HIGH SPEED MULTILANE ARTERIALS

Designing for Bicyclist and Pedestrian Safety

MODULE OBJECTIVES

- Characteristics of high speed multilane arterials
  - Defining high speed and multilane
  - Development and land use patterns
  - Complex intersections with long distance between crossings
- Common problems on multilane arterials
  - Symptoms of high speed multilane arterials
  - Safety risk factors for pedestrians, bicyclists, and motorists
- Design solutions and countermeasures
  - Access management and lane reduction
  - Enhancing crossings (Medians, RRFBs, PHBs, signals)
  - Lighting
  - Speed management

DEFINING "HIGH SPEED" AND "MULTILANE"

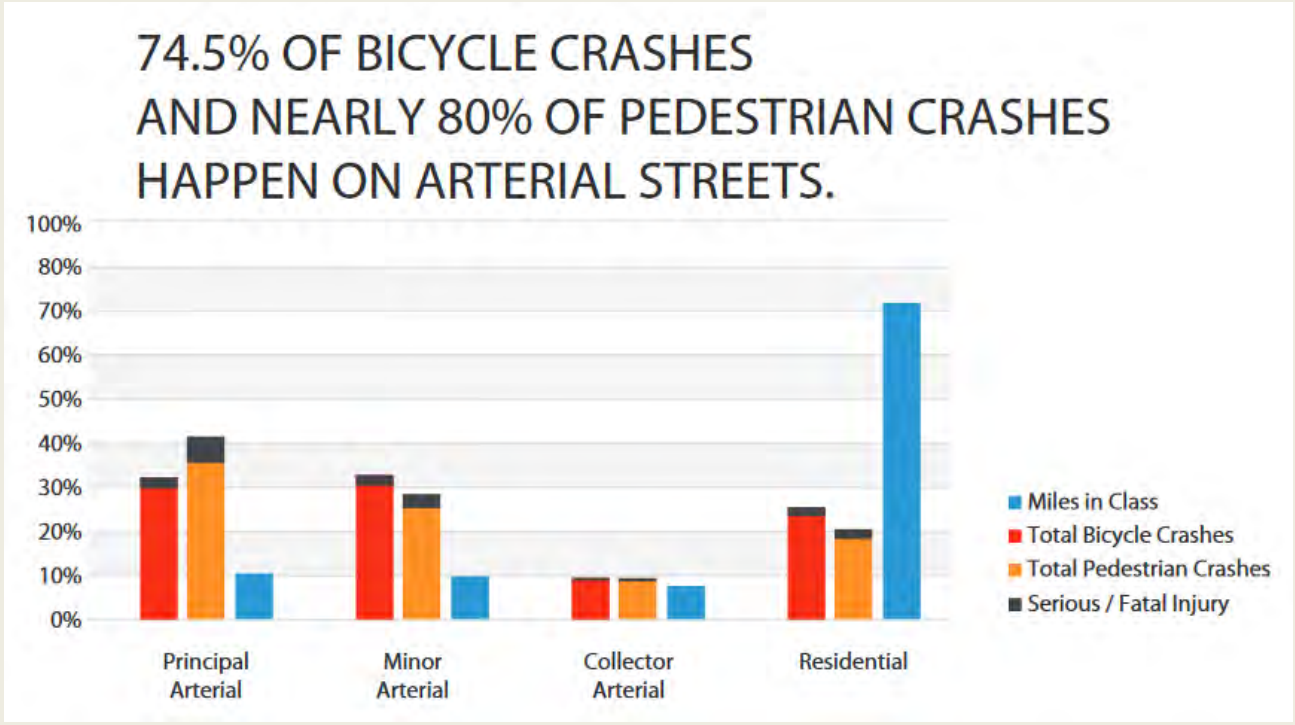
- For the purposes of this module:
  - High Speed: Posted or operating speeds exceeding 35 miles per hour
  - Multilane: More than three lanes, but primarily:
    - Four lane undivided or divided (median)
    - Five lane (with two-way left turn lane)
    - Six lane (divided with median)

IMPORTANCE OF DESIGNING FOR NONMOTORIZED ROAD USERS

- High speed, multilane arterials are traditionally auto-focused
- Decisions prioritize level of service and capacity, not safety or comfort of peds or bikes
- These corridors account for sizable share of crashes, but can be areas where pedestrians and bicyclists are dismissed as secondary road users

IMPORTANCE OF DESIGNING FOR NONMOTORIZED ROAD USERS

- In Los Angeles, pedestrian crashes on arterials were seven times more deadly than those on non-arterials
- In Seattle, most crashes involving bikes and peds occur on arterials



Taken from Seattle's Bicycle and Pedestrian Safety Analysis

DESIGNING FOR CONTEXT

- Street design isn't a one-size-fits-all approach
- Land use, user needs and other factors should drive decision-making, and design approaches should be flexible
- NCHRP 855 developed An Expanded Functional Classification System for Highways and Streets that builds upon existing AASHTO guidance, as well as other design guides from FHWA and NACTO

NCHRP REPORT 885

- Expanded Functional Classification System (FCS) establishes a framework to consider all user needs based on roadway and context

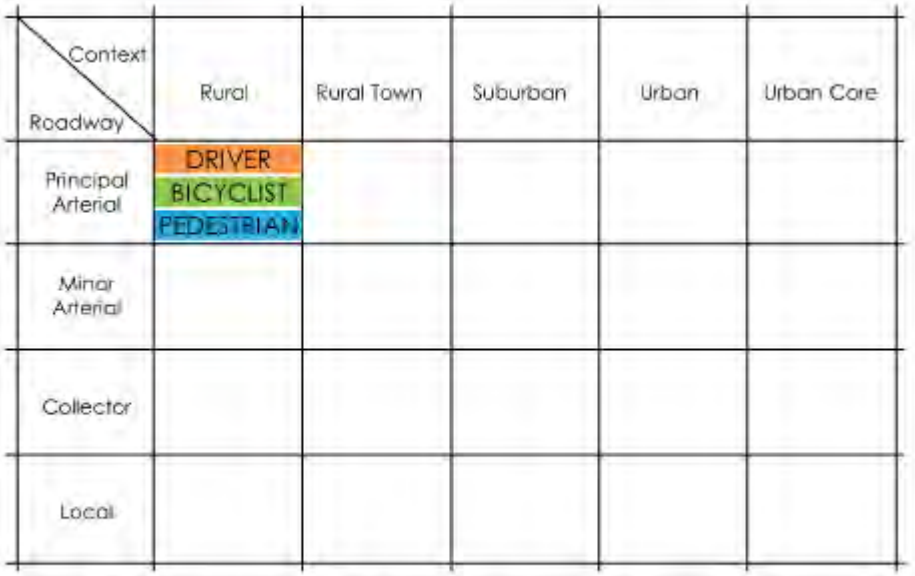


Figure 4. Expanded FCS framework user matrix.

