DESIGNING IN CONTEXT OF COMPLETE STREETS
Guiding Principles

- Safety
- Accommodation and Comfort
- Coherence
- Predictability
- Context Sensitivity
- Experimentation

Source: Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts
Connectivity creates a walkable street system by:
- Reducing walking distances;
- Offering more route choices on quiet local streets;
- Dispersing traffic – reducing reliance on arterials for all trips
Can you increase connectivity with paths, greenways?

Network Connectivity

- Reduces walking distances: YES
- Offers more route choices: YES
- Disperses traffic: NO
Lack of connectivity => overly wide streets
Lack of connectivity => few but large intersections
Design Strategies

- Disconnected Street Networks
  - Keep block sized small
  - Connect Cul-de-sacs

- Barriers (Highways, Railroad, etc)
  - Bridges
  - Tunnels

- Pedestrian Connections
  - Sidewalks
  - Narrow Travel Lanes
  - Reduce Crossing Distance

- Bicycle Connections
  - Separated facilities
  - Contraflow Lanes
Design Strategies

- Automobiles
  - Grid Street Pattern
  - Target Speed 35 mph
  - Signal Timing

- Transit
  - Stop Locations
  - Frequency of Service
  - First Mile/Last Mile

- Freight
  - Loading Zones
  - Intersection Design
Design Strategies
- Freight
  - Intersection Design – Minimize Curb Radius with Truck Apron
Design Strategies: Pedestrians: Block length – Safe Crossing Frequency

300’ Block Length

1,500’ – 2,000’ Block Length
NETWORK CONNECTIVITY

Ped/Bike Access through Interchanges

- Balance
  - Shortest Crossing Distance
  - Visibility
  - Least Out-of-Direction Travel
  - Proper ADA Ramp Placement
- Where free-flow ramps are used (least desirable) Crosswalk should be placed where it’s visible
 Barrier should not obscure crosswalk
Figure 177. Illustration. Pedestrian movements in a DCD interchange.
Figure 178. Illustration. Proposed pedestrian accommodation in the median of the DCD interchange in Springfield, MO.
Leading up to the protected Center Crossing
Walking down the protected Center Crossing
Learning Outcomes

- Connect Streets to dissipate traffic and provide short travel distance for pedestrians and bikes
- Design – convenient, safe, and comfortable
- Connect Modes – evaluate for the chained trips
  - Pedestrians – sidewalks, reduce crossing distances
  - Bicycles – separate facilities, contra-flow lanes
  - Automobiles – grid system, signal timing
  - Transit – stop locations, first mile/last mile
  - Freight – loading zones, intersection design
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)
RRFB
Beacons required on the both right side and on the left side or in a median if practical
PEDESTRIAN HYBRID BEACONS (PHB)

- 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
PEDESTRIAN HYBRID BEACONS (PHB)
PEDESTRIAN 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 – Placement near Intersections

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.
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
MUTCD PEDESTRIAN SIGNAL WARRANT

Can be difficult to meet the pedestrian volume warrant
MUTCD PEDESTRIAN SIGNAL WARRANT

For Speeds > 35 mph

Old minimum ped volume: 190

Easier to meet on streets with high vehicle volumes
More difficult to meet on streets with low vehicle volumes

Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)

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
TRAFFIC SIGNALIZATION

Techniques that favor ped crossings

- Equipment placement – push buttons and signal heads
- Pedestrian Recall or Wide Permissive Window
- Short Cycle Lengths – geometry important
- Passive detection in special context – peds need more time
- Protected Left Turn Phasing and Lagging Lefts
- No Turn on Red
- Exclusive Ped Phase (Barnes Dance)
- Leading Pedestrian Interval (LPI)
TRAFFIC SIGNAL EQUIPMENT

Proper pushbutton placement

On side of pole

At top of ramp
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
TRAFFIC SIGNAL EQUIPMENT

Pedestrian Head Placement

- Close to the Crosswalk
- Visible to Pedestrians
  - Especially with long crossings

Poor Placement

Good Placement

Height: 7’ – 10’

2009 MUTCD Section 4E.05
TRAFFIC SIGNAL PHASING

- Pedestrians should get a signal at every cycle “Ped Recall” – OR –
- Open the Permissive Window to accept the pedestrian actuation
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.
60' crosswalk @ 3.5'/sec = 17sec + 7sec min walk = 24 sec walk plus ped clearance
60' crosswalk + 6' = 66’ total; @ 3'/sec = 22 sec walk plus ped clearance

Smaller intersections require less pedestrian phase length.

