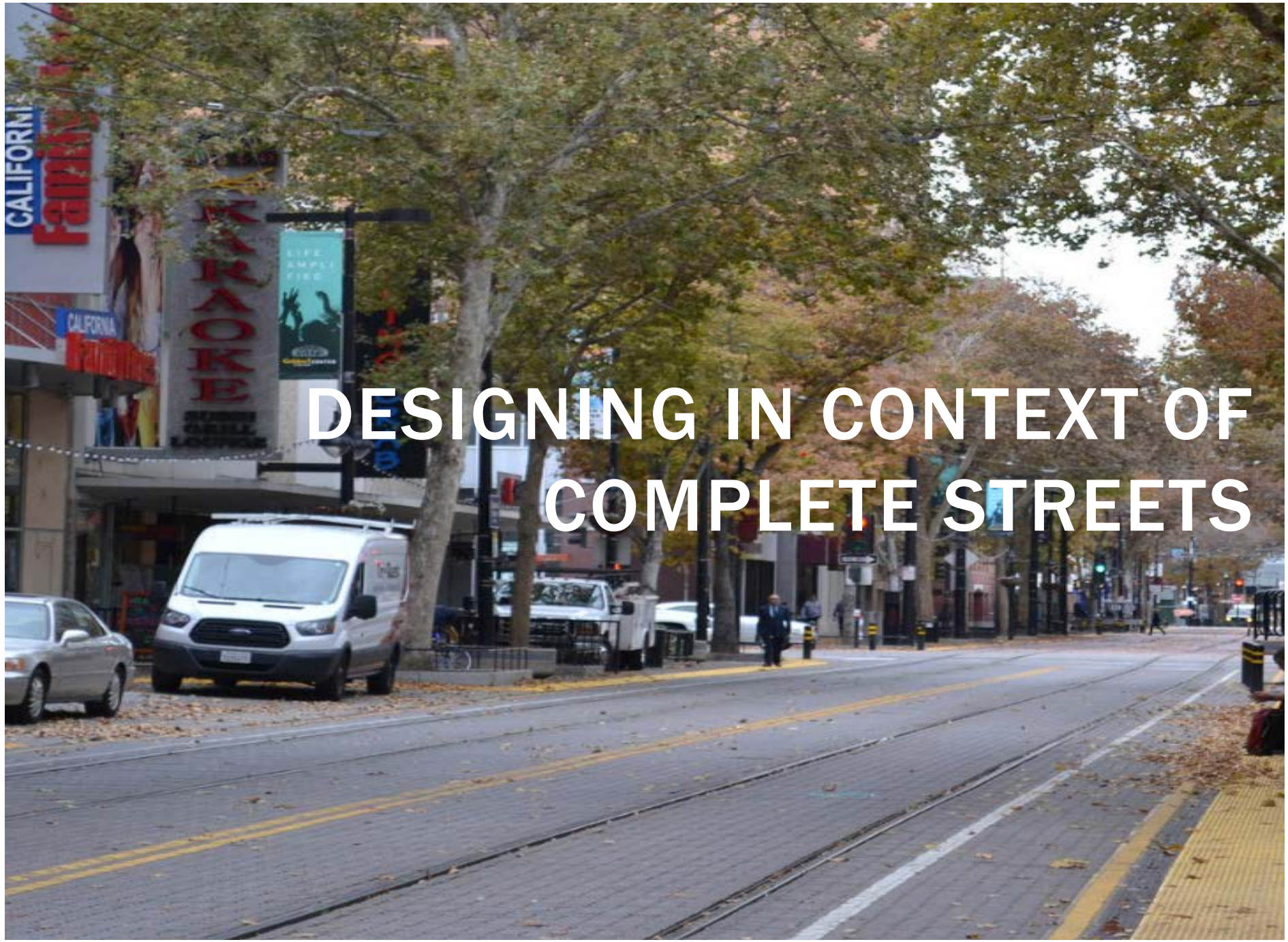


DESIGNING IN CONTEXT OF COMPLETE STREETS

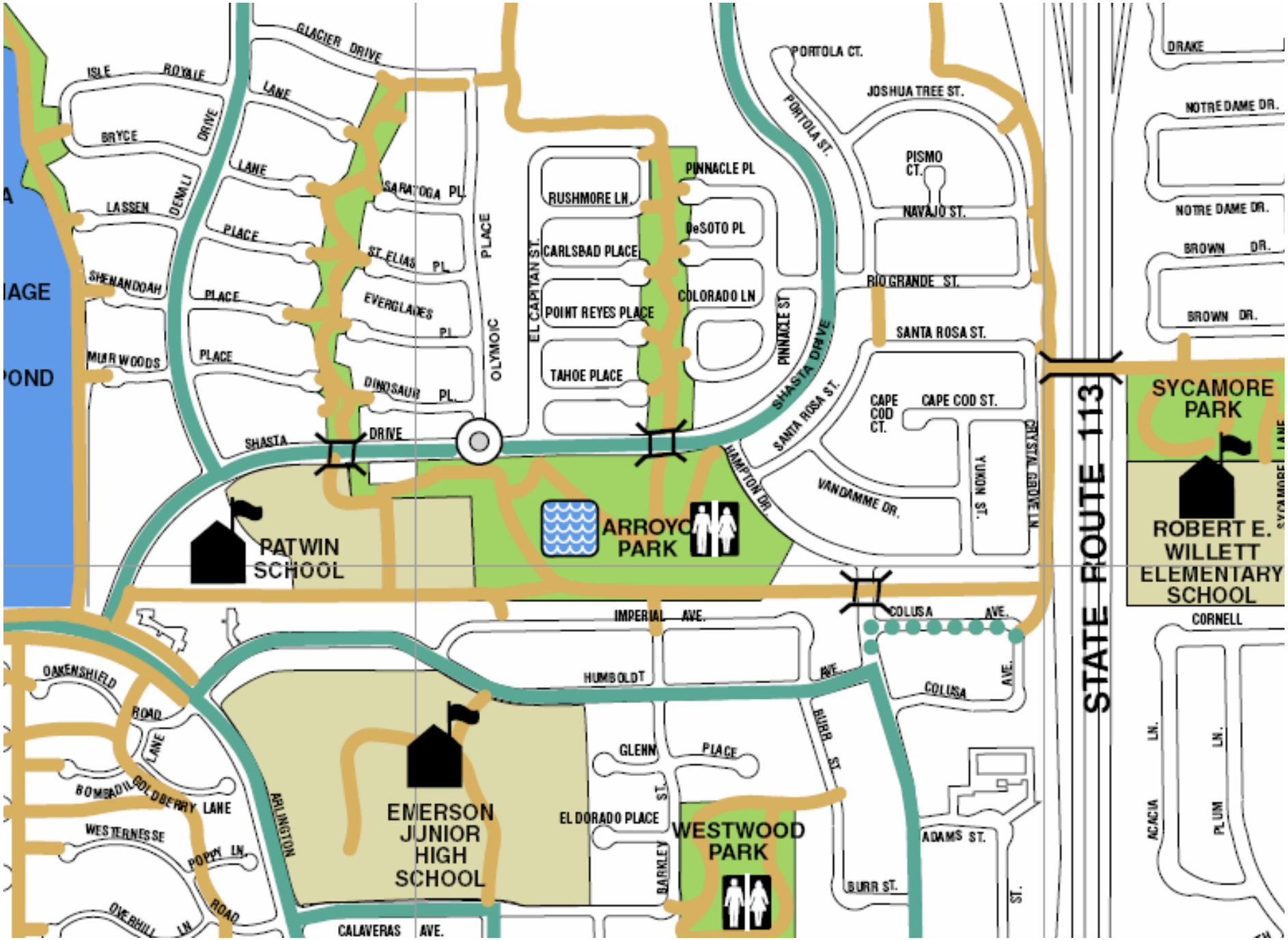
DESIGN

Module 6

Network Connectivity

Traffic Beacon/Signal Design

Performance Measures

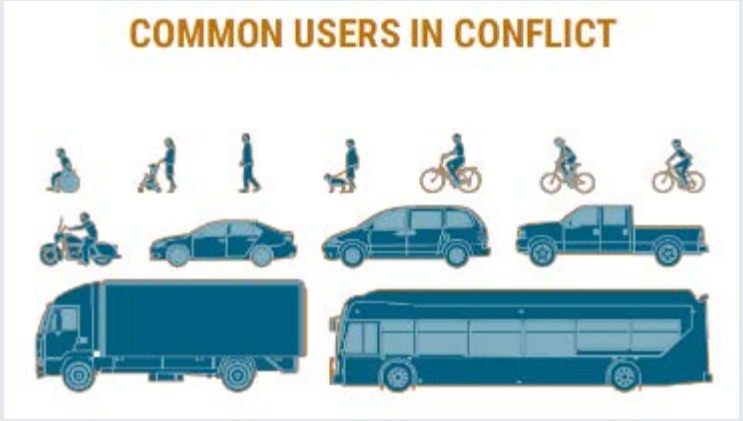


NETWORK CONNECTIVITY

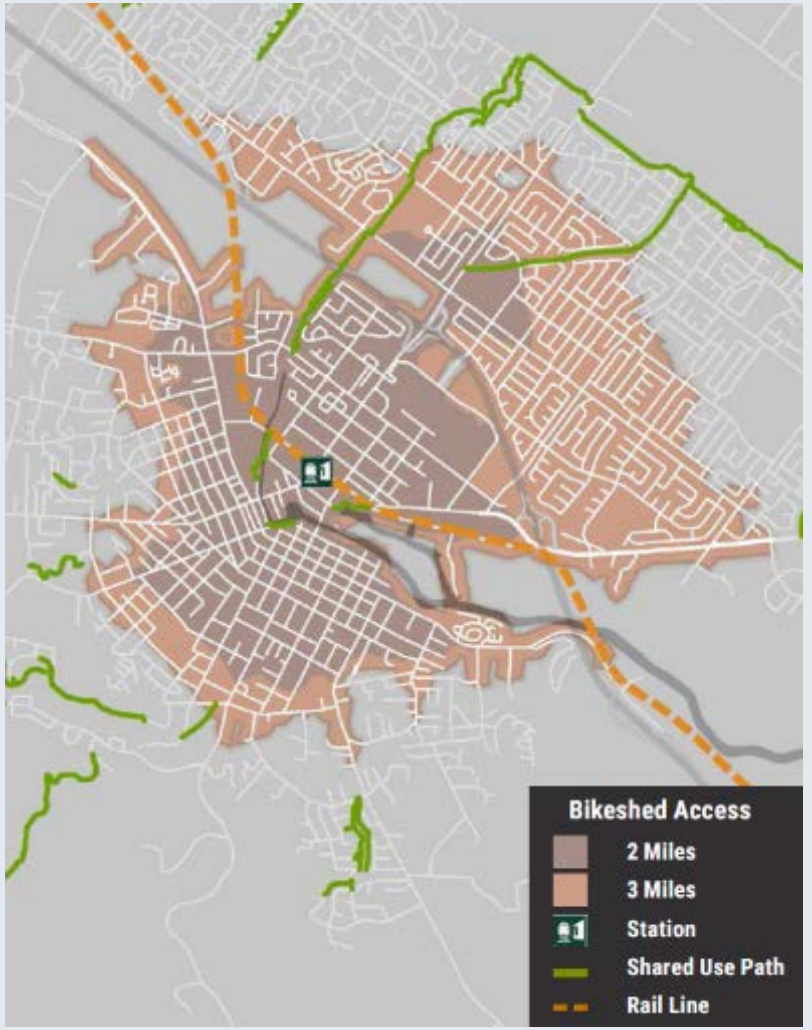
NETWORK CONNECTIVITY

Guiding Principles

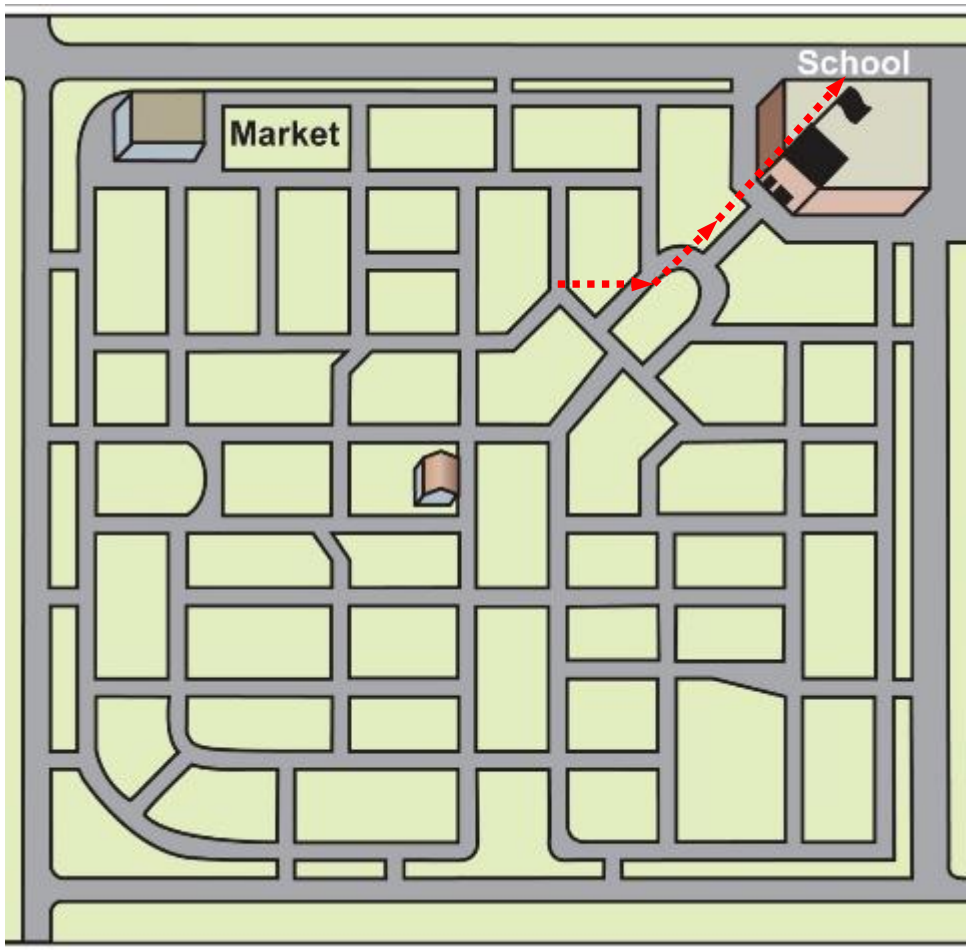
- Safety
- Accommodation and Comfort
- Coherence
- Predictability
- Context Sensitivity
- Experimentation