NCHRP REPORT 885

- Expanded Functional Classification System (FCS) establishes a framework to consider all user needs based on roadway and context

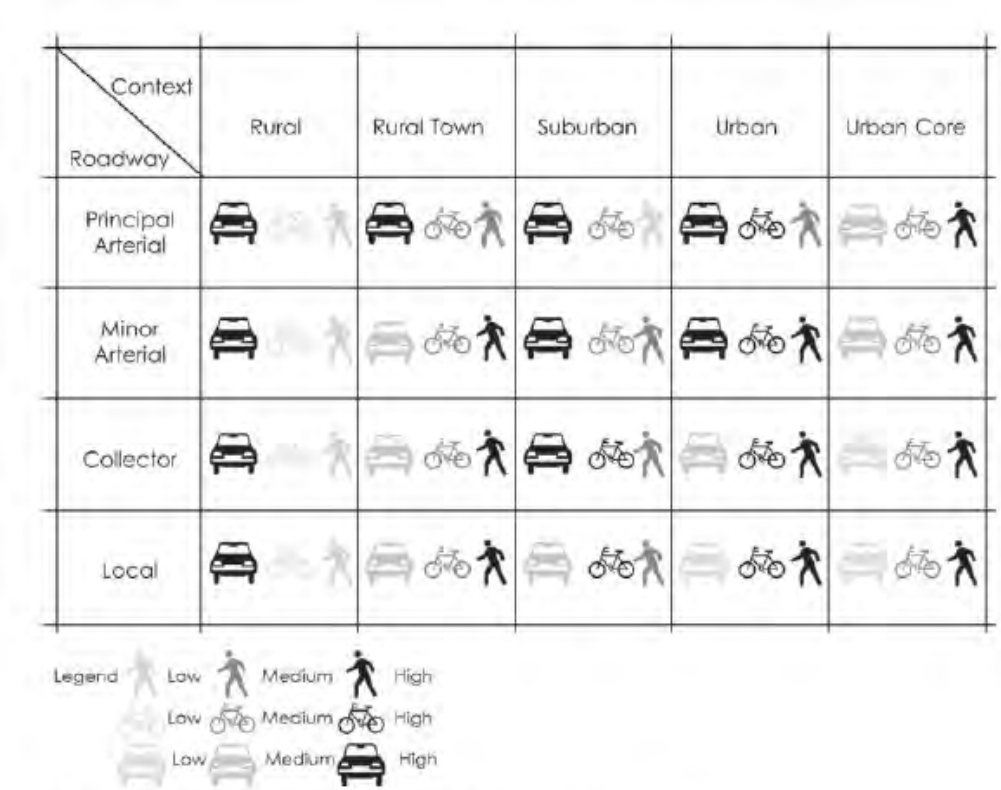


Figure 5. Typical user priorities in the Expanded FCS.

PROBLEMS ON HIGH SPEED MULTILANE ARTERIALS

LONG DISTANCE BETWEEN SIGNALS

Destinations are further apart, and signals are spaced according to vehicle needs

Resulting intersections handle more traffic and aren't spaced for bikes/peds

Decision to find a gap or walk/bike long distances to nearest intersection

COMPLEX INTERSECTIONS

Reduced signal density increases signal complexity

Longer cycle lengths, more delay

Complex crossing maneuvers for bicyclists, pedestrians

FEW GAPS IN TRAFFIC

Platooning of vehicles across multiple lanes means that pedestrians and bicyclists have a more difficult time finding gaps

Crossings are especially difficult if there is no median to break crossing into two parts

CONFLICTS AT DRIVEWAYS

Development patterns lead to more driveways

Driveway designs de-emphasize sidewalk

Undivided roads with more driveways results in more opportunities for conflicts

LITTLE SEPARATION FOR BICYCLISTS

These corridors often do not have bicycle facilities

Bicyclists are forced to ride far to the right or in the gutter pan

Many may resort to riding on the sidewalk

Not comfortable for most adults – LTS 4

Even bike lanes on these corridors are not comfortable – LTS 3

SOLUTIONS FOR HIGH SPEED MULTILANE ARTERIALS

SOLUTIONS FOR HIGH SPEED MULTILANE ARTERIALS

Speed Management

Lighting Improvements

Bicycle Facilities

Road Diets

Crossing Enhancements

Signal Improvements

SPEED MANAGEMENT

- Signal Timing
- Driver Speed feedback signs
- Automated Speed Enforcement (where permitted by State Law)
- Speed Feedback to Trigger Signals
- Roundabouts
- Other geometric improvements to reduce design speed

SPEED MANAGEMENT

- Coordinated signals can be timed to manage progression speed of traffic
- More challenging as signal density decreases
- San Francisco and Portland have both had success lowering speeds through signal timing changes

Signal Timing

Driver Speed feedback Signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

SPEED FEEDBACK SIGNS

- Dynamic speed feedback signs can provide reminders to drivers
- Los Angeles uses speed feedback signs to trigger downstream red lights for speeding drivers

Signal Timing

Driver Speed Feedback Signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

AUTOMATED ENFORCEMENT

- Can be controversial, but effective in reducing speeds and crashes
- Scan of 90 studies found 20 to 25 percent reduction in injury crashes
- Be careful to roll programs out carefully and be transparent about where funding goes

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

ROUNDABOUTS

- Reduce speeds and conflicts at intersections using roundabouts
- Especially useful at transition zones, such as ramps from interstates where speeds change quickly

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Other geometric improvements to reduce design speed

GEOMETRIC DESIGN

- A host of other geometric improvements have been shown to reduce speeds, such as:
  - Curb extensions and bulb-outs
  - Reduce curb radius

Signal Timing

Driver Speed feedback signs

Automated Speed Enforcement

Roundabouts

Geometric Design to Reduce Speeds

CROSSING ENHANCEMENTS

- Traffic signals & two-stage crossings
- PHBs & BikeHAWKs
- RRFBs
- Advance Stop/Yield Lines and Signs
- Medians and Refuge Islands
- Crossing Placement (Transit Stops)

MEDIANS AND REFUGE ISLANDS

- Medians and refuge islands are proven to reduce crashes
- Needed where volumes, speeds, and number of lanes make crossings difficult

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

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Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

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Advance Stop or Yield Lines

Crossing Placement and Transit Stops

MEDIANS AND REFUGE ISLANDS

- Crossing islands can help shorten distances at intersections
- Proper design needed to manage slip lane traffic and move peds safely from curb to island

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

TWO-STAGE CROSSINGS

- Where long distances exist between signals, incorporate two-stage crossings using median islands
- Allows for traffic to stop in one direction at a time to improve traffic flow

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

TWO-STAGE CROSSINGS

- Individual crossings enhanced w/ PHB or RRFB
- Example from Scottsdale, AZ:

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

RRFBs

- Improve yielding rates and reduce crashes
- Wide range of applications: trail crossings, uncontrolled midblock locations, uncontrolled intersections, roundabouts

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

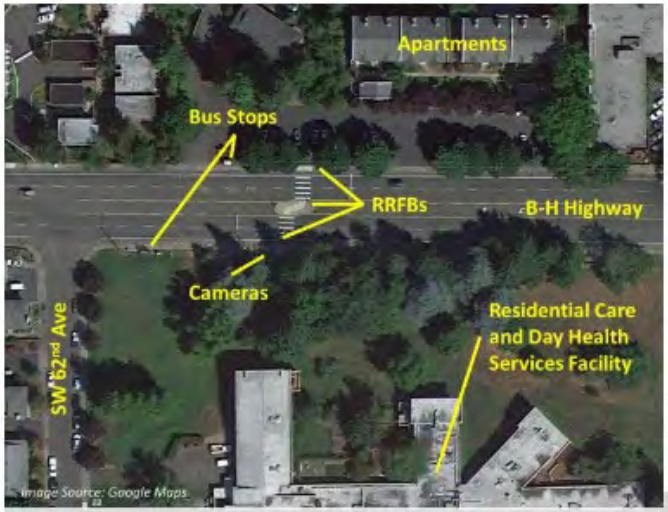
RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