Note: pushbutton is considered the departure point for older pedestrians and people in wheelchairs.
Use Short Cycle Lengths

Long wait causes stacking: pedestrians wait in street, or don’t wait and cross against the signal
## Traffic Signal Detection

### Passive Detection for Pedestrians and Bicyclists

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Bicycle Presence</th>
<th>Ability to Distinguish Between a Bicycle and a Pedestrian within the Detection Zone</th>
<th>Collect Bicycle Count Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEA Industrial</td>
<td>IS40</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>FLIR/Traficon</td>
<td>SafeWalk</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Iteris</td>
<td>SmartCycle</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Migma Systems, Inc.</td>
<td>MigmaBicycle</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MS Sedco</td>
<td>SmartWalk</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Use passive detection to extend pedestrian time only when needed
Microwave sensors are aimed at the crosswalks to track pedestrian presence.
Passive Detection

- 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.
Reducing Conflicts between Pedestrians and Turning Vehicles

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

Countermeasures

- Yield to Ped Signs
- Right Turn on Red Restrictions
- Protected vs. permissive turns
- Lagging Left Turn Phasing
- Exclusive Pedestrian Phase
- Leading Pedestrian Interval
TRAFFIC SIGNALS

Signs: Remind turning drivers to Yield to Pedestrians

R10-15 in 2009 MUTCD

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

- Leesburg, FL
- Juneau, AK
- Orlando, FL

MUTCD Sec. 2B.53, Paragraph 09
Right Turn on Red Restrictions
(protecting the pedestrian stepping in front of the driver)

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

MUTCD Section 2B.54
Right Turn on Red Restrictions

1. At all times
Right Turn on Red Restrictions

2. When Pedestrians are present . . . . difficult to enforce . .
Right Turn on Red Restrictions

3. By time of day
Right Turn on Red Restrictions

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 (LPI)
Protected vs. Permissive Left Turn Phasing

* CMF = 0.3 (CRF 70%) (veh and ped crashes) converting permissive left turns to protected only left turns
TRAFFIC SIGNALS

Protected vs. Permissive Left Turn Phasing

1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed or based on time of day

2. Flashing Yellow Arrow (details on the next slide)
Flashing left yellow arrow during steady green ball warns drivers: yield to pedestrians and oncoming vehicles.
Lagging Left Turn Phasing

- Pedestrian ALWAYS goes 1st

... pairs well with the LPI
TRAFFIC SIGNALS

Exclusive Pedestrian Phase (Barnes Dance)

- Popular because all traffic stops and pedestrians can cross in any direction (must ban turns on red)

Pasedena CA

MUTCD Figure 3B-20 (Markings)
Vehicles pay a price in delay

Pedestrians pay the price in delay if the conventional pedestrian phasing is not used in conjunction with the exclusive phase
LEADING PEDESTRIAN INTERVAL

Gets pedestrians established in crosswalk

Taken from StreetFilms: http://www.streetfilms.org/lpi-leading-pedestrian-interval/
LEADING PEDESTRIAN INTERVAL

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Green Time</th>
<th>Red Time</th>
<th>Yellow Time</th>
<th>Fixed-time LPI Actuated</th>
<th>Fixed-time LPI Not Actuated</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd Ave – LPI Actuated</td>
<td>58 sec R</td>
<td>27.5 sec G</td>
<td>5 Y</td>
<td>53 sec DW</td>
<td>19.5 sec W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Y</td>
<td>13 FDW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.5 DW</td>
<td></td>
</tr>
<tr>
<td>3rd Ave – LPI NOT Actuated</td>
<td>53 sec R</td>
<td>32.5 sec G</td>
<td>5 Y</td>
<td>53 sec DW</td>
<td>19.5 sec W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Y</td>
<td>13 FDW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.5 DW</td>
<td></td>
</tr>
</tbody>
</table>