Source: Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts

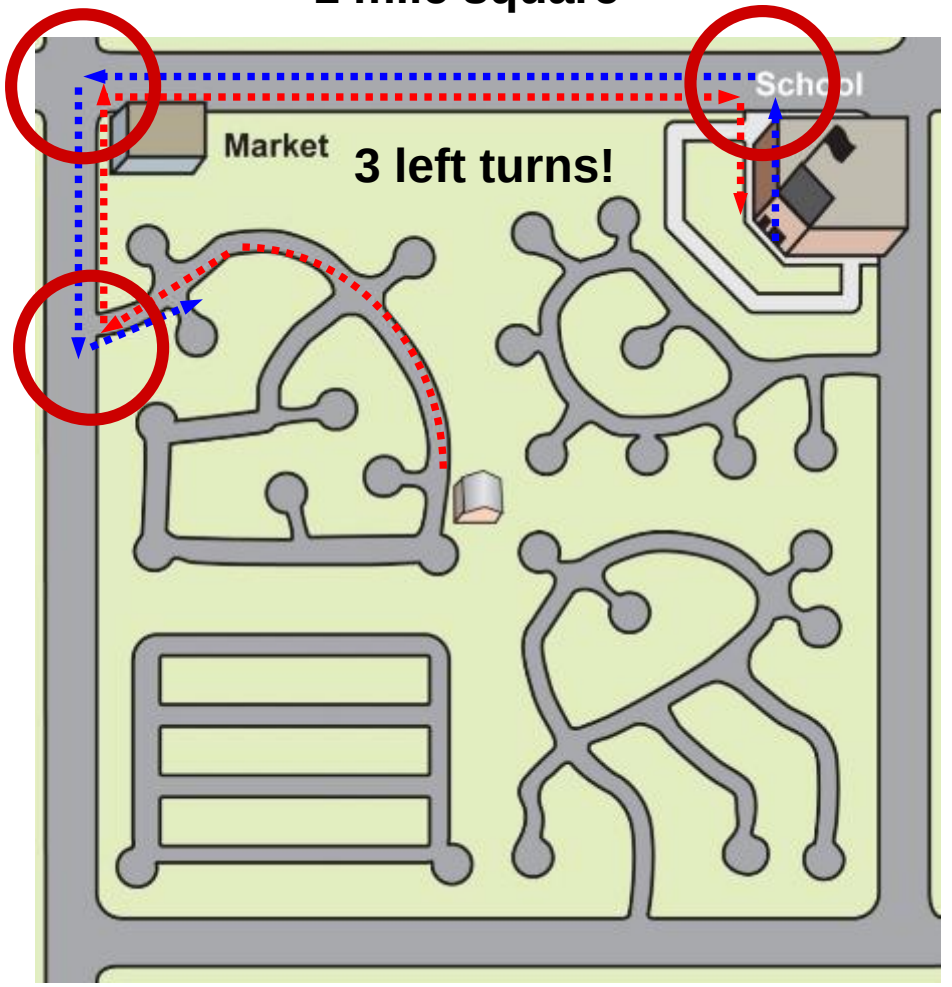


<- 1 mile square ->



Connected Streets

<- 1 mile square ->

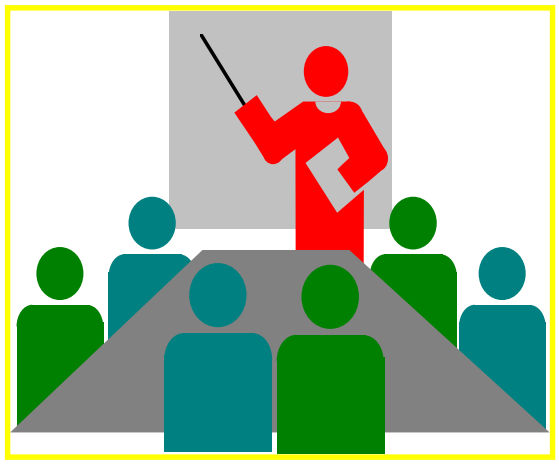


Lollipop pattern

Network Connectivity

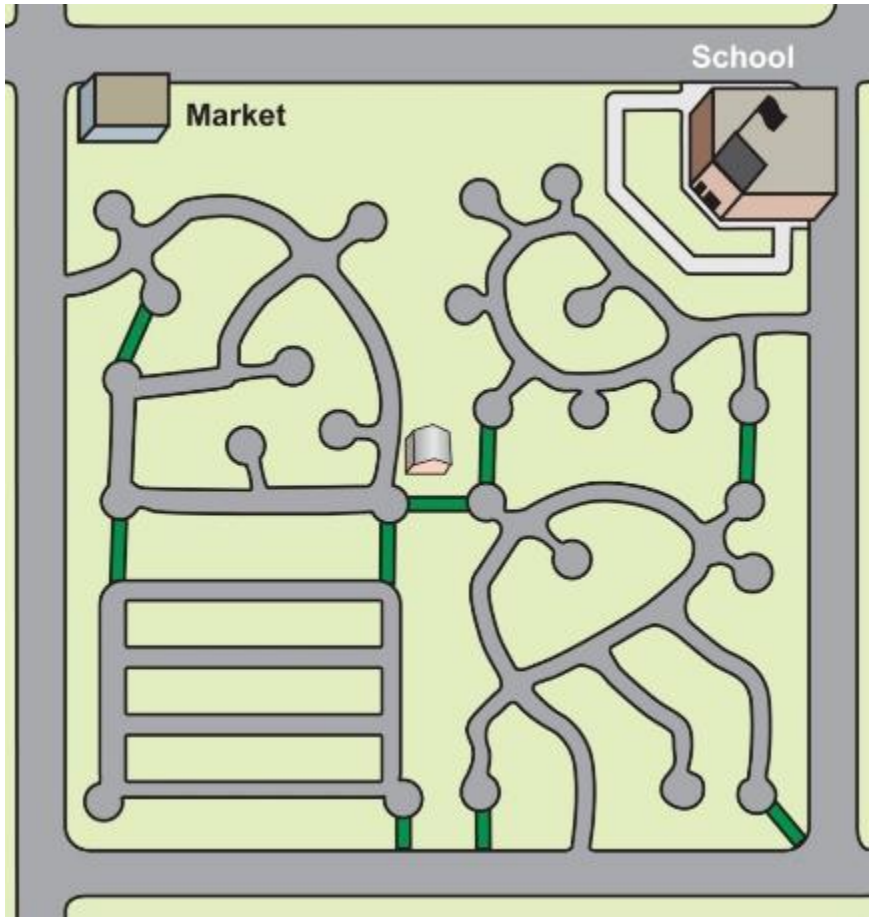
Connectivity creates a walkable street system by:

- 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?

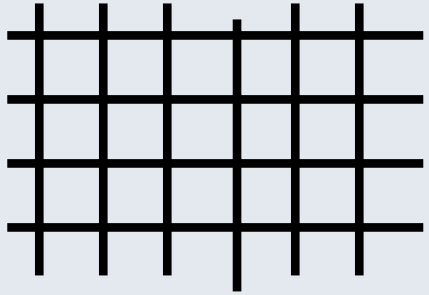
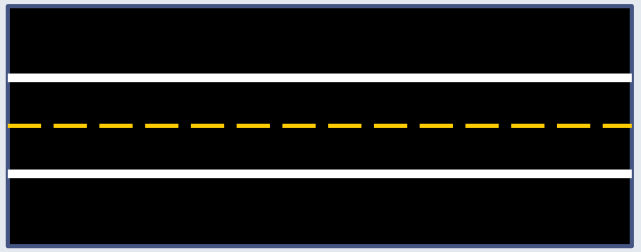
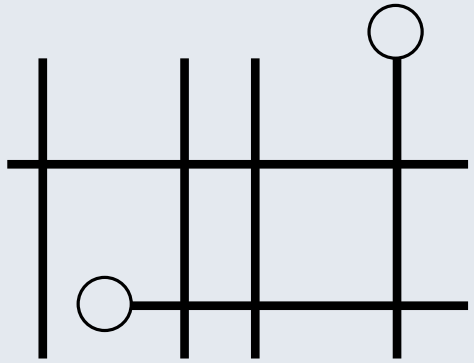
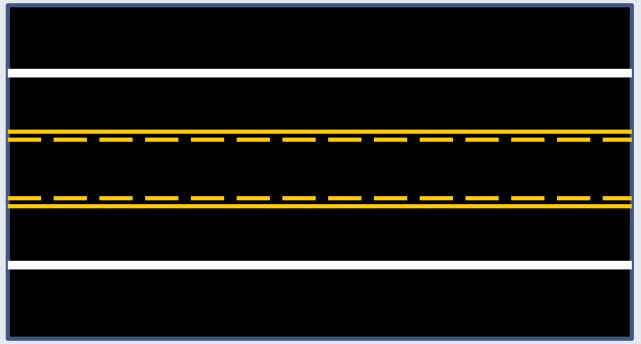
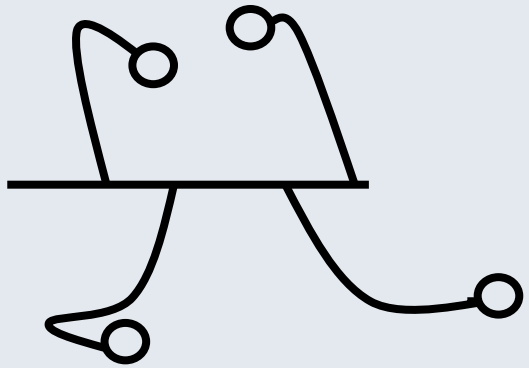
<- 1 mile square ->



Lollipop pattern

Network Connectivity

- Reduces walking distances: YES
- Offers more route choices: YES
- Disperses traffic: NO

Level of Connectivity	Pattern	Travel Lanes Required
High Connectivity		
Moderate Connectivity		
Low Connectivity		