RRFBs

- Two-stage crossing applications in Portland, OR
- Researchers found high rates of compliance with RRFB-equipped two-stage ("Z") crossings in Portland
- 4 travel lanes; 40mph posted speed limit

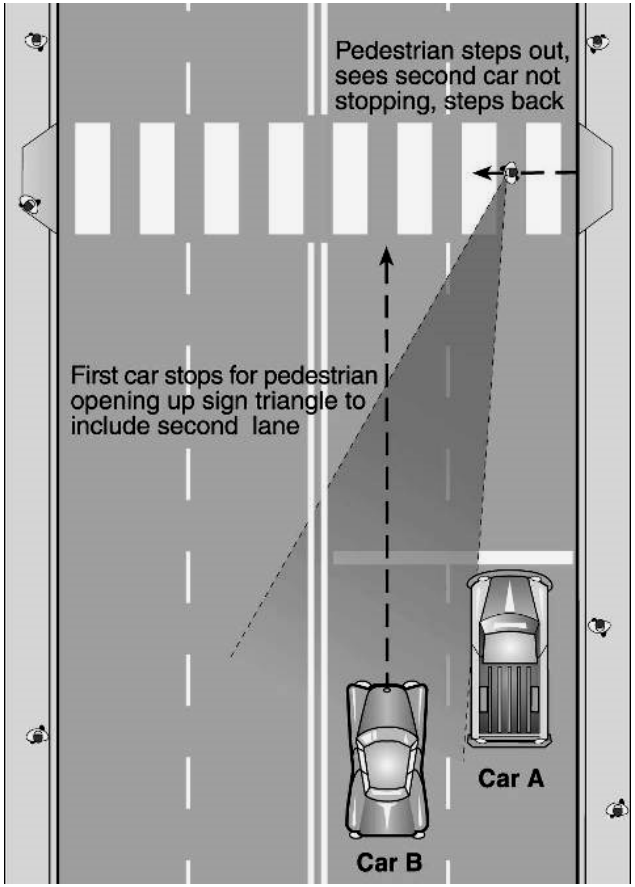


4 travel lanes; median island; 26,400 ADT volume; posted speed: 40 mph

Evaluating Driver and Pedestrian Behaviors at Enhanced Multi-lane Midblock Pedestrian Crossings: A Case Study in Portland, OR

ADVANCE STOP/YIELD LINES

- Improve visibility by pulling vehicles back from crosswalk
- Proven reduction in crashes



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

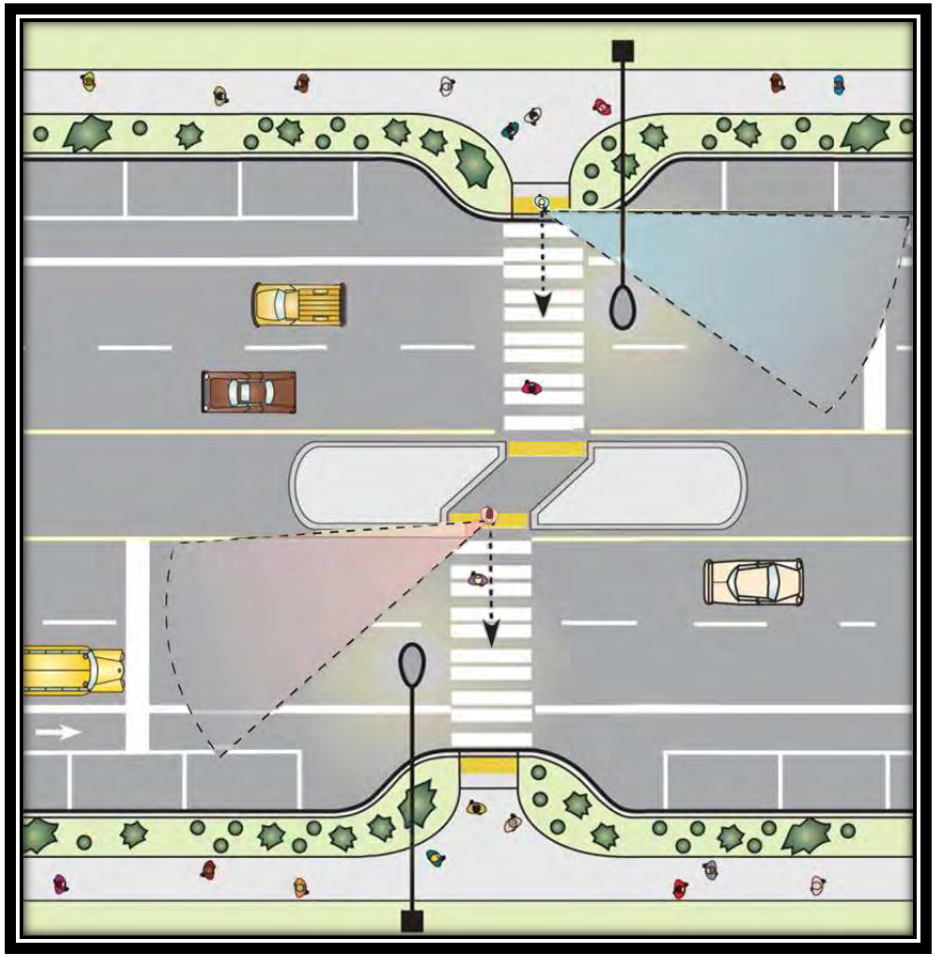
RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

ADVANCE STOP/YIELD LINES

- Used in combination with other treatments already discussed



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

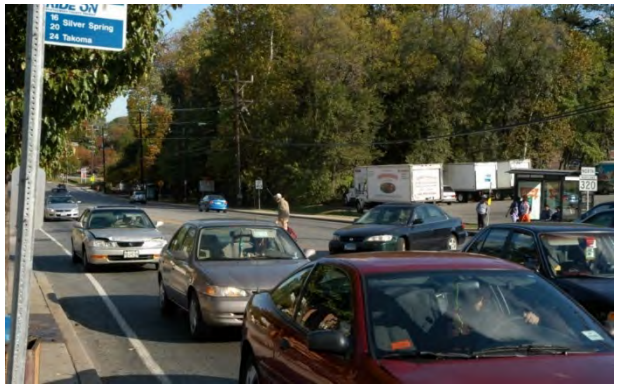
RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

TRANSIT STOP PLACEMENT

- Transit stops are major generators of pedestrian trips
- High speed arterials are often transit corridors
- Use field observations to determine ideal placement



Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

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Crossing Placement and Transit Stops

TRANSIT STOP PLACEMENT

- Advantages and disadvantages for locating transit stops at:
  - Far-side of intersections
  - Near-side of intersections
  - Mid-block locations

