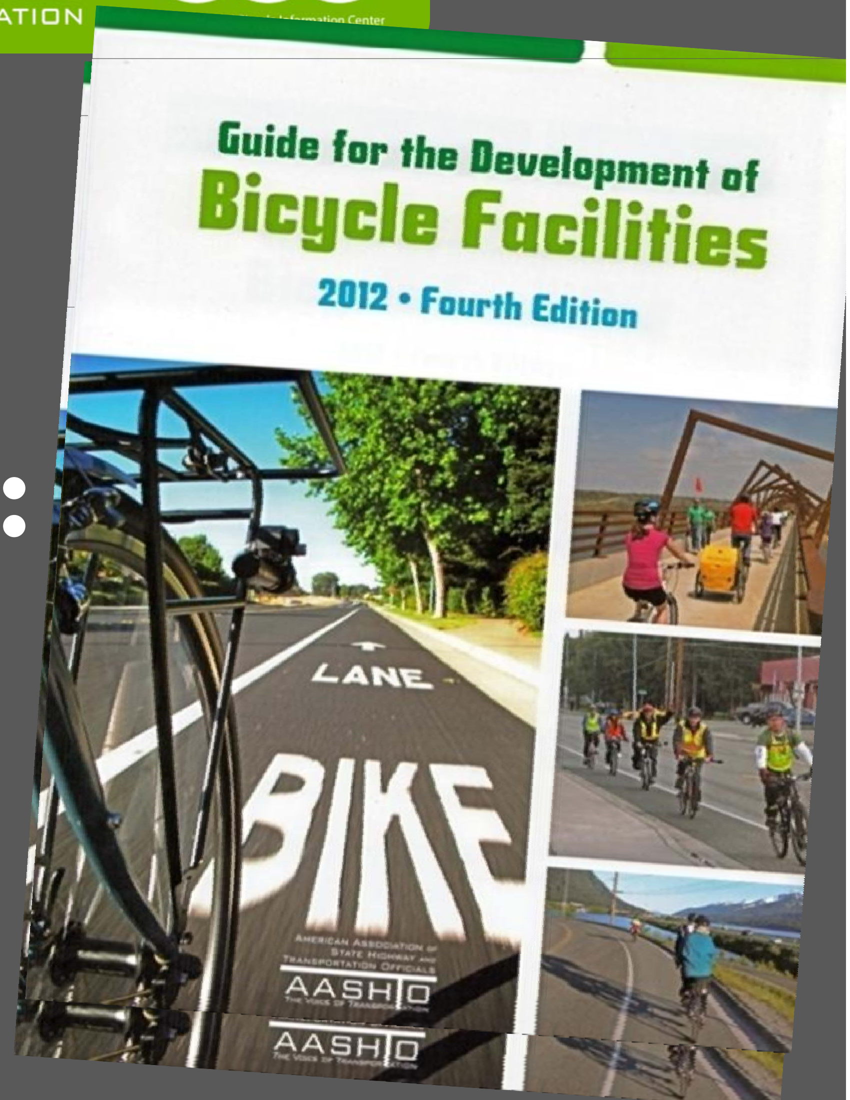
U.S. Department of Transportation
Federal Highway Administration

AASHTO
THE VOICE OF TRANSPORTATION



On Road Bikeways Part II: Non-Bike Lane Design

Presentation by:

Bill Schultheiss, P.E.

Tina Fink, P.E.

September18, 2012

Toole Design Group

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- Toole Design Group is live tweeting this webinar
  - @tooledesign
  - #AASHTO #BikeGuide

PAST & FUTURE WEBINARS

- August 10: Overview
- August 22: Planning Chapter
- September 4: On-Road Bikeways Part I
  - Bike Lanes (including Intersections)
- September 18: On-Road Bikeways Part II
  - Shared lanes
  - Bicycle boulevards & signing
  - Signals
- **October 9: Shared Use Paths**
  - **General design principles**
  - **Pathway geometry**
- October 23: Shared Use Paths
  - Intersection Design
  - Mid-block crossings
- November 6: Bikeway Maintenance and Operation