Network Connectivity: Las Vegas NV

Lack of connectivity => overly wide streets

Network Connectivity: Albuquerque NM

Lack of connectivity => few but large intersections

NETWORK CONNECTIVITY

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

NETWORK CONNECTIVITY

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

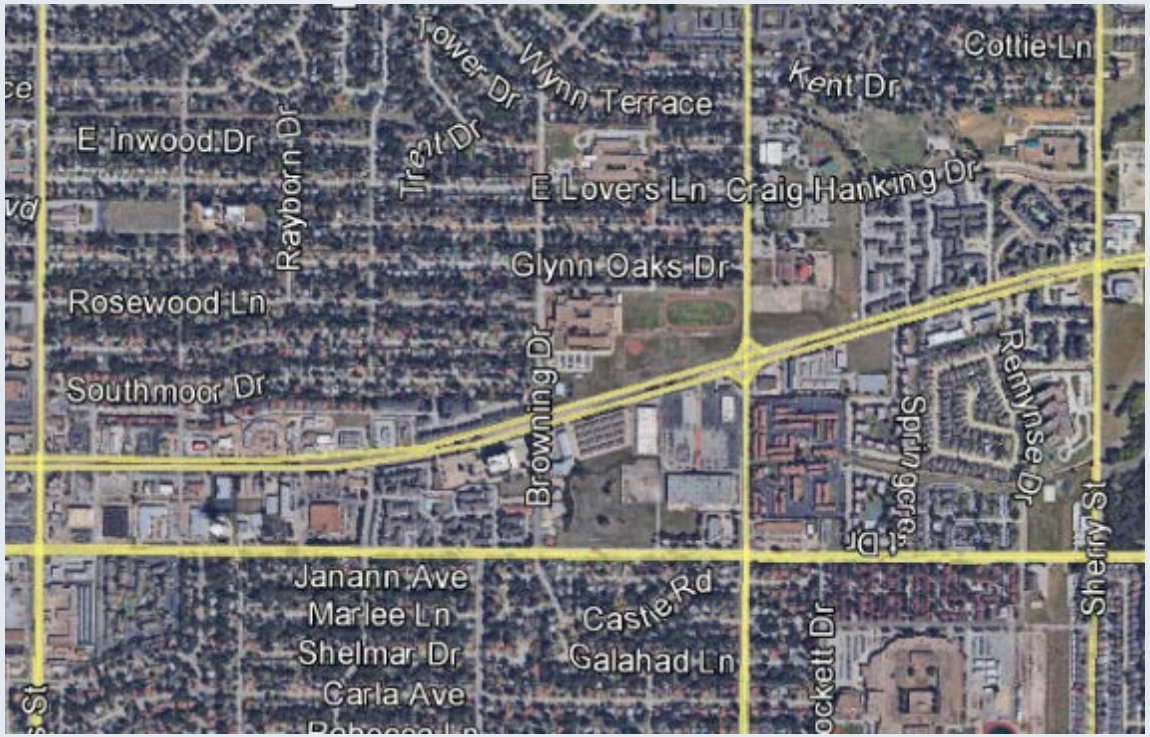
NETWORK CONNECTIVITY

Design Strategies

- Freight
  - Intersection Design – Minimize Curb Radius with Truck Apron

NETWORK CONNECTIVITY

Design Strategies: Pedestrians: Block length – Safe Crossing Frequency



300’ Block Length

1,500’ – 2,000’ Block Length

Arlington, TX

NETWORK CONNECTIVITY

Ped/Bike Access through Interchanges

- Balance
  - Shortest Crossing Distance
  - Visibility
  - Least Out-of-Direction Travel
  - Proper ADA Ramp Placement

Access Through Interchanges: Salem OR

- Where free-flow ramps are used (least desirable) Crosswalk should be placed where it's visible

Access Through Interchanges: Salem OR

- Barrier should not obscure crosswalk

DIVERGING DIAMOND INTERCHANGE (DDI)

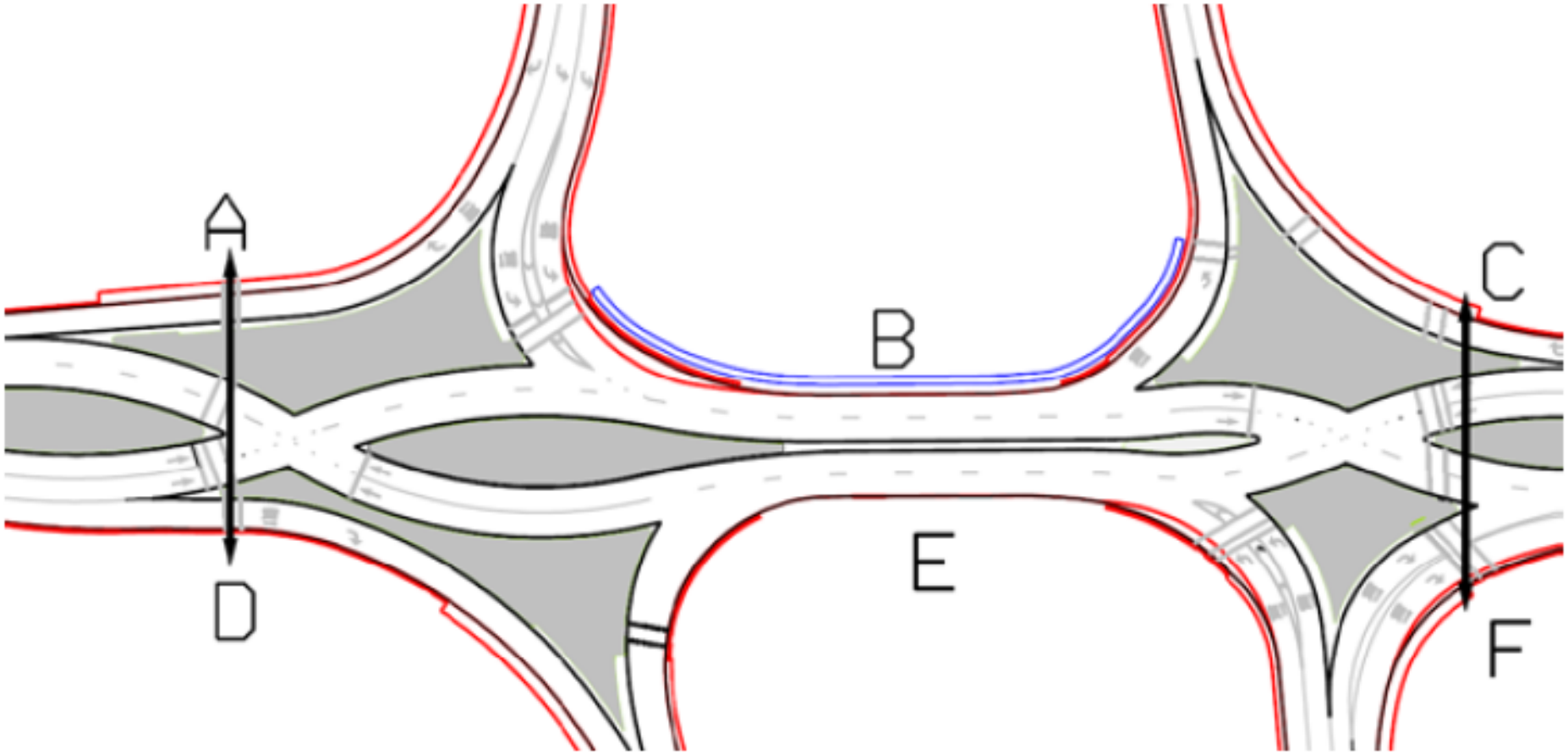


Figure 177. Illustration. Pedestrian movements in a DCD interchange.

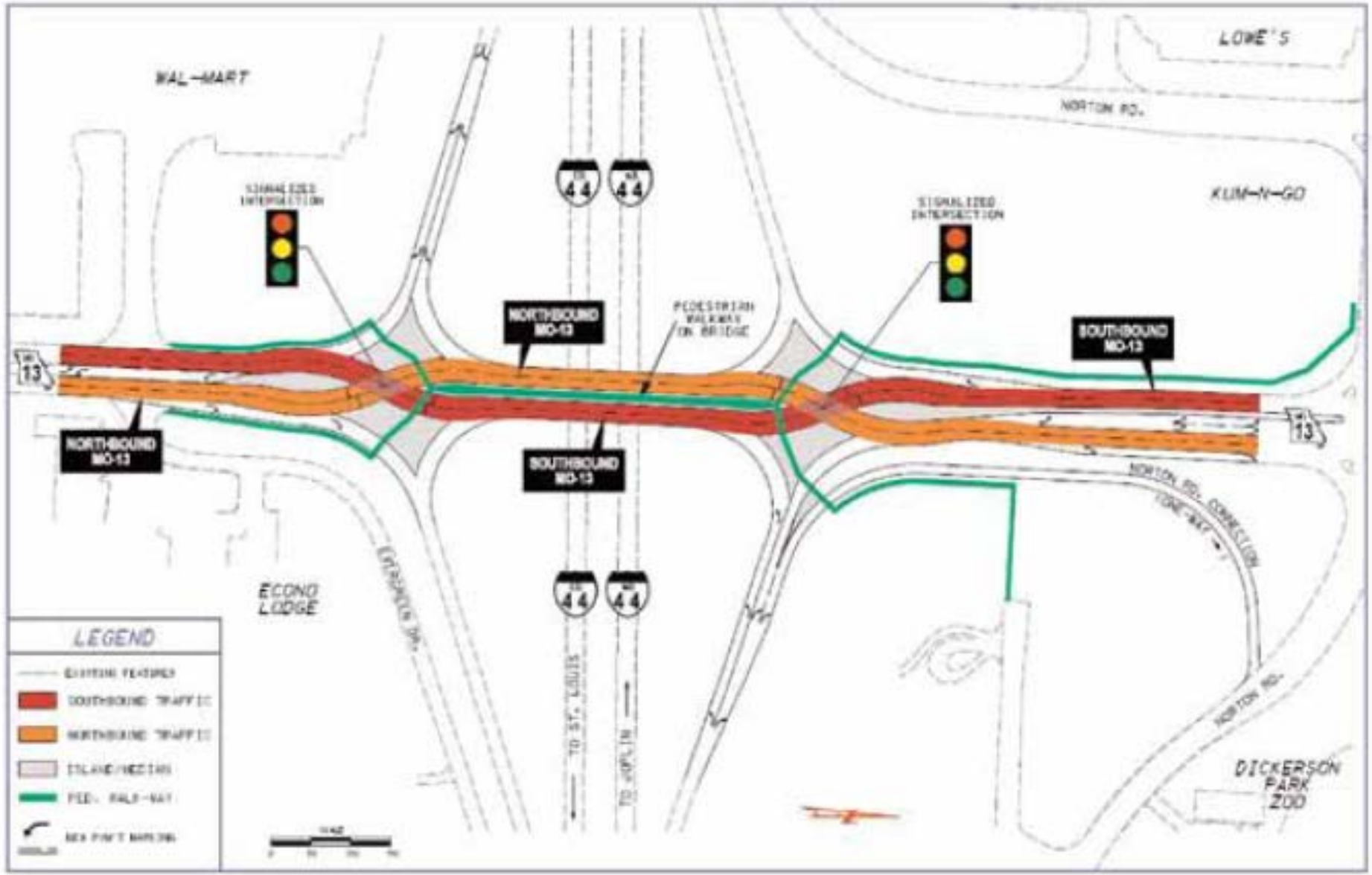


Figure 178. Ilustration. Proposed pedestrian accommodation in the median of the DCD interchange in Springfield, MO.

DIVERGING DIAMOND INTERCHANGE

Leading up to the protected Center Crossing

DIVERGING DIAMOND INTERCHANGE

Walking down the protected Center Crossing

NETWORK CONNECTIVITY

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

TRAFFIC BEACONS & SIGNAL DESIGN

RECTANGULAR RAPID FLASH BEACON (RRFB)

- **MUTCD currently not issuing any interim approvals due to patent litigation**
  - **Agencies that have Interim Approval can continue to use**

- 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

RRFB: St. Petersburg FL

Beacons required on the both right side and on the left side or in a median if practical.

PEDESTRIAN HYBRID BEACONS (PHB)

PEDESTRIAN HYBRID BEACON SEQUENCE

1

Blank for drivers

2

Flashing yellow

3

Steady yellow

4

Steady red

5

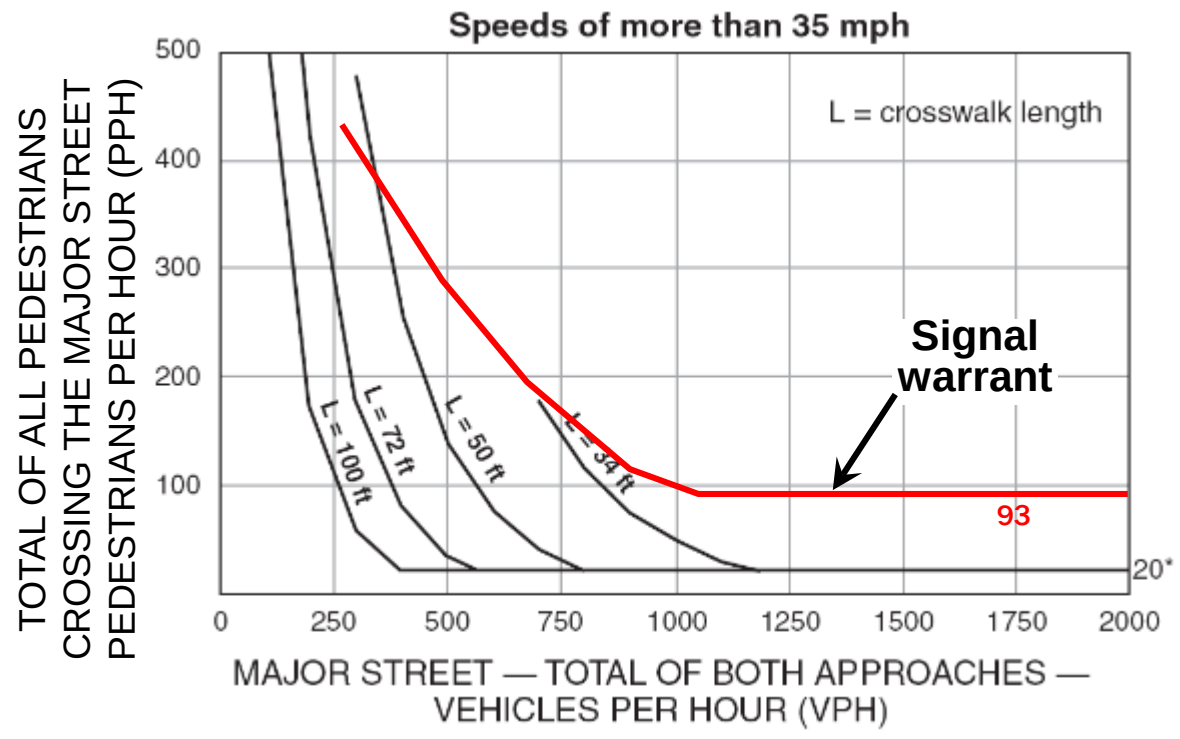
Wig-Wag

Return to 1

2009 MUTCD Section 4F.3

PEDESTRIAN HYBRID 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 BEACON

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.