Stop Location		Advantages	Disadvantages
Far-Side Stop		- Encourages peds to cross behind bus	- Sight distance issues for crossing vehicles and pedestrians
Near-side Stop		- Allows passengers to access bus closest to crosswalk	- Sight distance issues for veh to right of bus and crossing peds - Obscures curb signals and peds
Mid-Block Stop		- Min sight distance problems for vehicles and pedestrians - May reduce congestion at passenger waiting areas	- Encourages midblock crossing. - Increases walking distance for peds crossing at intersections

Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops, TRB, 1996

Medians, Refuge and Crossing Islands

Two-Stage Crossings

PHB and Bike HAWK

RRFBs

Advance Stop or Yield Lines

Crossing Placement and Transit Stops

SIGNAL IMPROVEMENTS

- Adding Traffic Signals
- Bicyclist Detection
- Bicyclist Clearance intervals
- Pedestrian countdown signals
- Leading Pedestrian Intervals

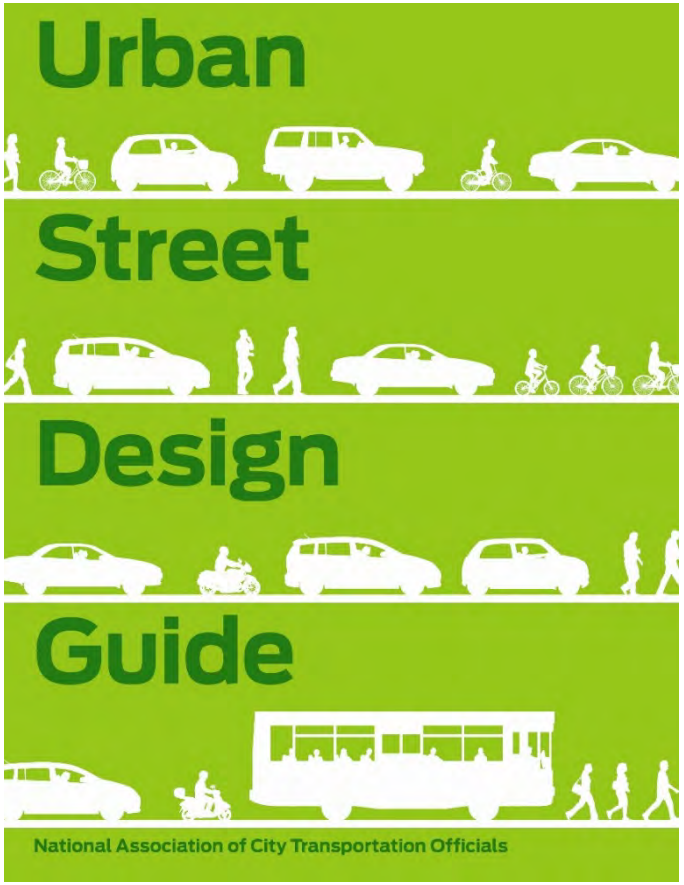
ADDING TRAFFIC SIGNALS

- Increasing signal density can help manage progression of traffic and create more opportunities for crossings
- Can be expensive and difficult to justify many new signals

SIGNAL TIMING STRATEGIES

Summarized from the NACTO Urban Street Design Guide:

- Coordinate signal timing to achieve desired progressions speeds
- Adjust peak and off-peak timing
- Fixed time is preferred over actuated signals
- Semi-actuated signals more common along major/minor intersections
- Shorten cycles and minimize phases to minimize wait times

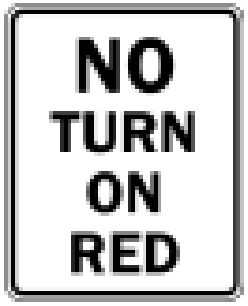


PEDESTRIAN SIGNALS

- Belong at every signalized intersection
- Time signals to maximum 3.5 feet/second (can use slower speeds in areas with children or seniors)

LEADING PEDESTRIAN INTERVAL

- Gives pedestrians 5-7 second head start
- Provide in areas with turning conflicts
- Must restrict RTOR when used



ROAD DIETS

- Road Diets (lane reduction)
- Lane Diets (Narrowing)
- Use space for other purposes
- Minimize crossing distances and intersection size

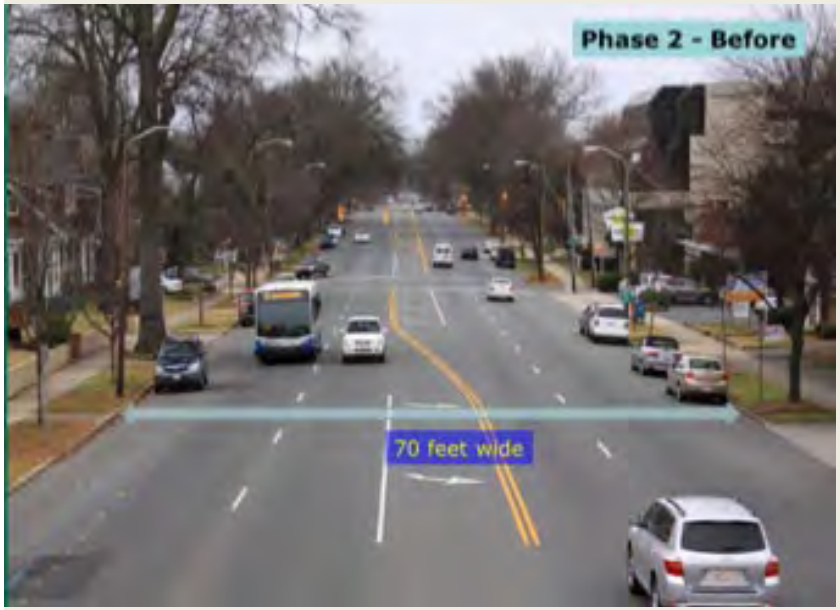
ROAD DIET CANDIDATE GUIDELINES

- ADT (Road Diet Candidate)
  - 24,000 or less
- Peak hourly volume (Road Diet Candidate)
  - Below 875 vehicles per day in one direction
- Case with higher ADT
  - Lake Washington Blvd. Kirkland, WA
    - Initial volume of 23,000 vehicles per day
    - Increased nearly 26,000 after conversion
    - During one period about 30,000 vehicles per day

Summarized from FHWA Road Diet Informational Guide

EXAMPLE: EAST BOULEVARD, CHARLOTTE NC

- ADT ranged from 16,000 to 24,000
- Posted Speeds: 35 mph
- After project, 85th percentile speeds reduced from 43 to 40 mph



ROADWAY VS. PEDESTRIANWAY

- Roadway lighting typically 25 ft or higher
  - Overhead streetlights
  - Light source over roadway

LED Streetlights on 10th Ave E

- Road lighting may be sufficient for motorists to navigate & avoid obstacles
  - Often insufficient for specialized pedestrian needs

Pedestrian lighting in South Lake Union

LIGHTING IMPROVEMENTS

- Along Corridors
- Lighting at Signals
- Lighting at Uncontrolled Crossings
- LED lighting

Pedestrian lighting in South Lake Union

PEDESTRIAN LIGHTING ALONG CORRIDORS

- Help pedestrians safely navigate sidewalks & pathways
- Provide for visibility & security at all hours
- Extend hours a business district is active
- Encourage walking as part of an active lifestyle
- Improve access to transit & other services at night/early morning