WEBINAR #4: OTHER BIKEWAY GUIDANCE IN THE 2012 AASHTO BIKE GUIDE

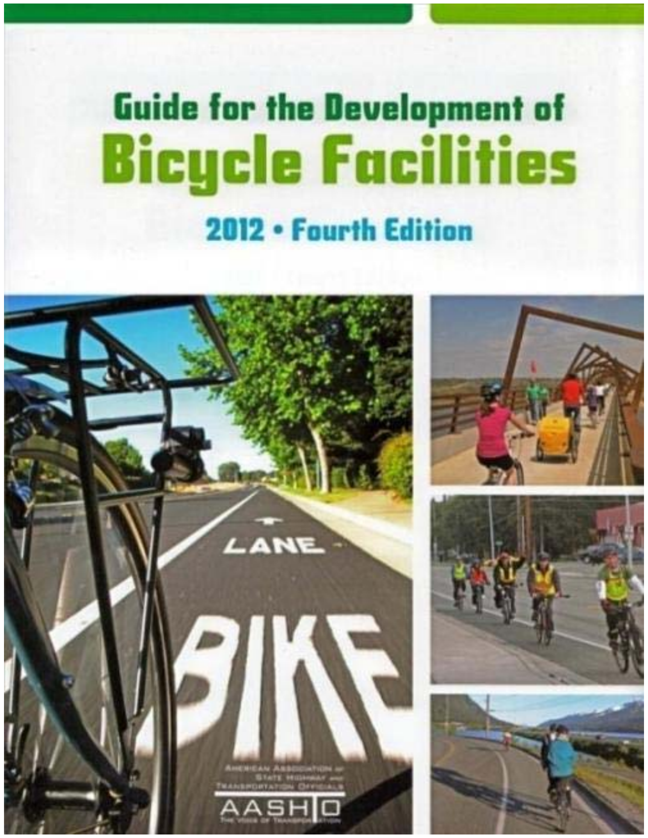
Today's Webinar

- Significant Updates & New Content
  - Shared Lanes
  - Paved Shoulders
  - Bicycle Travel on Freeways
  - Bridges, Viaducts, & Tunnels
  - Shared Lane Markings
  - Bicycle Boulevards
  - Guide Signs/Wayfinding
  - Bicycle Signals/Detection

