crosswalks.
Ped crossing signs: old vs. new MUTCD standards

Old

Primary Location: in advance of crosswalk

Supplemental at crosswalk

New

Placement

2009 MUTCD Sec. 2C.50 & Fig. 2C-10
In-street pedestrian crossing signs

R1-6  MUTCD signs
Yield or Stop
depends on state law

R1-6a

Tampa FL
In-street signs increase yield rates, especially on slow-speed streets
Pedestrian crossing sign with flashing beacon

Improves visibility of sign and crosswalk; CMF/CRF unknown
Rectangular Rapid Flash LED Beacon

- MUTCD Interim approval July 2008
  - Must submit a written request to the FHWA

- Studies indicate motorist yield rates increased from about 20% to 80%

- Beacon is yellow, rectangular, and has a rapid “wig-wag” flash

- Beacon located between the warning sign and the arrow plaque

- Must be pedestrian activated (pushbutton or passive)
Beacons required on the both right side and on the left side or in a median if practical
Advance Stop or Yield Line: Reduces Multiple-threat Crashes
Multiple Threat Crash Problem

- 1st car stops to let pedestrian cross, blocking sight lines
- 2nd car doesn’t stop, hits pedestrian at high speed
Multiple Threat Crash Solution

- Advance stop or yield line
- 1st car stops further back, opening up sight lines
- 2nd car can be seen by pedestrian
Signing to go along with markings

R1-5
(Use where local law says yield to pedestrians)

R1-5a

R1-5b
(Use where local law says stop for pedestrians)

R1-5c

MUTCD Sec. 2B.11 and Figure 2B-2
- Advance yield line (shark’s teeth) & sign
- Consider double white lines for no passing

2009 MUTCD Section 3B.16 and Figure 3B-17
Advance stop line and sign

2009 MUTCD Section 3B.16
- 20’ to 50’ setback (30’ preferred for effectiveness)
- Prohibit parking between line and crosswalk
Marking a Crosswalk Summary

When is it OK to mark a crosswalk without other treatments on roads with speed limits \( \leq 40 \) mph?

- 2-lane roads
- Multi-lane roads w/ ADT < 12,000 (no median)
- Multi-lane roads w/ADT < 15,000 (median)

How can you increase the effectiveness of marked crosswalks?

- Marked crosswalk: Add median, advance stop line
- Textured crosswalks: Smooth and white is best
- Signs: In road; supplement with striping
- In all cases (nighttime): Illumination!
Raised Medians And Islands

Significant crash reductions:

- Marked crosswalks
  - CMF = 0.54 (CRF = 46%)

- Unmarked crosswalks
  - CMF = 0.61 (CRF = 39%)
Continuous raised median – basic principle:
- Breaks long complex crossing into two simpler crossings
Step 1: look at traffic on left
Step 2: cross first half
Step 3: look at traffic on right
Step 4: cross second half
People figure out on their own how to use a median to cross in two steps
A flush median is not a refuge
Add a raised island
- Crossing island at marked crosswalk - same principle:
- Breaks long complex crossing into two simpler crossings
- Option: stagger or angle cut-through so pedestrians face oncoming traffic before 2nd crossing
Angled cut through: Line up ends with crosswalk direction for the blind

Wrong

Right
Medians:

- Why do medians reduce pedestrian crashes?
  - They reduce crossing distance and break up an otherwise complex task into 2 simpler crossings

- What is the crash reduction factor?
  - At marked crosswalks CMF = 0.54 (CRF = 46%)
  - At unmarked crosswalks CMF = 0.61 (CRF = 39%)
Pedestrian Signal
MUTCD signal warrants

1. Eight-hour vehicle volume
2. Four-hour vehicle volume
3. Peak hour
4. Pedestrian volume*
5. School crossing*
6. Coordinated signal system
7. Crash experience*
8. Roadway network
9. Intersection near a grade (rail) crossing

* = potential ped warrant

2009 MUTCD Chapter 4C
Very difficult to meet pedestrian volume warrant

You need many pedestrians
2009 MUTCD Pedestrian Volume Warrant for Speeds > than 35 mph

Old minimum ped volume: 190

Minimum ped volume: 93
Provide a HOT response

Otherwise pedestrians won't wait for the light
If wait is too long, pedestrians will seek gaps
And then traffic waits for no reason
Pedestrian Signal

2-stage crossing increases effectiveness and disrupts traffic less
1. Ped pushes button, waits, crosses to island
2. Ped crosses to island, proceeds to 2nd button
3. Ped on island – pushes button to finish crossing
Stage 1: Ped stops traffic in one direction
Stage 1: Ped crosses to median island
Stage 1 over: Traffic in one direction resumes
Stage 2: Ped stops traffic in other direction
Stage 2 over: Traffic resumes
Detail 1: Requires ped push button on island
Detail 2: Fences force peds to walk against on-coming traffic
Pedestrian Hybrid Beacon aka “HAWK” (High Intensity Activated Crosswalk)
Hybrid Beacon Sequence

1. Blank for drivers
2. Flashing yellow
3. Steady yellow
4. Steady red
5. Wig-Wag

Return to 1

2009 MUTCD Section 4F.3
# Pedestrian Hybrid Beacon Effectiveness

## Table 21. Summary of motorist yielding compliance from three sources for red signal or beacon and active when present.