MUTCD PEDESTRIAN SIGNAL WARRANT

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

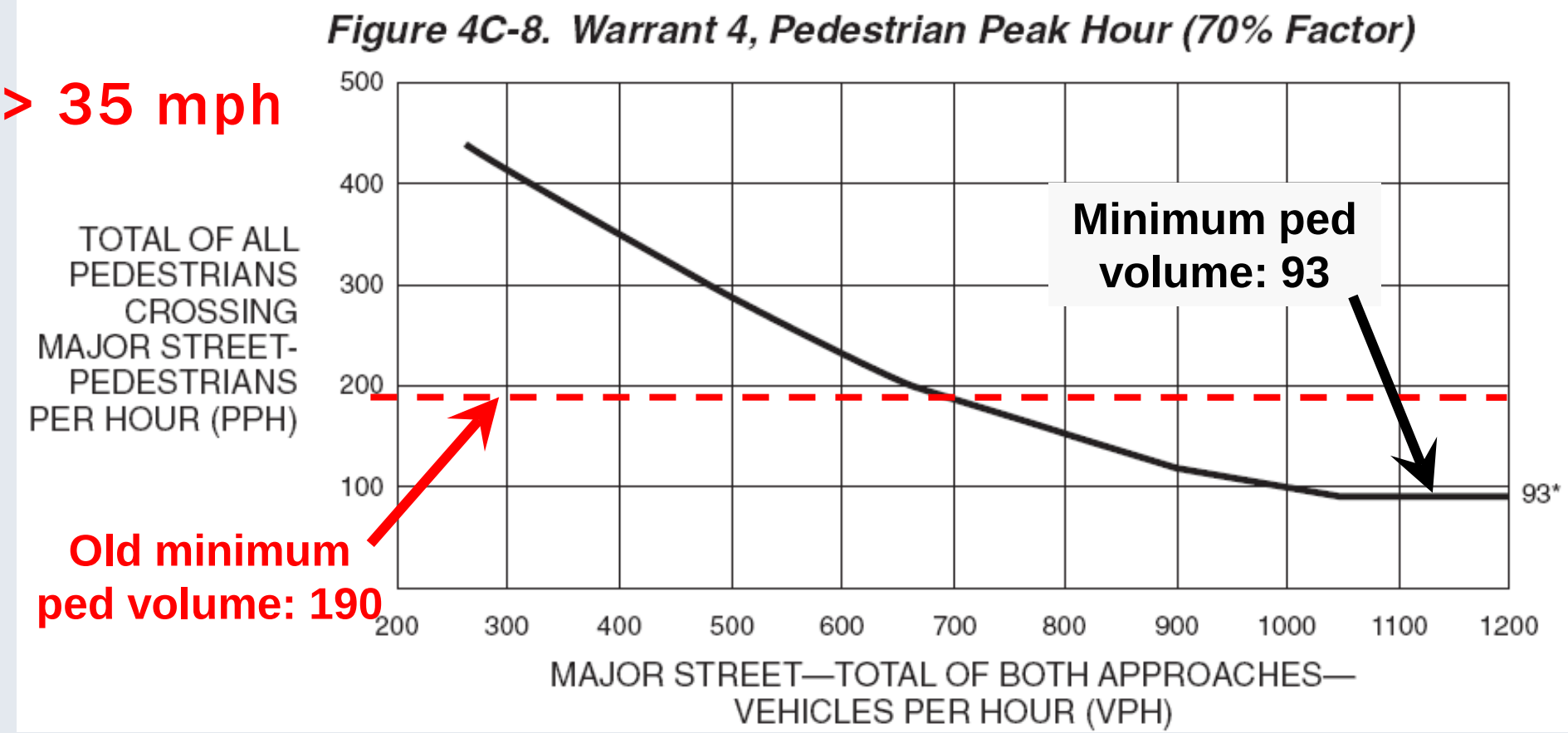
2009 MUTCD Chapter 4C

MUTCD PEDESTRIAN SIGNAL WARRANT

Can be difficult to meet the pedestrian volume warrant

MUTCD PEDESTRIAN SIGNAL WARRANT

For Speeds > 35 mph



Easier to meet on streets with high vehicle volumes

More difficult to meet on streets w/ low vehicle volumes

Pedestrian Signal: Washington DC

- Provide a HOT response
- Otherwise pedestrians won't wait for the light

Pedestrian Signal: Corvallis OR

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

TRAFFIC SIGNAL EQUIPMENT

Pedestrian Feedback/Confirmation

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

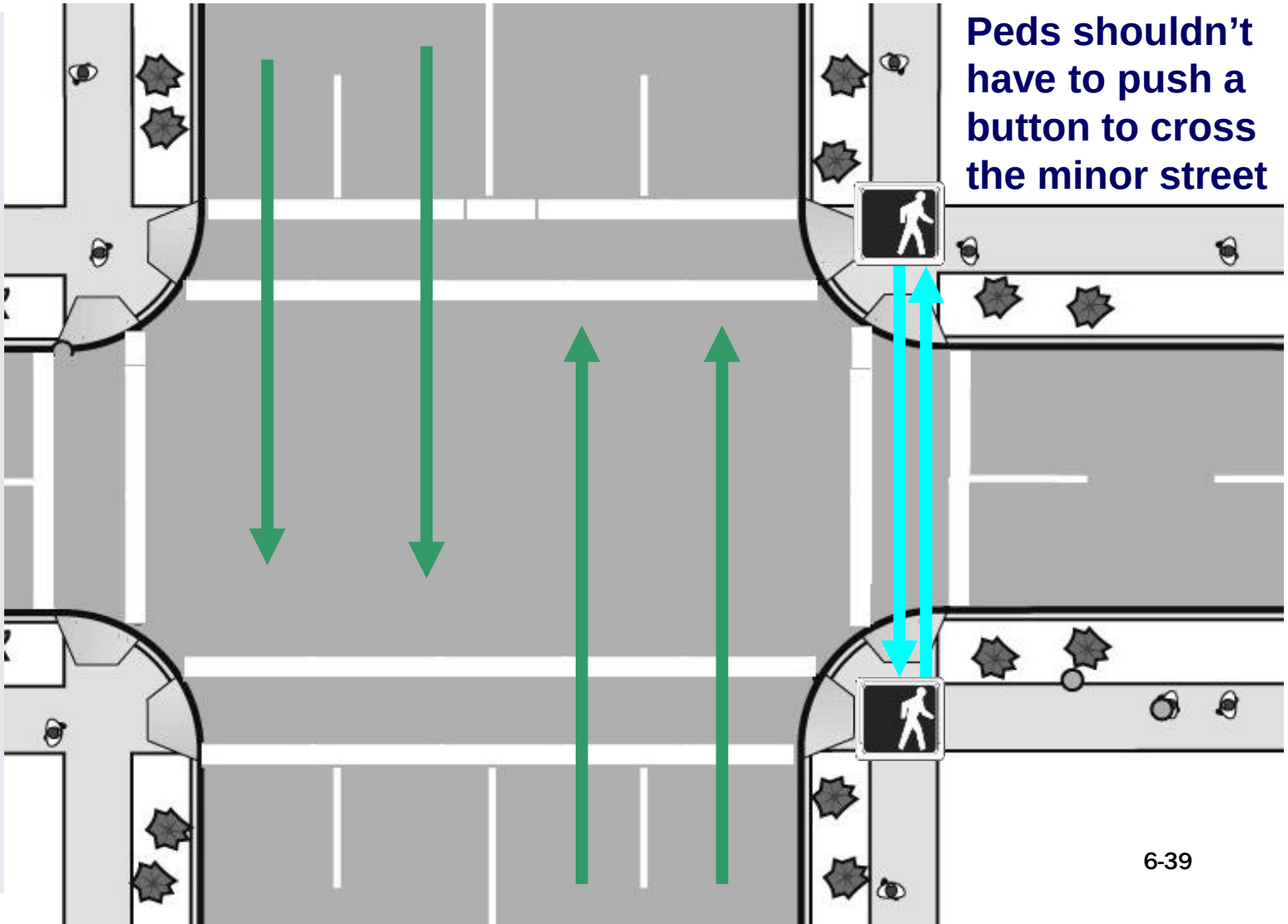
2009 MUTCD Section 4E.05

TRAFFIC SIGNAL PHASING

- Pedestrians should get a signal at every cycle “Ped Recall” – OR –
- Open the Permissive Window to accept the pedestrian actuation

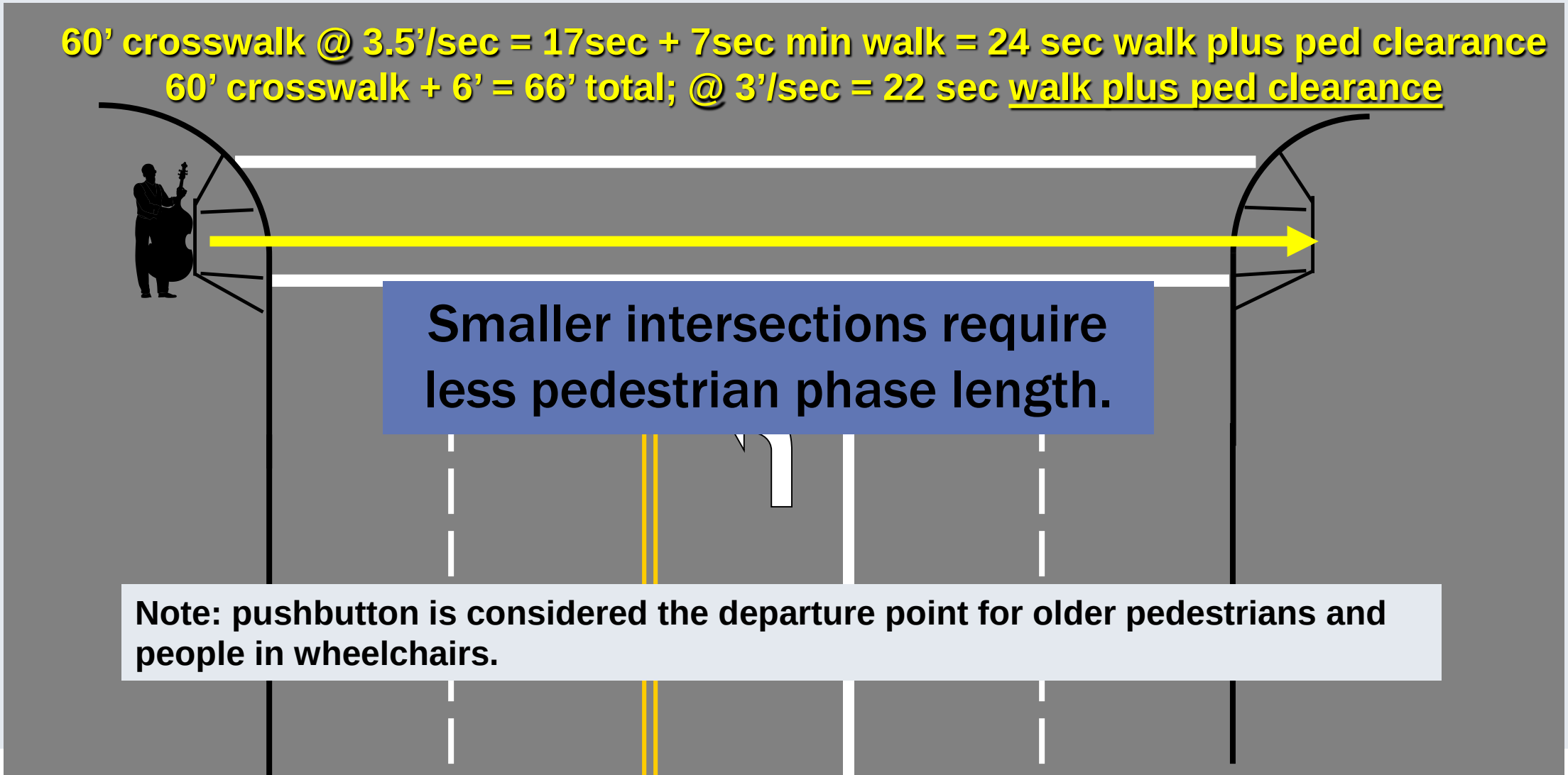
TRAFFIC SIGNAL PHASING

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

TRAFFIC SIGNAL PHASE LENGTH



TRAFFIC SIGNAL CYCLE LENGTH

Use Short Cycle Lengths

Portland OR

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

Non-Invasive Bicycle Detection Systems				
Manufacturer	Model	Bicycle Presence	Ability to Distinguish Between a Bicycle and a Pedestrian within the Detection Zone	Collect Bicycle Count Data
BEA Industrial	IS40	Yes	No	No
FLIR/Traficon	SafeWalk	Yes	No	No
Iteris	SmartCycle	Yes	No	No
Migma Systems, Inc.	MigmaBicycle	Yes	Yes	Yes
MS Sedco	SmartWalk	Yes	No	No

Traffic Signals: Portland OR

- Use passive detection to extend pedestrian time only when needed

Traffic Signals: Portland OR

- Microwave sensors are aimed at the crosswalks to track pedestrian presence.