DISCOUNT FOR WEBINAR PARTICIPANTS

http://www.walkinginfo.org/training/pbic/AASHTO_Promo_Flyer.pdf

Link will be emailed to webinar attendees

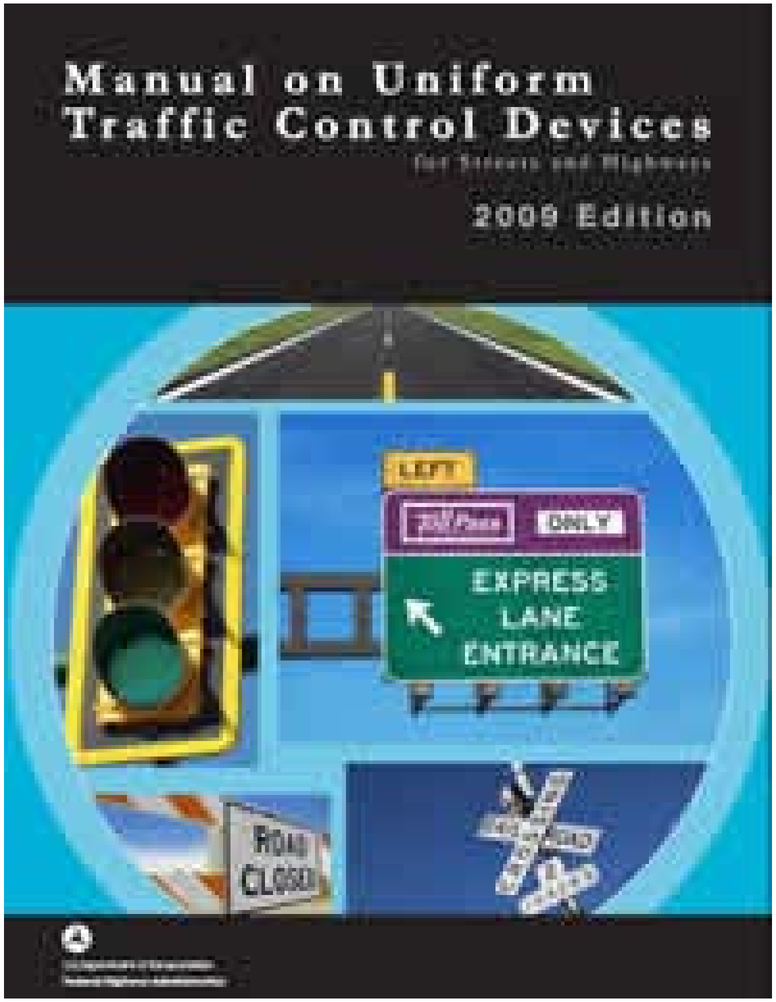


SOME BACKGROUND

- What is AASHTO?
  - Mission: “provides technical services to support states in their efforts to efficiently and safely move people and goods”
- Some history
  - Last Guide – 1999, largely written in 96-98
  - Survey to update Guide - 2004
- Standards vs. guidance (Shall vs. should or may)
- Relationship between AASHTO Guide and the MUTCD
- Innovation vs. accepted practice

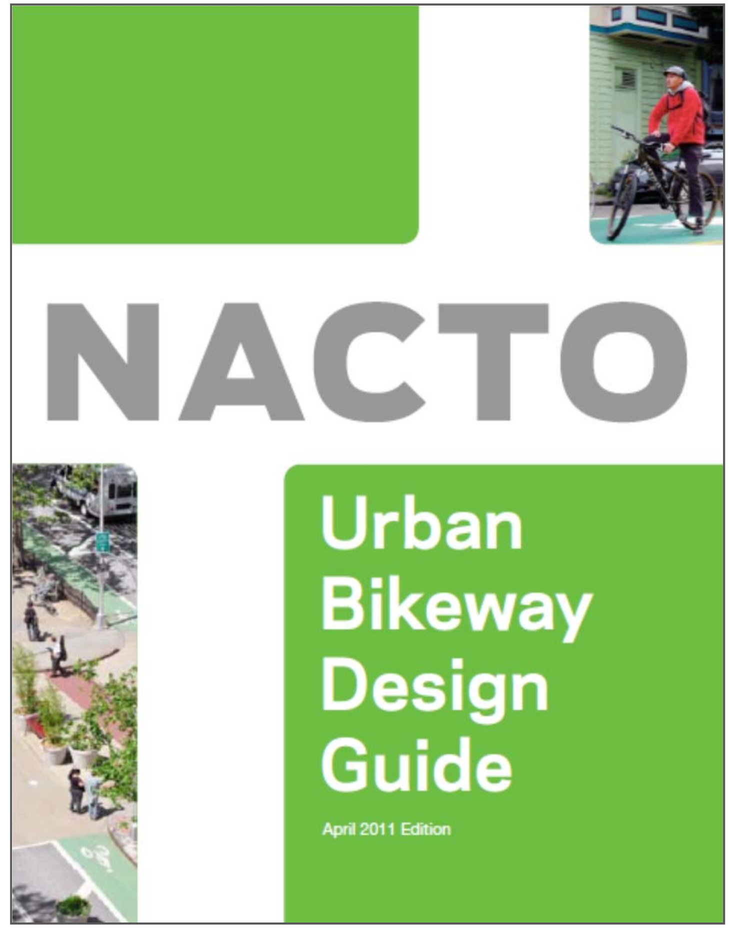
RELATIONSHIP TO OTHER MANUALS

- 2009 MUTCD – FHWA
- 2011 AASHTO Green Book
- Public Right-of-Way Accessibility Guidelines (PROWAG)
- 2010 Highway Capacity Manual