<table>
<thead>
<tr>
<th>Crossing Treatment</th>
<th>TCRP D-08/NCHRP 3-71 Study</th>
<th>Other Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compliance – Staged Pedestrian Crossing</td>
<td>Compliance – General Population Pedestrian Crossing</td>
</tr>
<tr>
<td></td>
<td># of Sites</td>
<td>Range (%)</td>
</tr>
<tr>
<td>Midblock Signal</td>
<td>2</td>
<td>97 to 100</td>
</tr>
<tr>
<td>Half Signal</td>
<td>6</td>
<td>94 to 100</td>
</tr>
<tr>
<td>HAWK Signal Beacon</td>
<td>5</td>
<td>94 to 100</td>
</tr>
<tr>
<td>In-Roadway Warning Lights</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Overhead Flashing Beacon (Pushbutton Activation)</td>
<td>3</td>
<td>29 to 73</td>
</tr>
<tr>
<td>Overhead Flashing Beacon (Passive Activation)</td>
<td>3</td>
<td>25 to 43</td>
</tr>
</tbody>
</table>
Excerpts from 2009 MUTCD Chapter 4F
For Pedestrian Hybrid Beacons

- The CROSSWALK STOP ON RED sign shall be used
- There are Guidelines (similar to signal warrants) for Pedestrian Hybrid Beacons – variables include:
  - Pedestrian volume
  - Traffic speeds
  - Traffic volumes
  - Crosswalk length

MUTCD Sections 4F.1 and 4F.2
2009 MUTCD Section 4F.02, paragraph 04 provides the following Guidance:

“When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then the PHB should be installed at least 100 feet from side streets or driveways controlled by STOP or YIELD signs.”

This MUTCD statement is “Guidance” not a “Standard” and has been recommended by the NCUTCD to be removed.
Over & Under crossings
In theory, grade separation = no conflicts
In reality, pedestrians often ignore structures placing themselves in greater danger
Why don’t they get used? Longer travel distance
Sometimes fences are needed to direct users
Grade separation is more useful for purposes beyond simply crossing from sidewalk to sidewalk:

- To connect buildings
- To connect land uses
- To cross freeways
- Light rail stations
Overcrossings are expensive because of their height, which requires long ramps.
Undercrossings require generous dimensions to be attractive: security is the main issue.

Good design practice: Users must see light at the end of the tunnel.
Undercrossing must not intimidate potential user
Undercrossings work best if roadway is elevated, even if it is just a small amount.
Elevated roadway allows open, airy undercrossing
Undercrossings work best if well lit & attractive
Over/undercrossings

- Why are they not effective for street crossings?
  - They add out-of-direction travel

- When are they useful?
  - To connect land uses separated by a roadway

- How can you increase their effectiveness?
  - By providing a direct route
  - By providing security
### Crossing treatments cost comparison:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Effectiveness</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signing</td>
<td>*</td>
<td>$500 – 1,000</td>
</tr>
<tr>
<td>High visibility markings</td>
<td>**</td>
<td>$2,000 – 15,000</td>
</tr>
<tr>
<td>Advance stop or yield line</td>
<td>****</td>
<td>$1,000 – 2,000</td>
</tr>
<tr>
<td>Illumination</td>
<td>****</td>
<td>$5,000 – 15,000</td>
</tr>
<tr>
<td>Median Islands</td>
<td>****</td>
<td>$15,000 – 90,000</td>
</tr>
<tr>
<td>Signals (including HAWK)</td>
<td>***</td>
<td>$75,000 – 400,000</td>
</tr>
<tr>
<td>Over/undercrossings</td>
<td>*</td>
<td>$1,000,000 – 4,000,000</td>
</tr>
<tr>
<td>Proper location</td>
<td>*****</td>
<td>“Priceless”</td>
</tr>
</tbody>
</table>
Case Studies

- These case studies show before and after pictures of locations where agencies developed projects specifically to enhance pedestrian safety.
- Some of these examples were done based on this workshop.
- St. Petersburg, FL – 4th Street North (US Hwy. 92)
- 3/4-mile signal spacing; No existing marked crosswalks between signals
Before: View from near Sunken Gardens entrance
After: Raised median, Signs with rapid flash beacons, Advance yield lines, High-visibility marked crosswalk
Phoenix, AZ – W. Van Buren Street. Before: 1/2-mile signal spacing; high-volume, high-speed; marked crosswalks at unsignalized intersections
Before: No frills marked crosswalk at intersection
Before: Challenging 6-lane crossing at Community Center
After: Marked crosswalk moved to midblock location near Community Center; Raised median with stagger; advance stop lines
After: Raised median with stagger, Advance stop lines (not visible), Location near destination
Learning outcomes: Street Crossings

- You should now be able to:
- Identify which crossing techniques are appropriate
- To ensure oft-requested solutions (crosswalks, signals, ped bridges) are effective
Questions?