LPI Can be Fixed-time or Actuated

- Fixed-time:
  - 24-hours
  - Time-of-day
- Push-button actuated
Learning Outcomes

- Rectangular Rapid Flashing Beacons
- Pedestrian Hybrid Beacons – 20 peds per hour
- Pedestrian Traffic Signals – 93 peds per hour
- Traffic Signal Techniques
  - Ped Recall
  - Short Cycle Lengths
  - Passive Detection
  - Protected Left Turn Phasing
  - Lagging Left turn (Pedestrian always go first)
  - No Turn on Red (Blank out sign actuated with push button)
  - Exclusive Ped Phase
  - Leading Pedestrian Interval
What is in your Complete Streets Policy?

- Crash Rate
- Injury Rate
- Speeding Analysis
- Traffic Volumes
- On/Off Street Parking Utilization
- Pedestrian Volumes
- Bicyclist Volumes
- Lane Miles of Pavement
- Number of Curb Ramps Installed
- High Crash Locations Addressed
- Number of Bike Racks Installed
- Miles of Transit Service Installed
- Number of Bus Stops Enhanced
- Linear Feet of Sidewalk Installed
- Miles of Bike Lanes Installed
Goal Setting for

- Quality of Service for each mode
- Health Impact Measures – Health in All Projects
- Equity – age, ability, income, race, or ethnicity
PERFORMANCE MEASURES

TABLE 3 COMMUNITY GOALS AND RELATED TRANSPORTATION MEASURES

<table>
<thead>
<tr>
<th>COMMUNITY GOALS CATEGORIES</th>
<th>TRANSPORTATION MEASURES CATEGORIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACCESSIBILITY</td>
</tr>
<tr>
<td>CONNECTIVITY</td>
<td>High</td>
</tr>
<tr>
<td>ECONOMY</td>
<td>High</td>
</tr>
<tr>
<td>ENVIRONMENT</td>
<td>High</td>
</tr>
<tr>
<td>EQUITY</td>
<td>High</td>
</tr>
<tr>
<td>HEALTH</td>
<td>High</td>
</tr>
<tr>
<td>LIVABILITY</td>
<td>High</td>
</tr>
<tr>
<td>SAFETY</td>
<td>High</td>
</tr>
</tbody>
</table>

ROAD DIETS

- Opportunity
- Resurfacing
- Drainage
Objective – Improve Safety
Features – School Zone and Previous treatments ineffective
ROAD DIETS – CASE STUDY: SANTA MONICA, CA

- **Context**
  - Schools
  - Retail
  - Recreational
  - Residential

- **Objective – Improve Safety**
  - Reduce Crashes
  - Reduce Travel Speed
    - 35 mph posted
  - Increase Ped Crossing Frequency

Ocean Park Boulevard looking east at 18th Street marked crosswalk and bicycle lane
ROAD DIETS – CASE STUDY: SANTA MONICA, CA
ROAD DIETS – CASE STUDY: SANTA MONICA, CA

- Results: Improved Safety
  - 9 months –
    - 65% reduction in all crashes
    - 60% reduction in injury crashes
  - Reduced Travel Speed
    - 27 mph 85th %ile speed
    - 10 mph higher outside area
  - Reduced Traffic
    - Diverted to I-10
    - Adjacent Streets Stable
  - Volumes
ROAD DIETS – CASE STUDY: RESTON, VA

- Reduce Crashes and Speeding
- Improve Safety and Connectivity for cyclists

Lawyers Road

2 miles

10,000 vehicles/day
ROAD DIETS – CASE STUDY: RESTON, VA
ROAD DIETS – CASE STUDY: RESTON, VA

- Repaving Project

- Results
  - After Speed Study changed posted speed from 45 mph to 40 mph
  - 70% reduction in crashes
Community Thoughts
■ 69% Seems Safer
■ 47% Cycle more often than before
■ 69% Travel time didn’t increase
■ 74% Agreed Lawyers Road Improved
Questions?