TRAFFIC SIGNALS

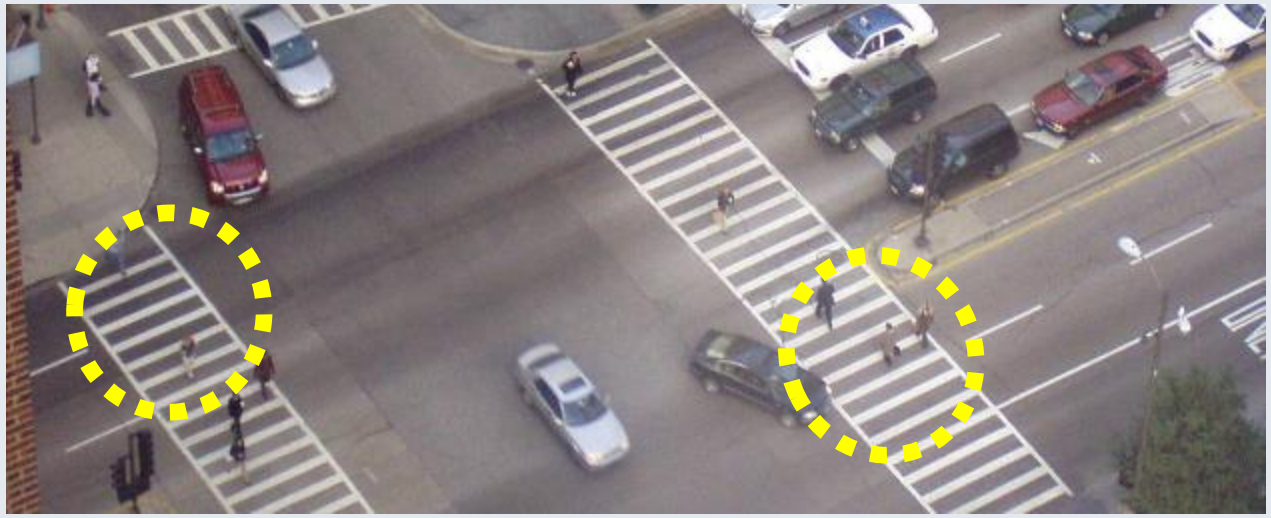
Passive Detection

- 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.

TRAFFIC SIGNALS

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

TRAFFIC SIGNALS

Right Turn on Red Restrictions

(protecting the pedestrian stepping in front of the driver)

Consider No Turn on Red signs where there is:

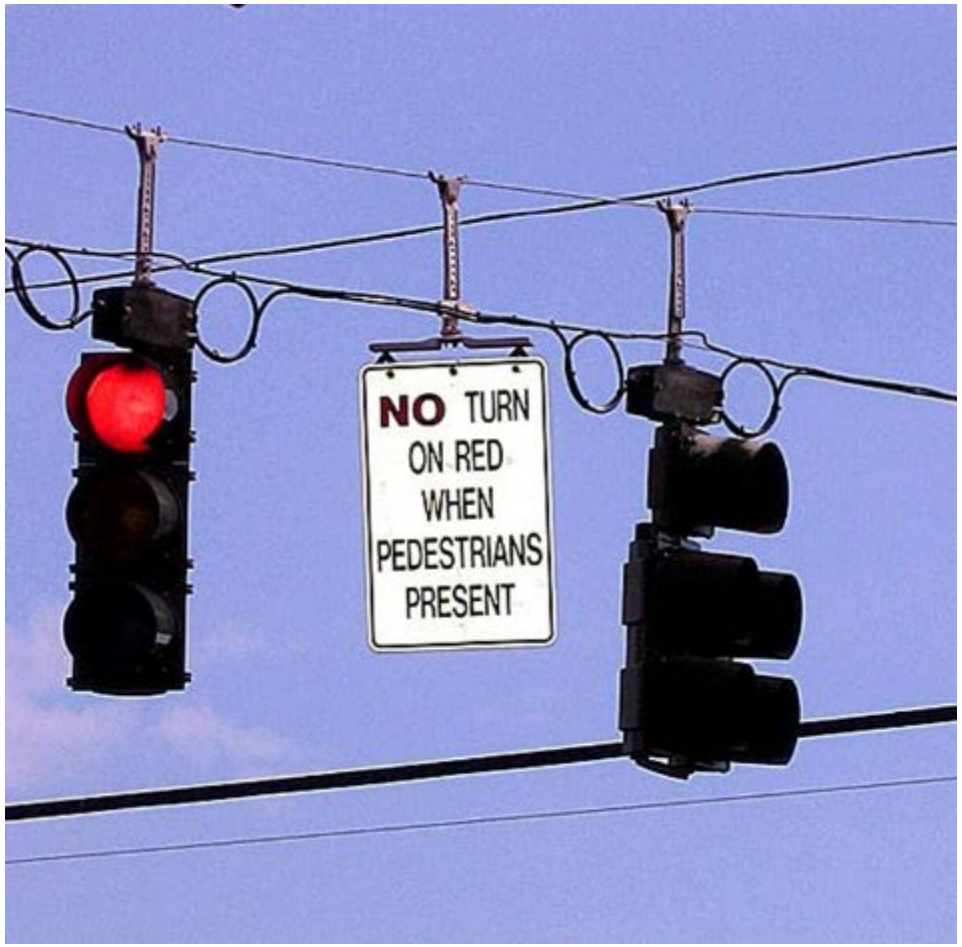
- Poor sight distance between vehicles and peds;
- An unusual number of ped conflicts with turns on red (compared to turns on green);
- An exclusive pedestrian phase; or
- A leading pedestrian interval

MUTCD Section 2B.54

Traffic Signals: Washington DC

Right Turn on Red Restrictions

1. At all times

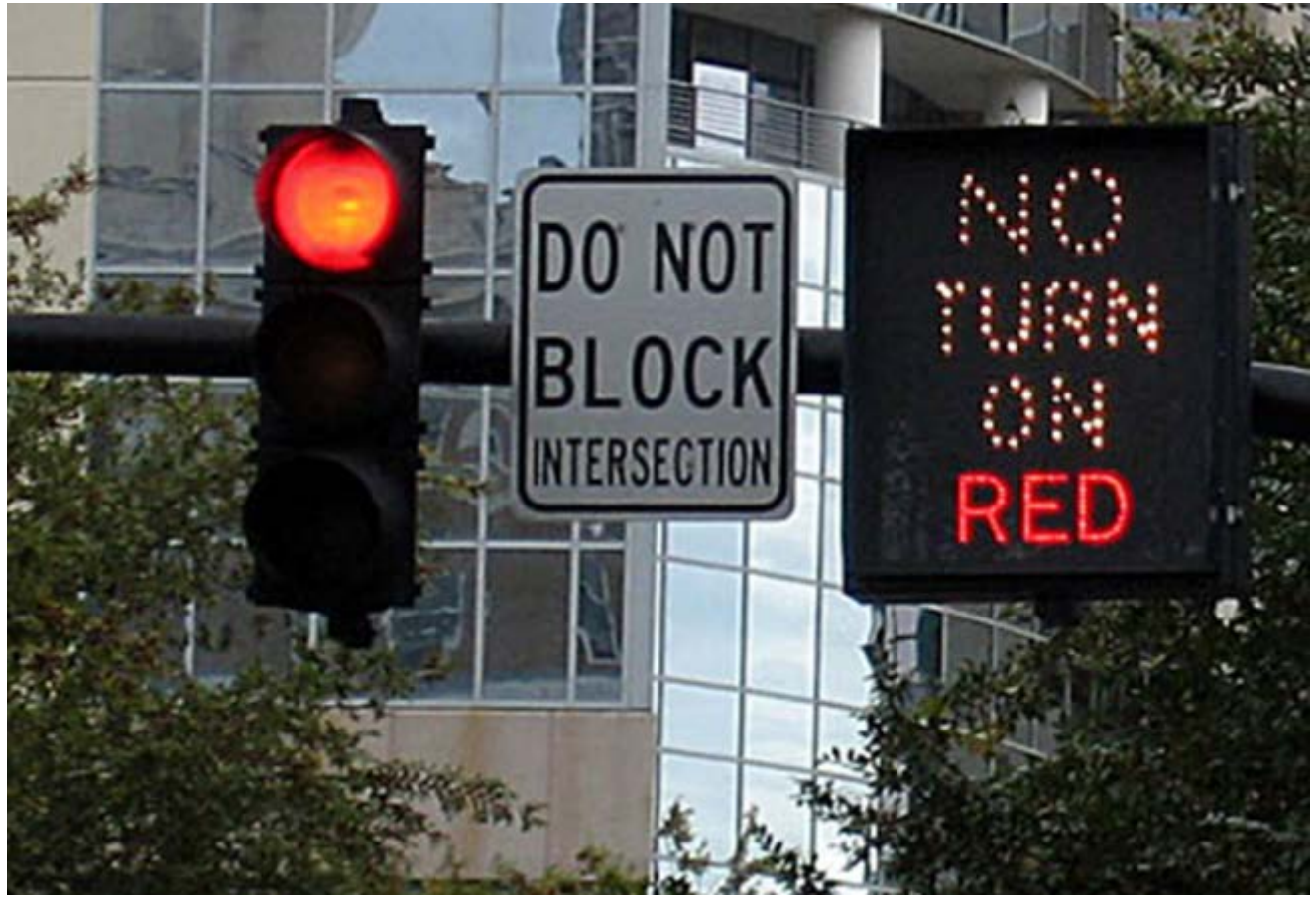


Right Turn on Red Restrictions

2. When Pedestrians are present . . . . difficult to enforce . .

Right Turn on Red Restrictions

3. By time of day



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

Right Turn on Red Restrictions

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

TRAFFIC SIGNALS

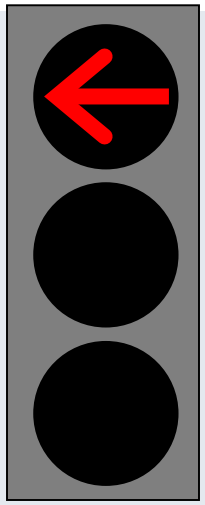
Protected vs. Permissive Left Turn Phasing

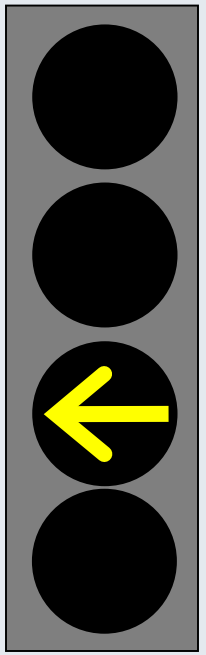
* CMF = 0.3 (CRF 70%) (veh and ped crashes) converting permissive left turns to protected only left turns