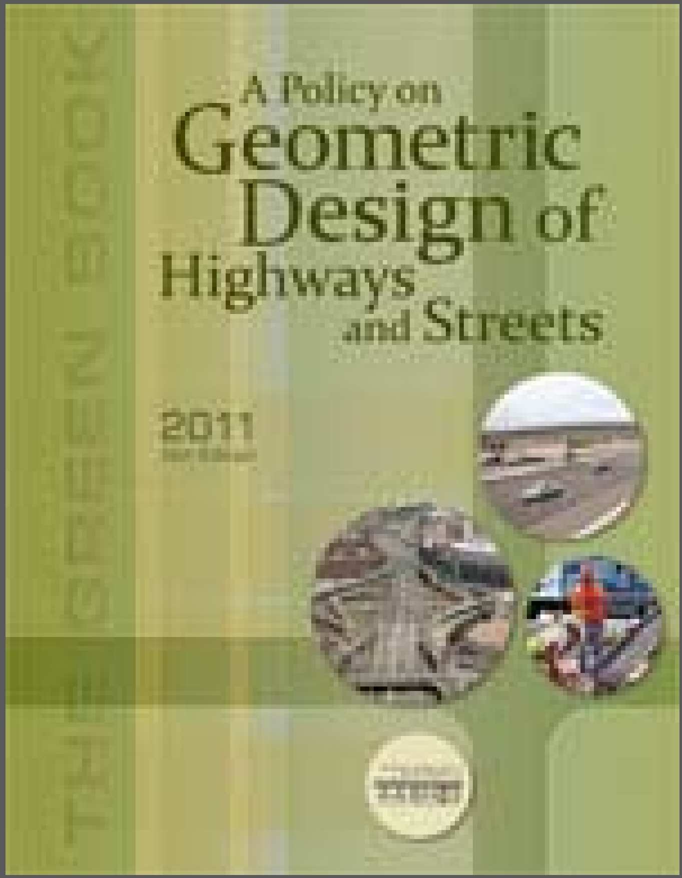
AASHTO VS. NACTO GUIDE: EITHER/OR?

- AASHTO covers paths + on-road bikeways
- AASHTO covers design comprehensively
- AASHTO covers many – but not all innovations
- NACTO is a source of information for solutions that are currently experimental



DESIGN GUIDANCE OF GREEN BOOK

- Streets designed to meet design principals of the "Green Book" will typically accommodate bikes by providing adequate:
  - sight distance
  - Vertical & horizontal curves
  - Cross slopes
  - Shoulders