Pedestrian lights at 1st Ave and Yesler Way

Lighting Along Corridors

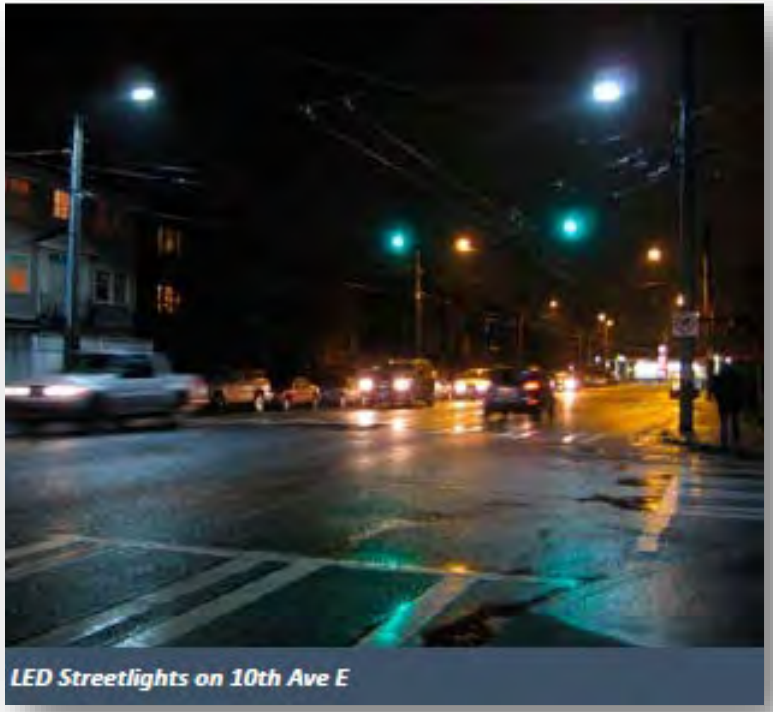
Lighting at Signals

Lighting at Uncontrolled Crossings

LED Lighting

LIGHTING ALONG CORRIDORS

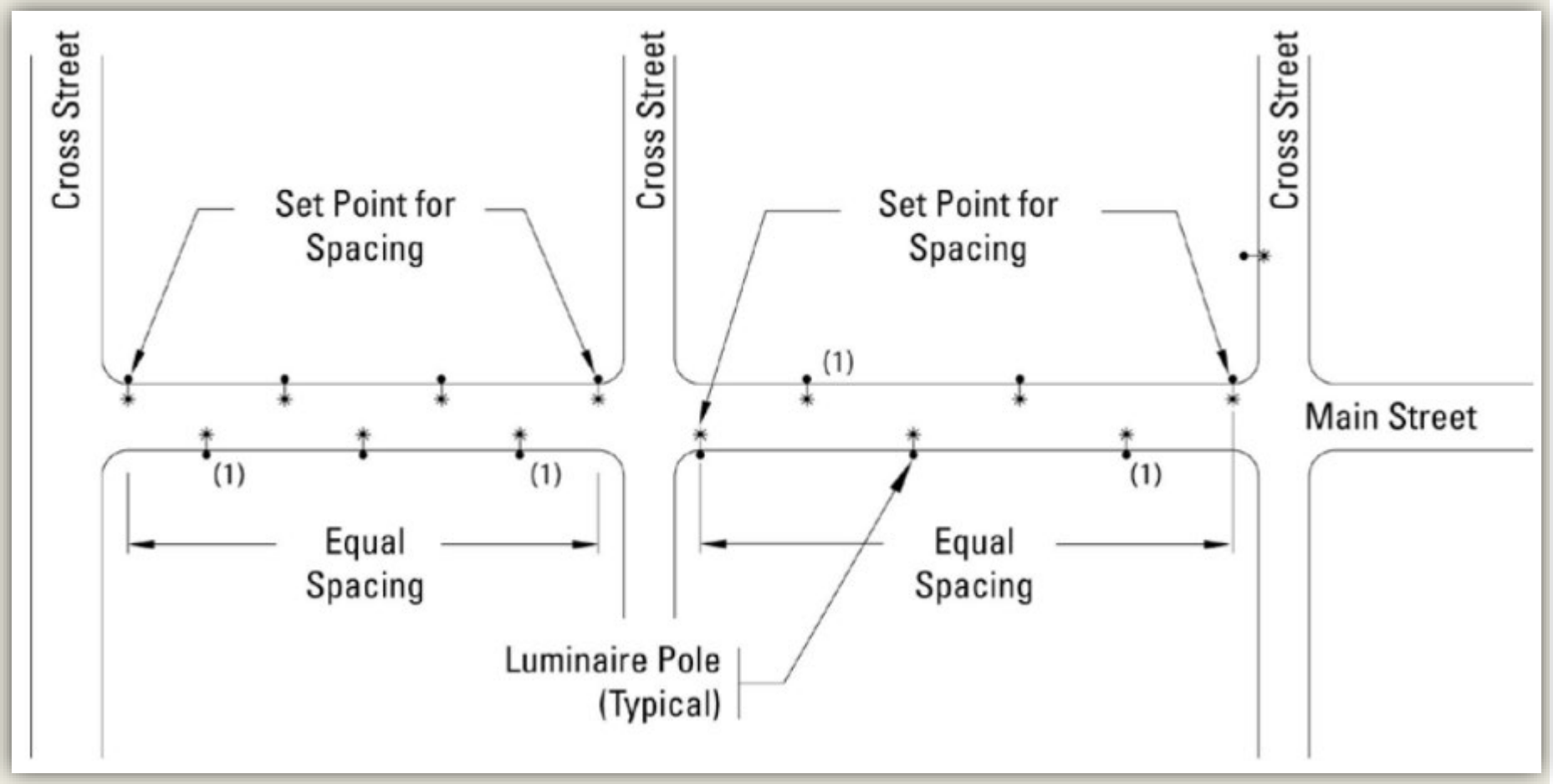
- Consider roadway and pedestrian-way lighting
- Roadway: 25 ft or higher
  - Works for motorists but often insufficient for pedestrians
- Pedestrian: 20 ft or less from surface