TRAFFIC SIGNALS

Protected vs. Permissive Left Turn Phasing

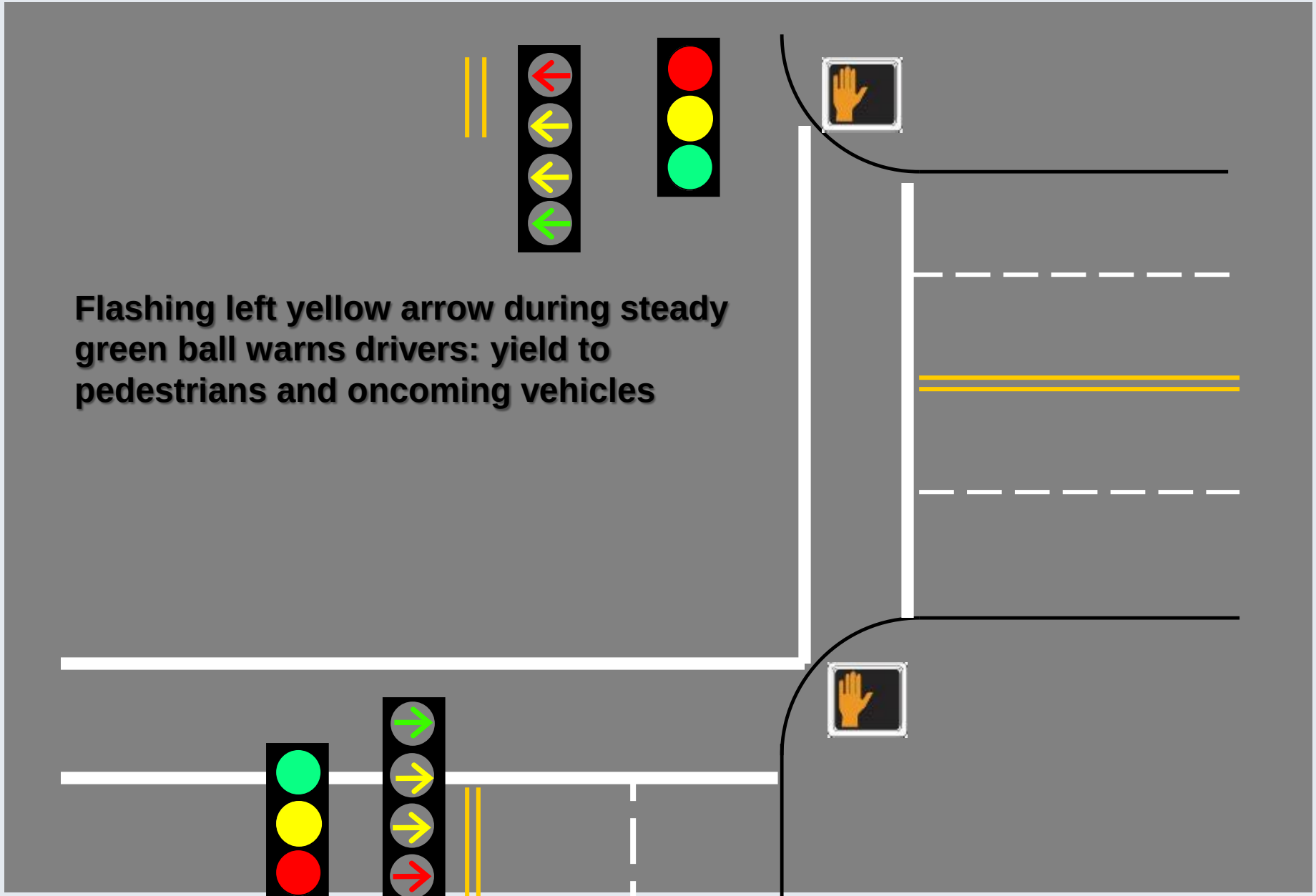
1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed or based on time of day
2. Flashing Yellow Arrow (details on the next slide)





MUTCD Sec. 4D.20

FLASHING YELLOW ARROW



MUTCD Sec. 4D.20

TRAFFIC SIGNALS

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)

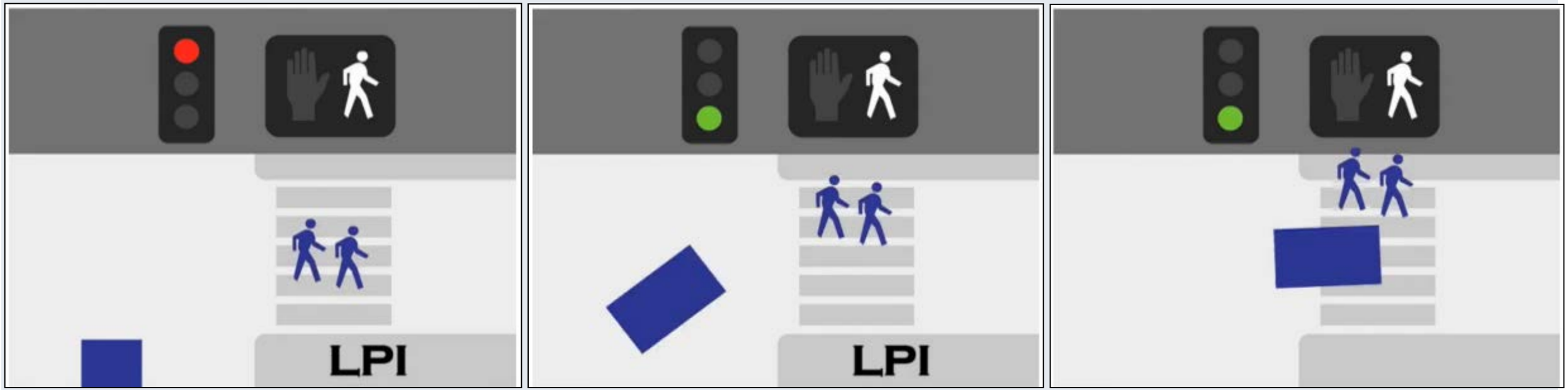
MUTCD Figure 3B-20 (Markings)