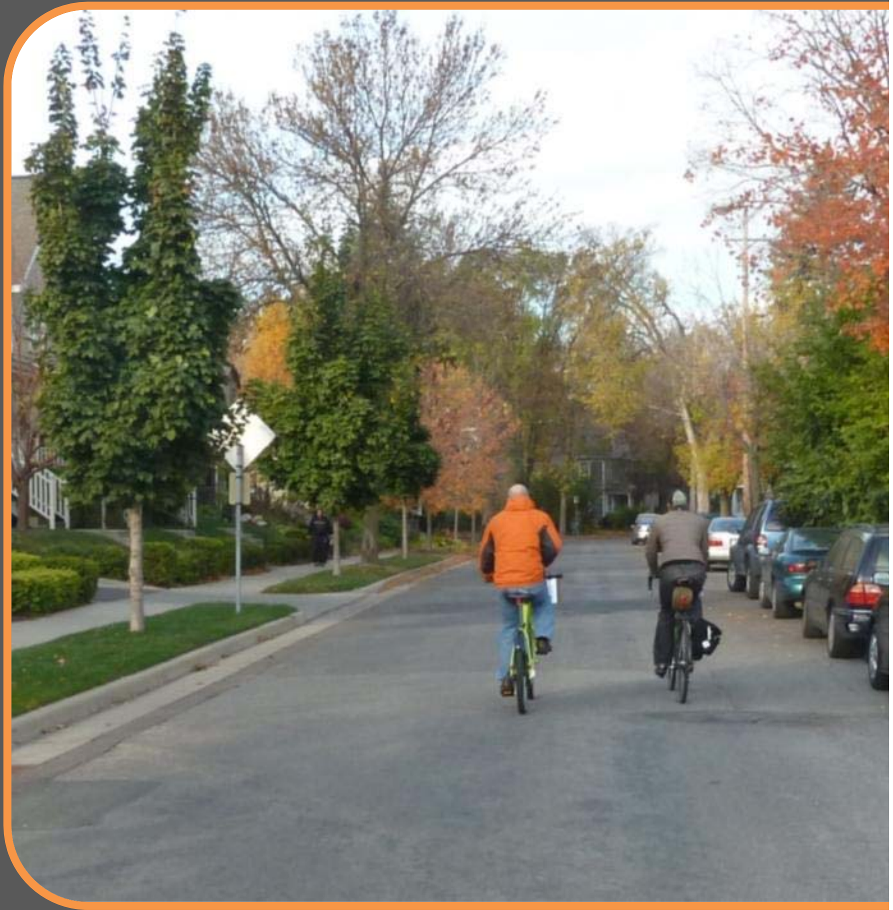


ENGINEERING JUDGMENT

"The treatments described reflect typical situations; local conditions may vary and engineering judgment should be applied."

SHARED LANES

- Exist everywhere
- Increased comfort where roads have:
  - Lower Volumes/Speeds
  - Good pavement quality
  - Adequate sight distances
  - Compatible drainage grates
  - Safe bridge expansion joints
  - Safe railroad crossings
  - Access to traffic signals



SHARED LANE WIDTHS

Lane Width (not including gutter)	
13 Feet or Less	Motorists will likely encroach into next lane
14 Feet	Allows motorists to pass without encroaching into next lane
15 Feet	Allows more maneuverability for cyclists for drainage grates, raised delineators, on-street parking, etc.
16 Feet or More	May encourage the undesirable operation of two motor vehicles side by side in congested areas

WIDE OUTSIDE LANE

- Lane widths of 14 feet or greater

SHARED LANE BEHAVIOR

SHARED LANE SUPPLEMENTAL SIGNS

SHARED LANE SIGNS

< 13 Feet

SLM middle of lane

≥ 13 Feet

SLM at 11’ from curb face

APPLICATION OF SHARED LANE SIGNS IN DIFFERENT CONTEXTS

Share the Road

- Lane width ≥14 feet

Bikes May Use Full Lane

- Lane width <14 feet

BICYCLE LANE VS WIDE OUTSIDE LANE

2012 Guide

"The provision of wide outside lanes should also be weighed against the likelihood that motorists will travel faster in them…, resulting in decreased level of service for bicyclists and pedestrians.

Bike lanes are the appropriate and preferred bicycle facility for thoroughfares in both urban and suburban areas."

SHARED LANES – RURAL CONDITIONS

- Suitable where:
  - good sight distance
  - low traffic volumes
  - Speeds 55 mph or less
- May comprise high % of:
  - Local bicycle routes
  - State bicycle routes
  - US Bicycle Routes

PAVED SHOULDERS VS SHARED LANES

"when sufficient width is available to provide bike lanes or paved shoulders, they are the preferred facilities on major roadways"

- Overtaking and rear end crashes:
  - Large proportion of rural crashes
  - Often fatal

PAVED SHOULDERS

- Bike lanes are travel lanes → No Parking
- Paved shoulders are not travel lanes → parking ok
- 4-foot minimum width when no curb is present
- 5-foot minimum
  - curb, guardrail, or other barrier
- Additional width
  - Improves BLOS
  - 50 mph
  - Heavy trucks