LED Streetlights on 10th Ave E

Pedestrian lighting in South Lake Union

POLE SPACING



DESIGN LIGHTING POLE HEIGHT, TYPES & LUMINAIRE WATTAGE

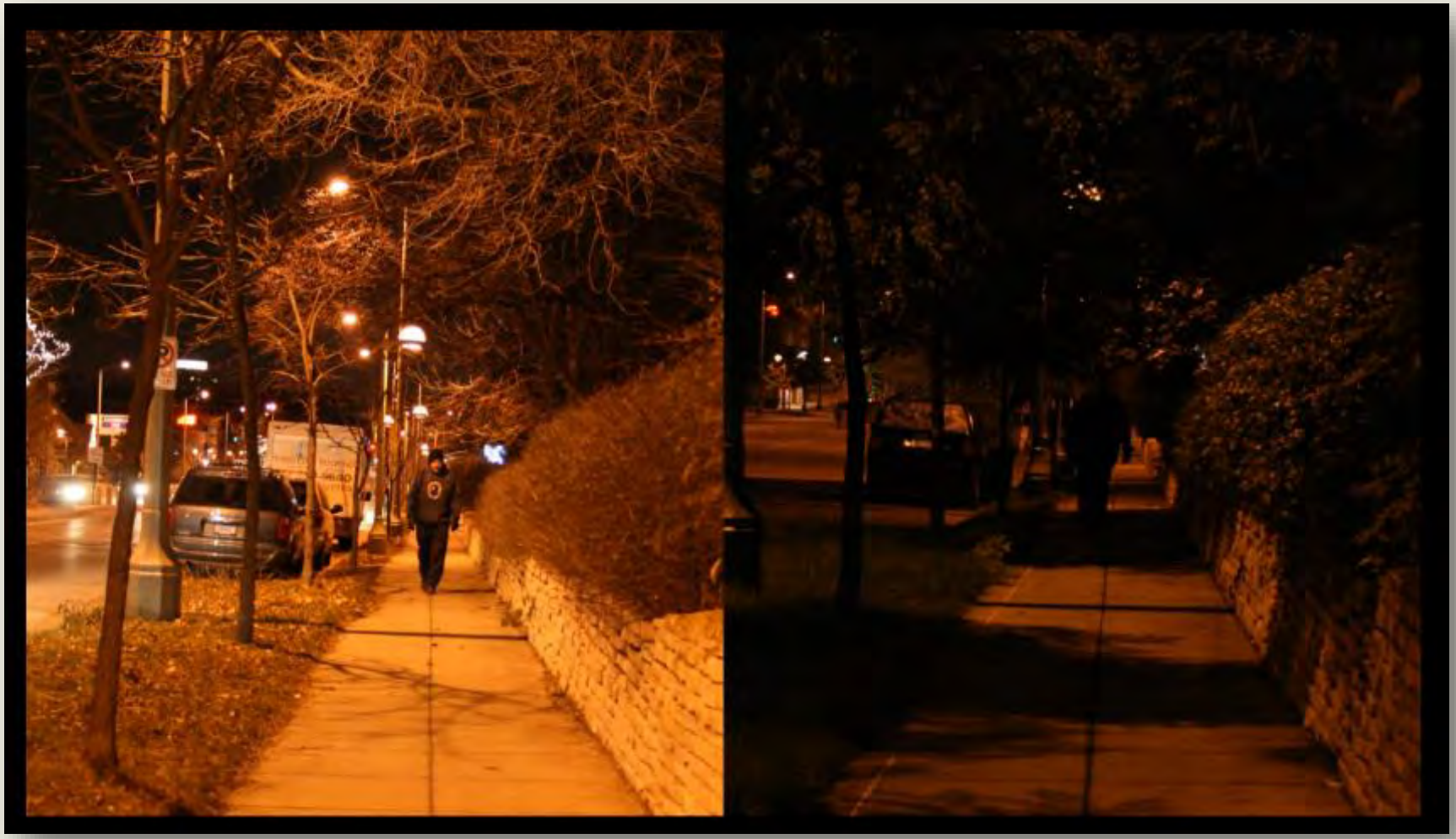
Consider:

- Land use
- Road width

Other Factors:

- Pole spacing and system layout
- Luminaire photometrics
- Wattage
- Road geometrics
- Power line conflicts
- Lighting levels and uniformity
- Aesthetics
- Obtrusive lighting issues

LIGHTING
CONSIDER TREE EFFECTS



TRR 2120 - Trees, Lighting, and Safety in Context-Sensitive Solutions

INTERSECTION LIGHTING

- No specific research done to address higher background luminance typically found at intersections
- 30 vertical lux considered conservative estimate

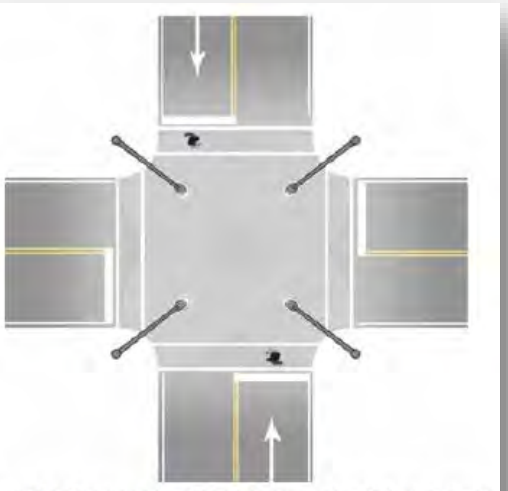


Figure 13. Drawing. Traditional intersection lighting layout.

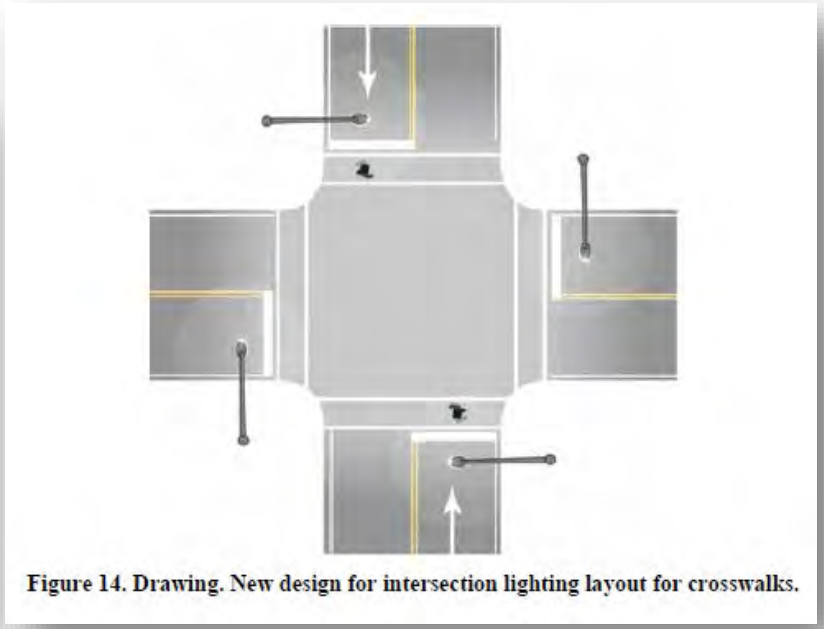


Figure 14. Drawing. New design for intersection lighting layout for crosswalks.

LED LIGHTING

- More agencies moving toward LED lighting due to:
  - Whiter light/better color recognition
  - Lower energy costs
  - Less maintenance

Advantages

- Lower energy use
- Longer lamp life
- No warm-up time
- Good light quality
- Directional (less light pollution)
- Environmentally friendly