Exclusive Pedestrian Phase: Pasadena CA

- 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

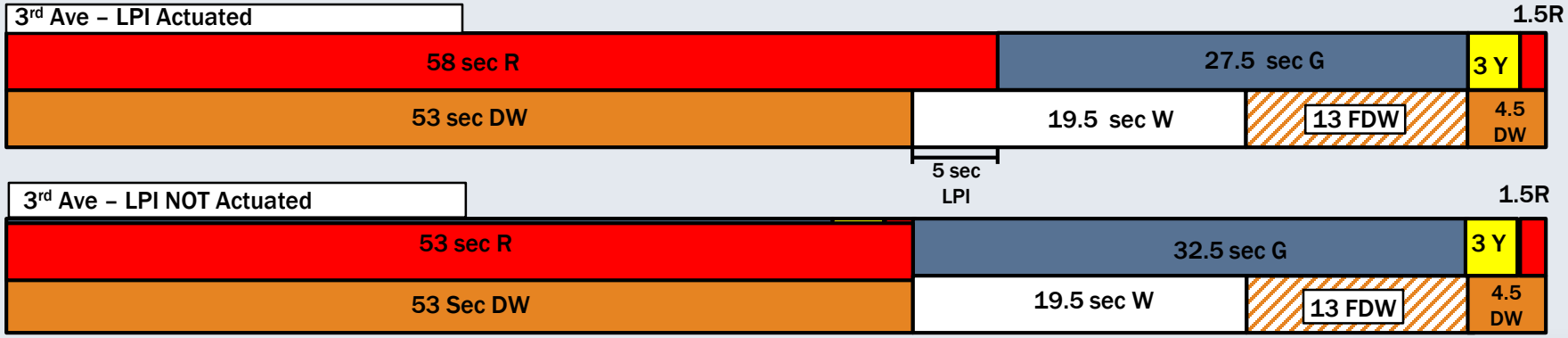
LEADING PEDESTRIAN INTERVAL

Gets pedestrians established in crosswalk



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

LEADING PEDESTRIAN INTERVAL



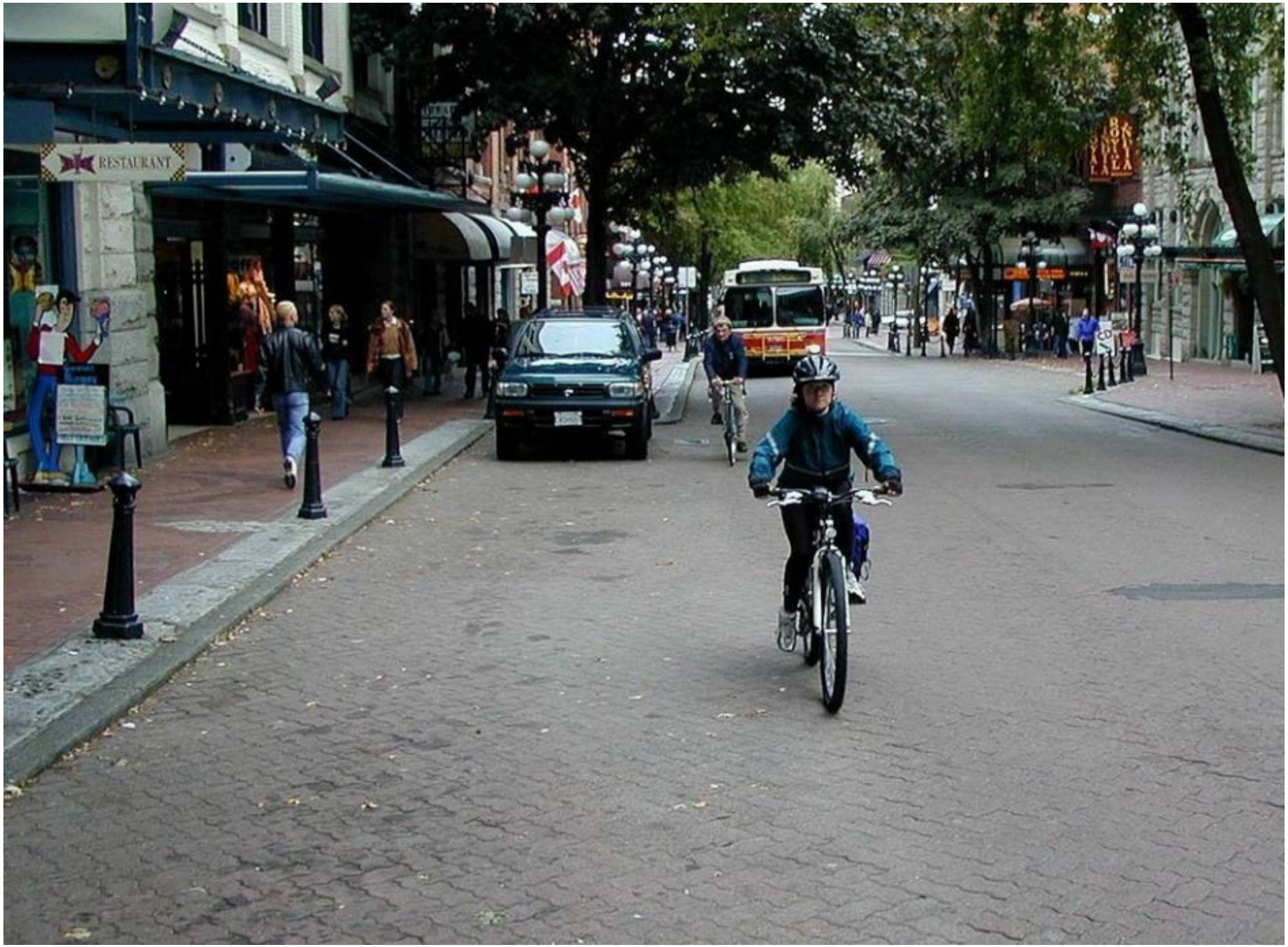
LPI Can be Fixed-time or Actuated

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

TRAFFIC BEACONS & TRAFFIC SIGNALS

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



PERFORMANCE MEASURES

PERFORMANCE MEASURES

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

PERFORMANCE MEASURES

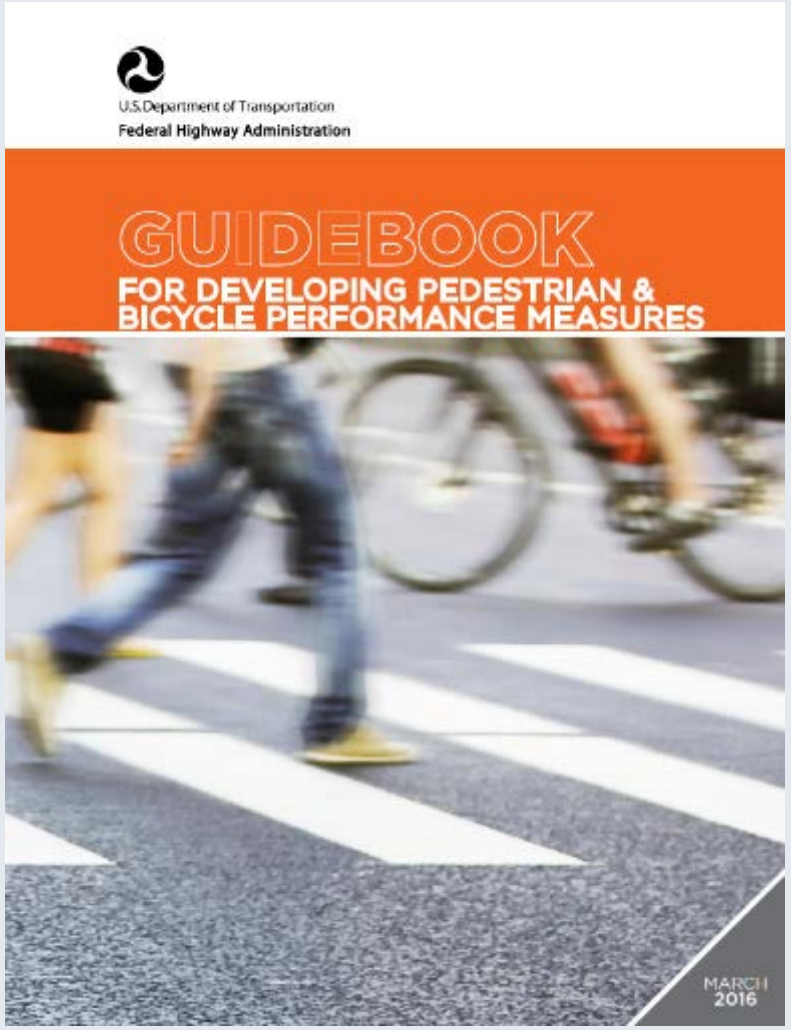
Goal Setting for

- 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

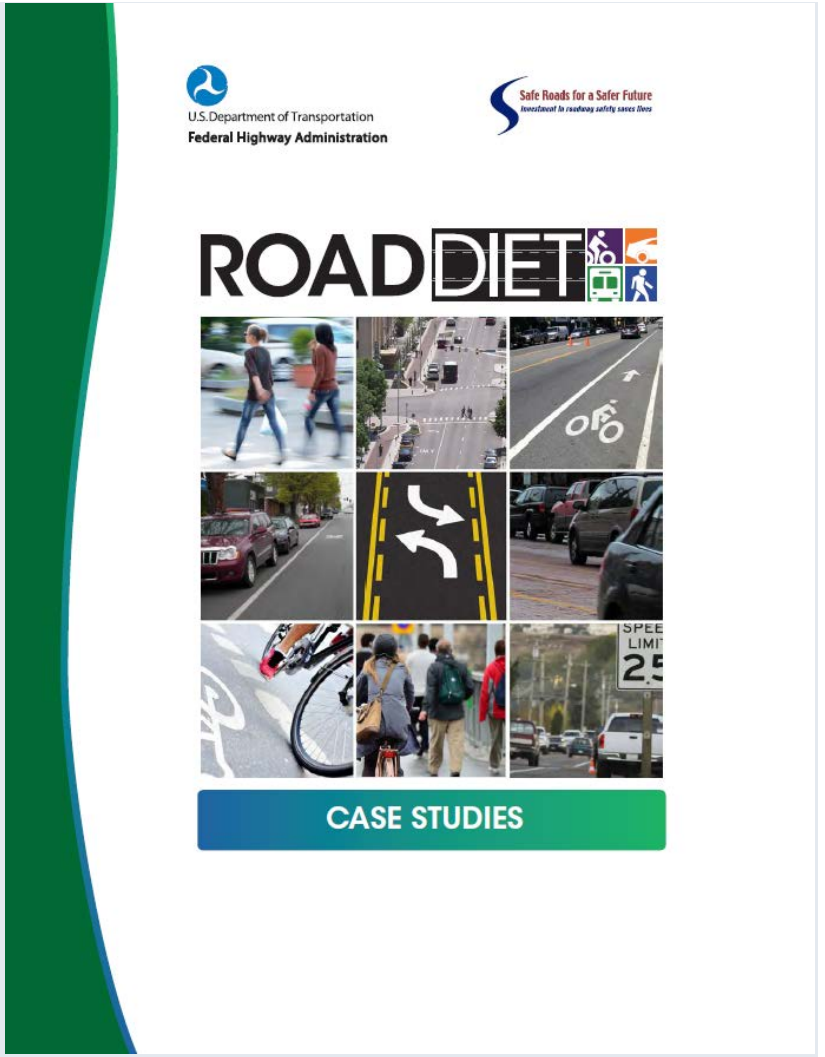
COMMUNITY GOALS CATEGORIES	TRANSPORTATION MEASURES CATEGORIES					
	ACCESSIBILITY	COMPLIANCE	DEMAND	INFRASTRUCTURE	MOBILITY	RELIABILITY
CONNECTIVITY	High	Low		High	High	Low
ECONOMY	High			Low	High	High
ENVIRONMENT	High		High		Low	Low
EQUITY	High	Low	Low	High	High	Low
HEALTH	High	Low	High	High	Low	Low
LIVABILITY	High	Low	Low	High	Low	High
SAFETY	High	High	High	High	High	Low



- https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/pm_guidebook.pdf

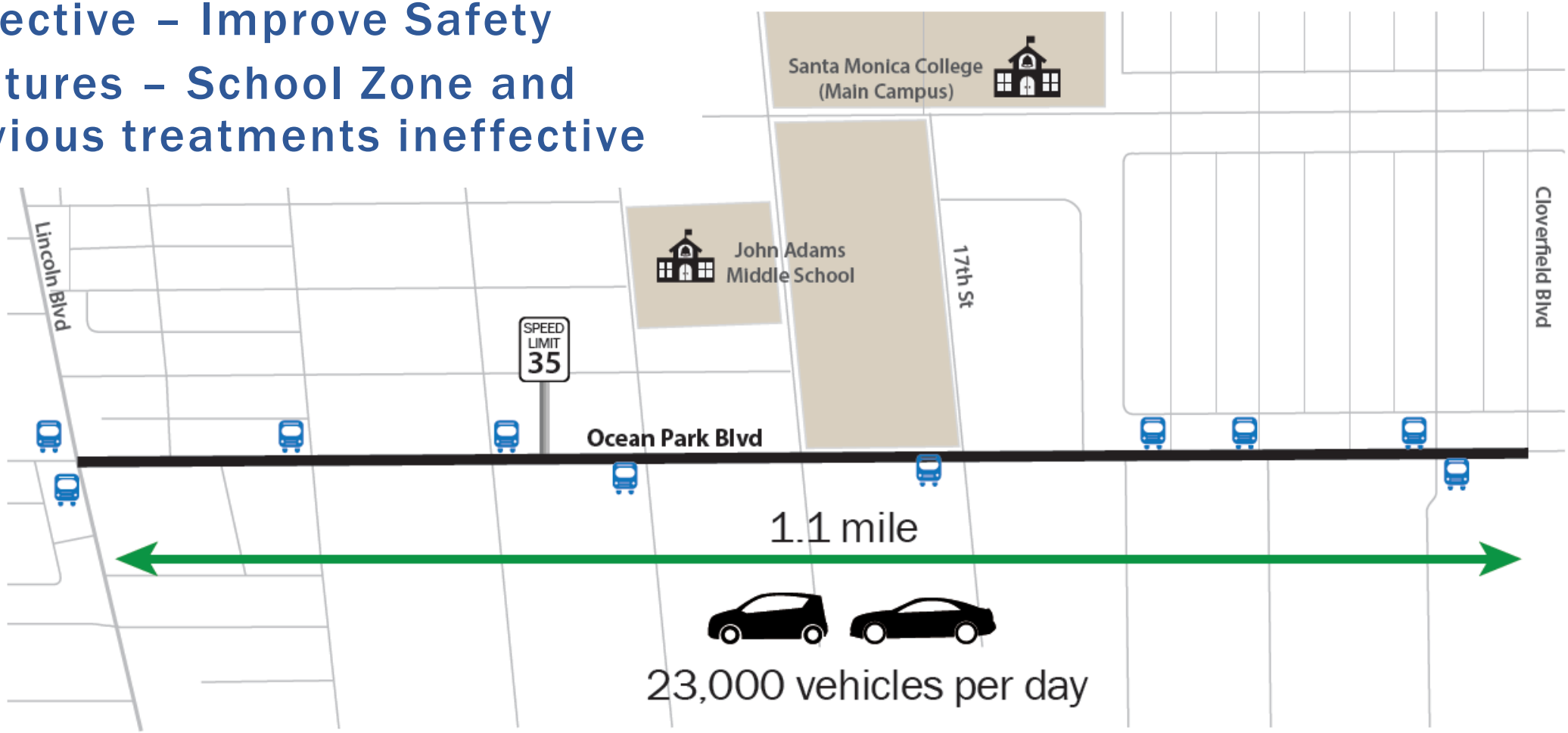
ROAD DIETS

- Opportunity
  - Resurfacing
  - Drainage

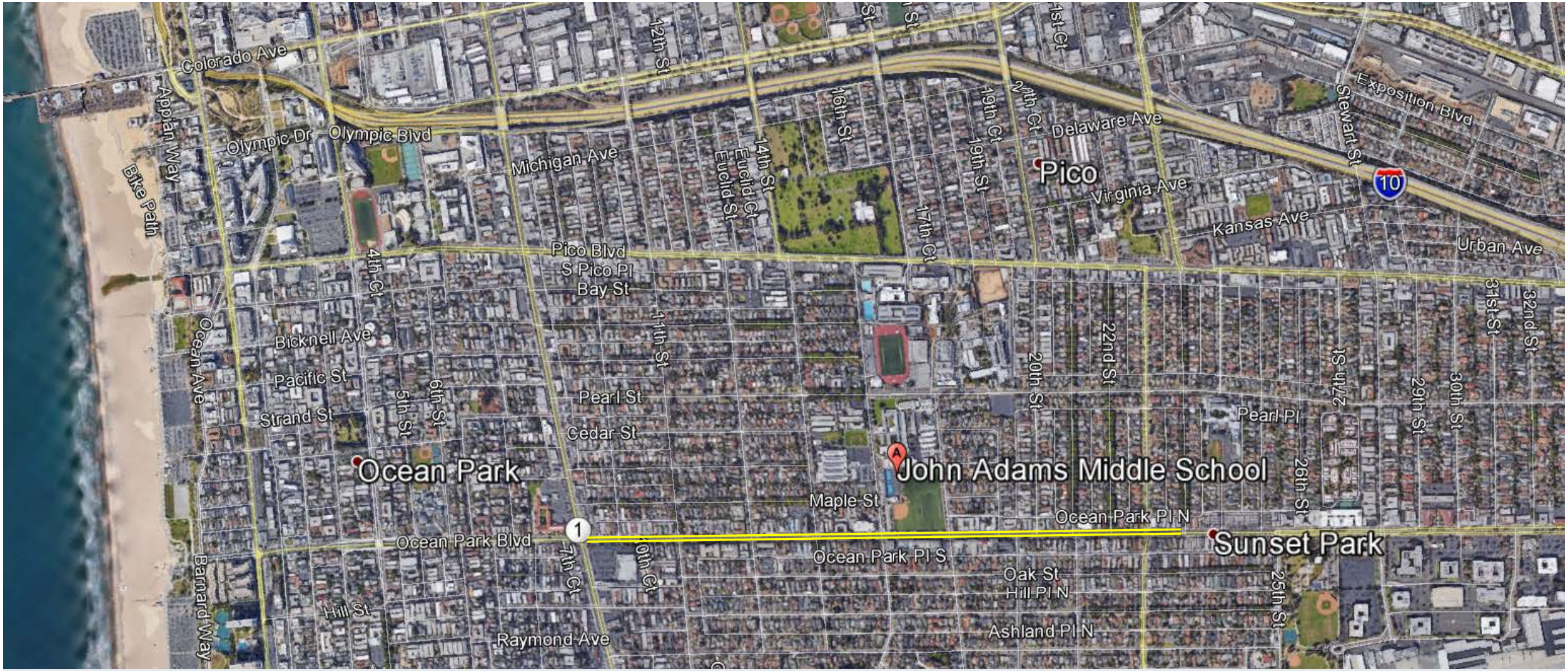


ROAD DIETS – CASE STUDY: SANTA MONICA, CA

- Objective – Improve Safety
- Features – School Zone and Previous treatments ineffective