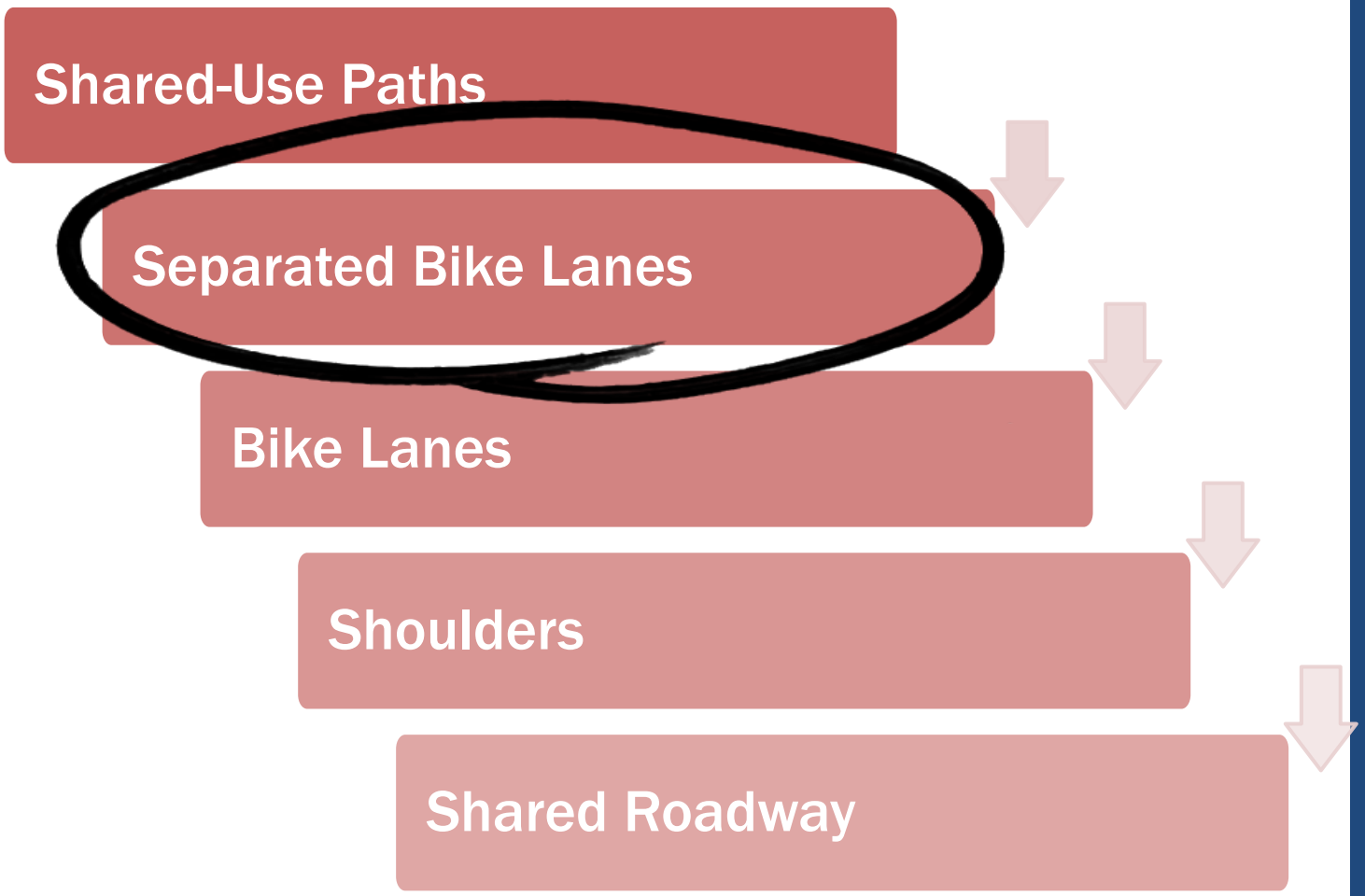
Disadvantages

- High initial cost
- Sensitive to heat
- Long-term performance issues

BICYCLE FACILITIES

- Mixing Zone Treatments at Intersections
- Protected Intersections
- Separated or Buffered Bike Lanes
- Use of Parallel Routes (Bicycle Boulevards)

OPTIONS FOR BIKE FACILITIES



Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

MIXING ZONES

- Mark conflict zones at and leading up to intersections to communicate desired movement

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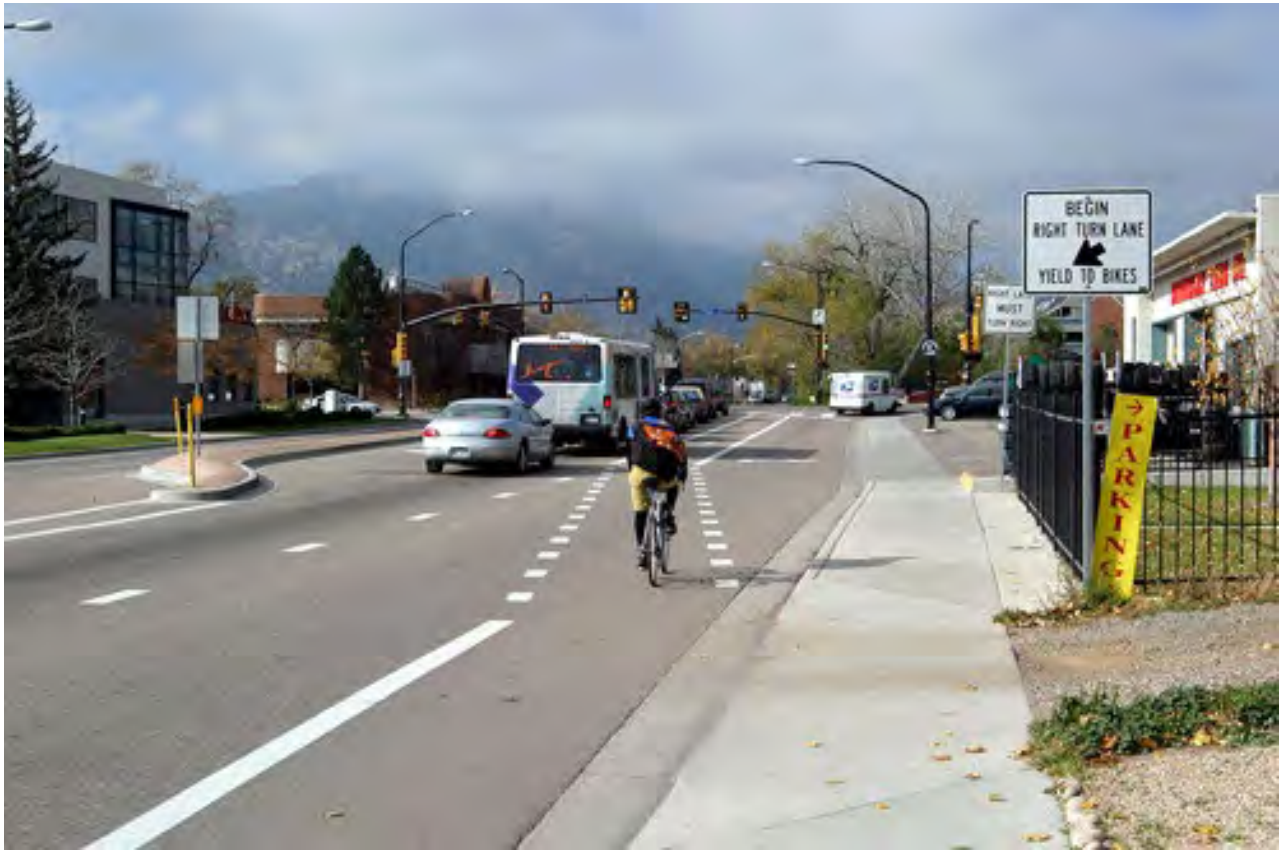