ROAD DIETS – CASE STUDY: SANTA MONICA, CA



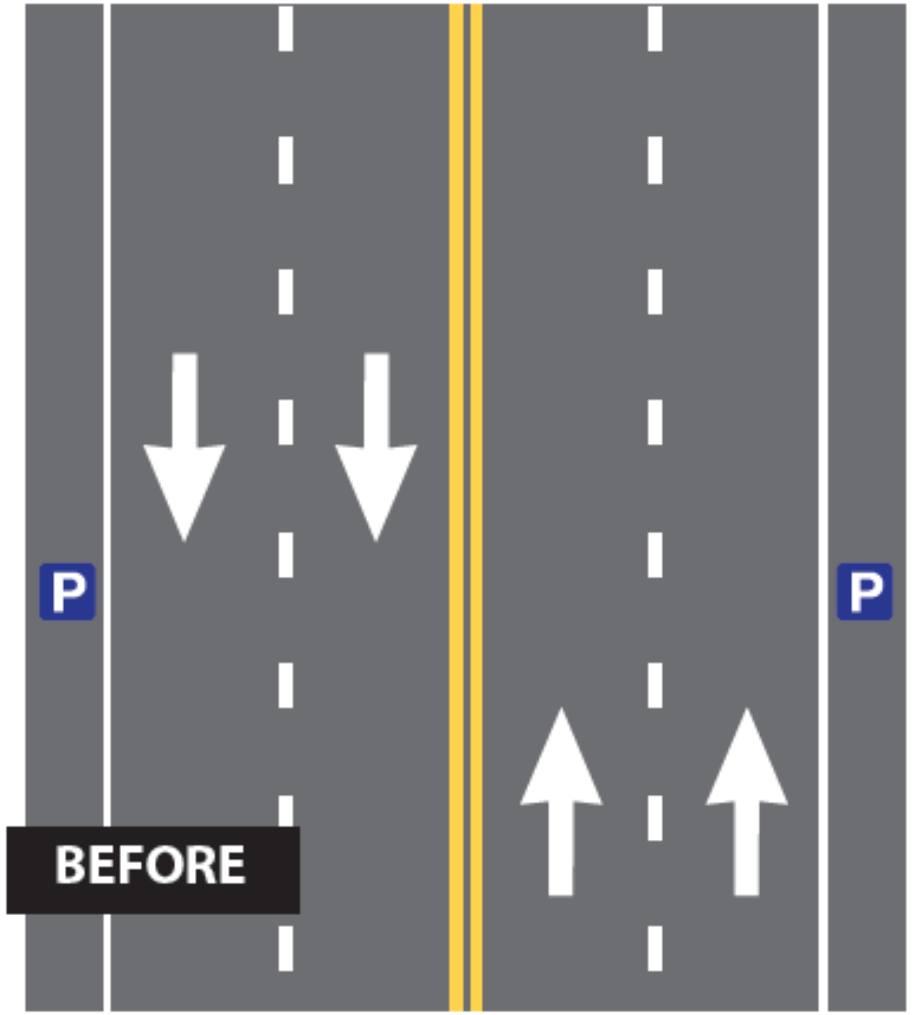
ROAD DIETS – CASE STUDY: SANTA MONICA, CA

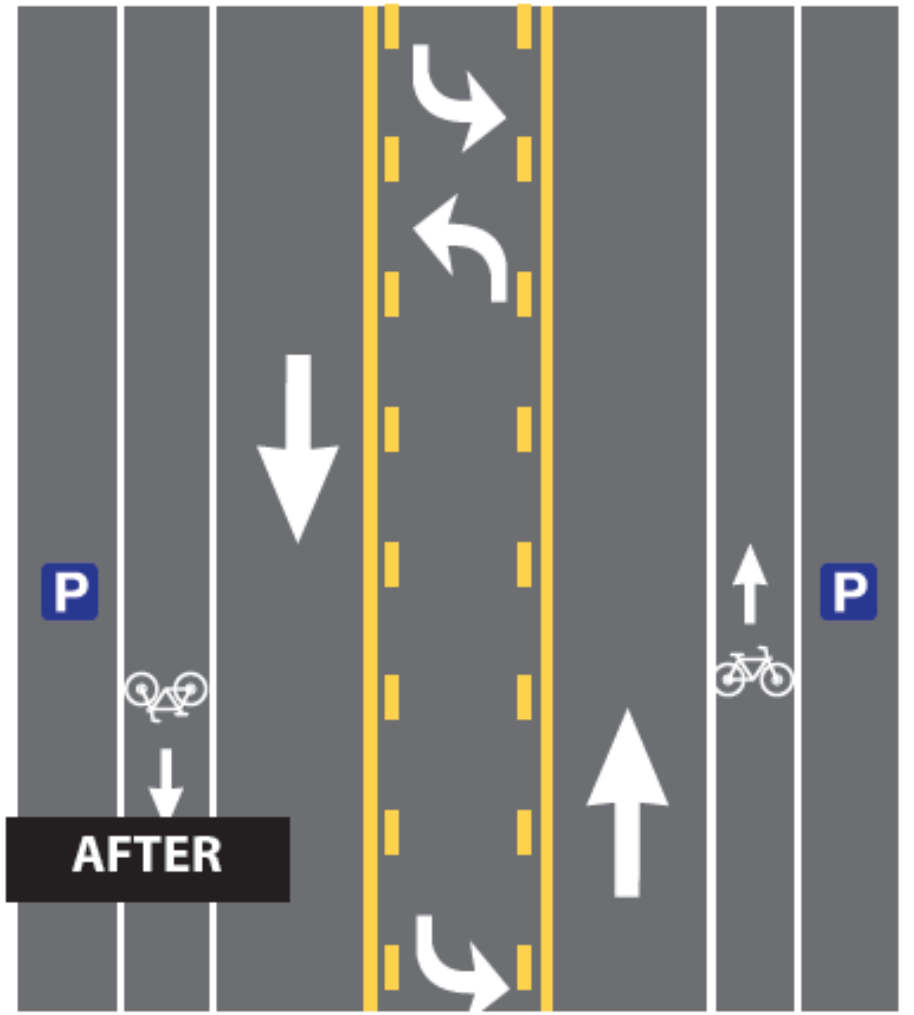
- Context
  - Schools
  - Retail
  - Recreational
  - Residential

- 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

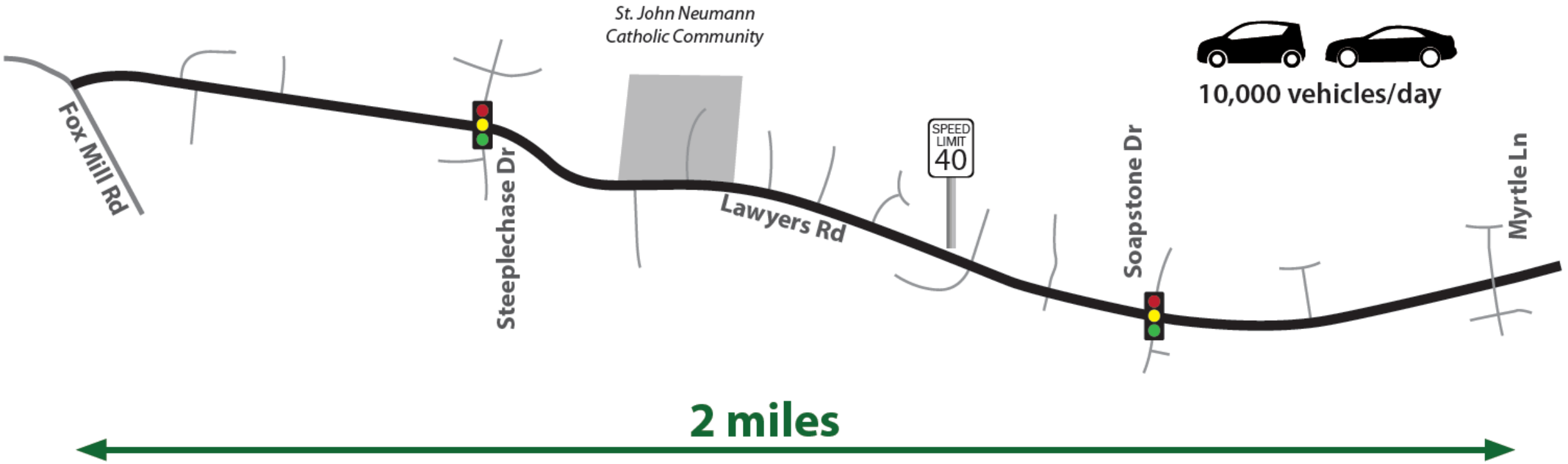
- Results: Improved Safety
  - 9 months –
    - 65% reduction in all crashes
    - 60% reduction in injury crashes
  - Reduced Travel Speed
    - 27 mph 85th %ile speed
    - 10 mph higher outside area
  - Reduced Traffic
    - Diverted to I-10
    - Adjacent Streets Stable Volumes

Ocean Park Boulevard looking east at 16th Street

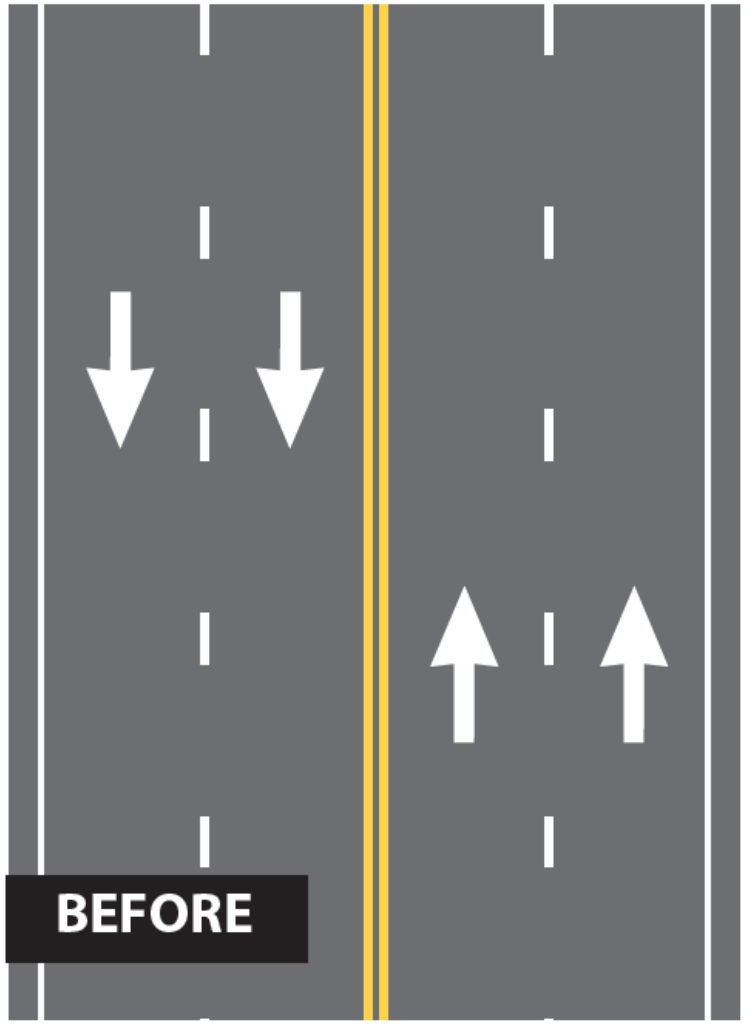
ROAD DIETS – CASE STUDY: RESTON, VA

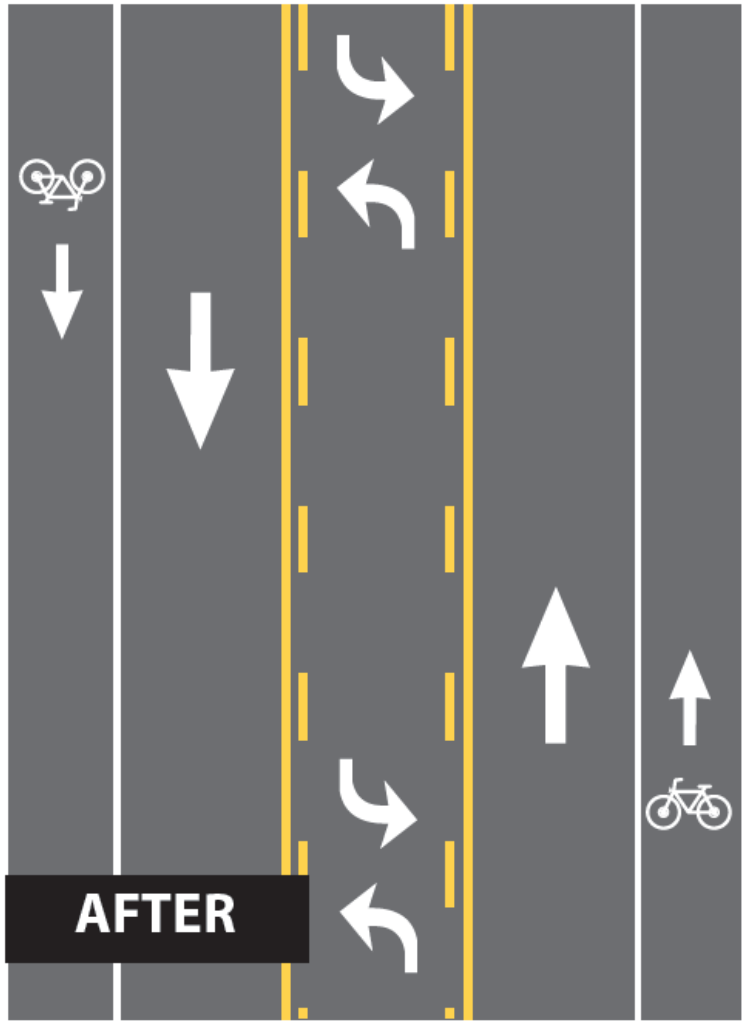
- Reduce Crashes and Speeding
- Improve Safety and Connectivity for cyclists

Lawyers Road



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

ROAD DIETS – CASE STUDY: RESTON, VA

Community Thoughts

- 69% Seems Safer
- 47% Cycle more often than before
- 69% Travel time didn't increase
- 74% Agreed Lawyers Road Improved

Photo Credit: Richard Retting

Questions?