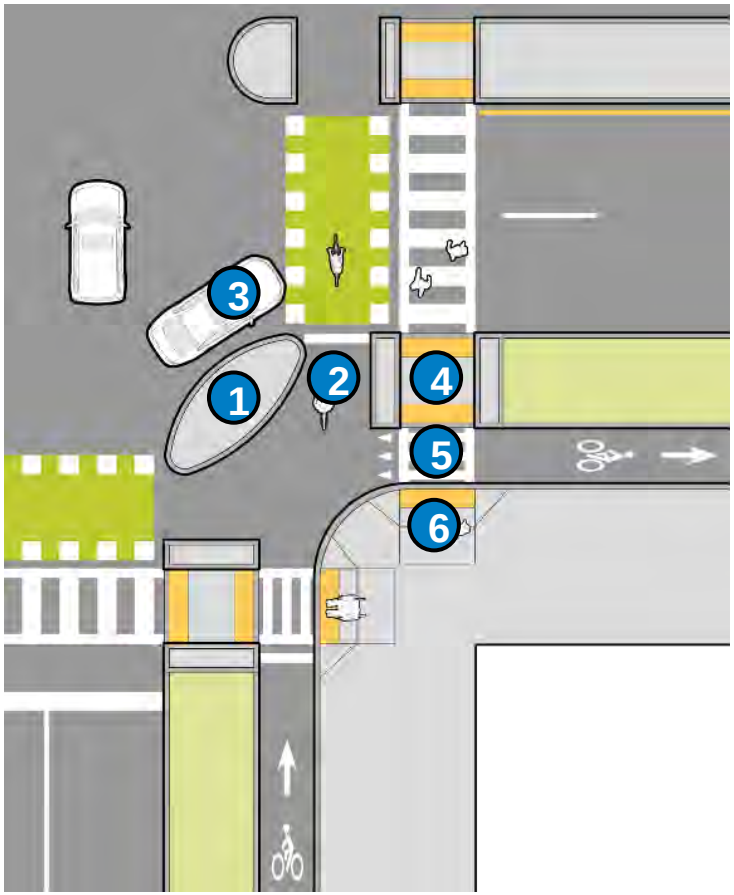
BIKE BOXES

- Allows bicyclists to queue at front of traffic when waiting for signal
- Improves visibility and reduces turning conflict

PROTECTED INTERSECTIONS

- **Newer design to reduce conflict points at intersections**

1. Corner refuge island
2. Forward bicycle queuing area
3. Motorist yield zone
4. Pedestrian crossing island
5. Pedestrian crossing of separated bike lane
6. Pedestrian curb ramp



massDOT

PROTECTED INTERSECTIONS

- Example from Chicago:

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

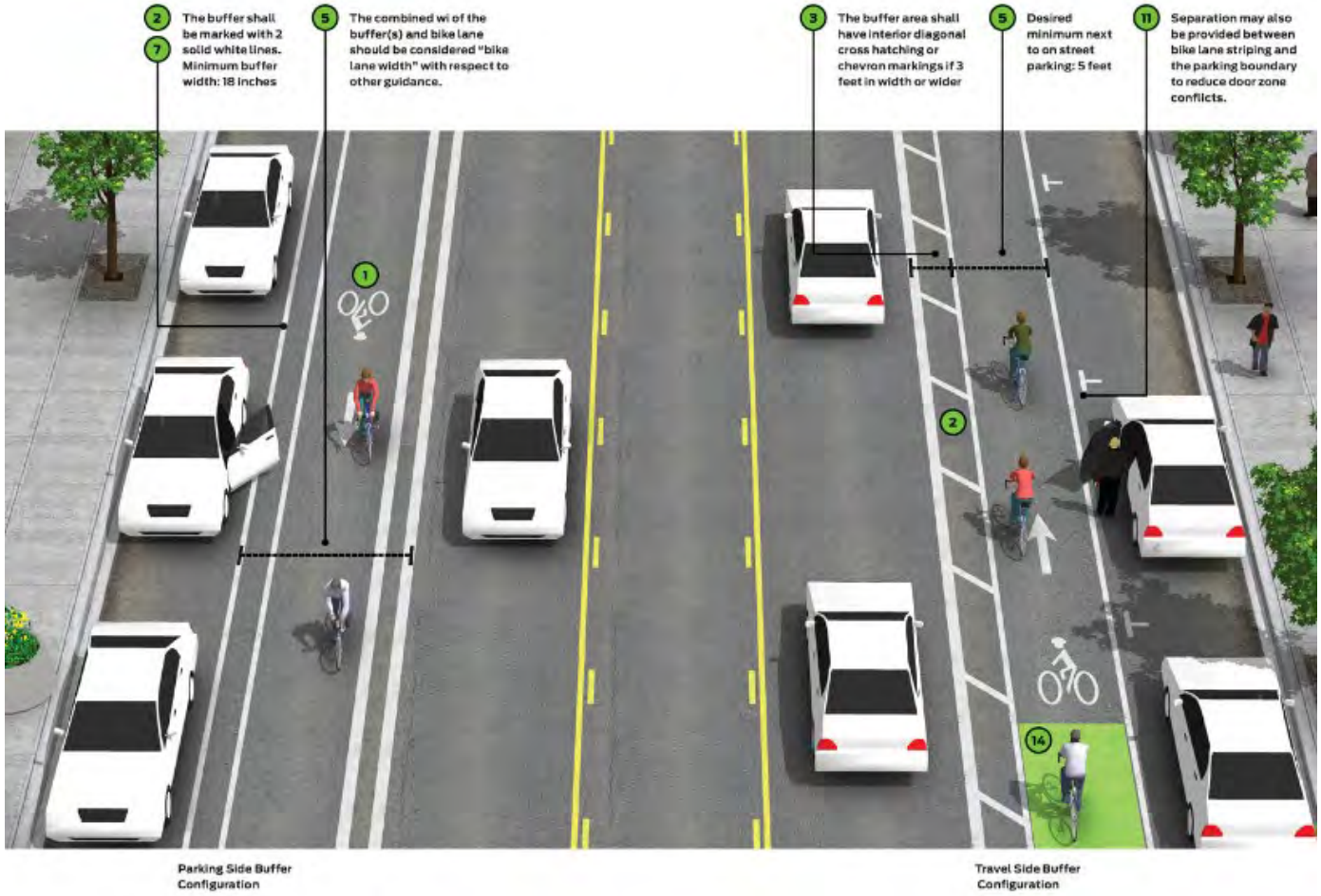
Separated or Buffered Bike Lanes

Parallel Routes

BUFFERED BIKE LANES

- Added buffer between bike lane and travel lane
- Shy distance allows more comfortable travel and weaving space to avoid door zones
- No physical separation means more opportunity for conflicts

BUFFERED BIKE LANES



Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

BUFFERED BIKE LANES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

SEPARATED BIKE LANES

- Vertical barrier separating bike lane from traffic lane
- Can be one-way, two-way, or contraflow
- Raised to sidewalk level or on roadway

SEPARATED BIKE LANES

Advantages

- Very low stress midblock
- Encourages bike riding
- More conspicuous
- Crash rate reductions

Disadvantages

- Special intersection treatments
- Special driveway treatments
- Additional space needed
- More costly than bike lanes
- More to learn

SEPARATED BIKE LANES

Bike Facility Options

Mixing Zone Treatments

Protected Intersections

Separated or Buffered Bike Lanes

Parallel Routes

SEPARATED BIKE LANES

Bike Facility Options

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QUESTIONS