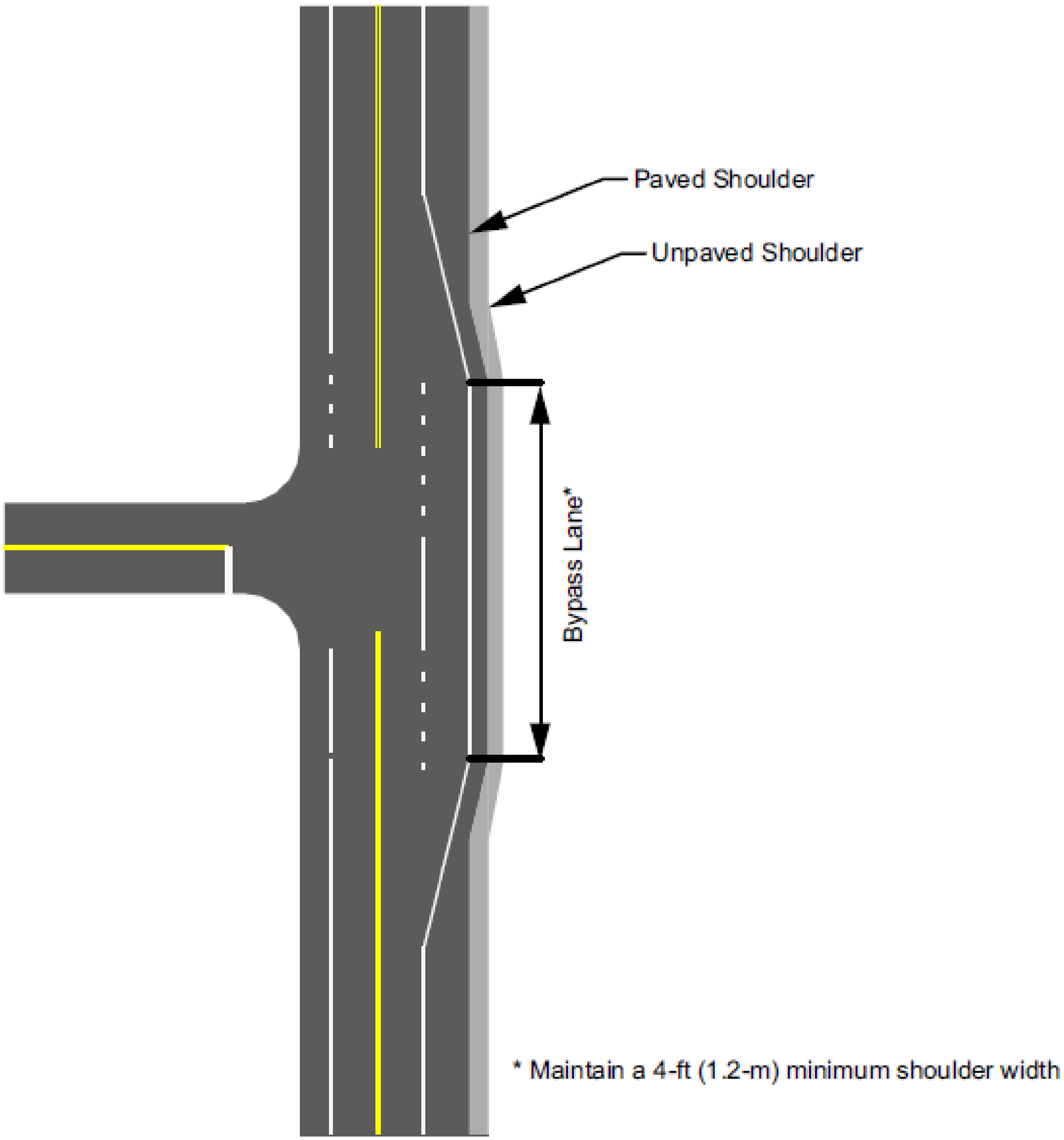
PAVED SHOULDERS AT INTERSECTIONS

- Paved shoulders typically stay to right of right turn lane
- To avoid conflicts with right turn lanes, bike lanes may be added at intersections to serve through-cyclists

PAVED SHOULDERS AT INTERSECTIONS

PAVED SHOULDERS AT INTERSECTIONS

- 4 - foot minimum shoulder width at shoulder "bypass lanes"



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AASHTO THE VOICE OF TRANSPORTATION

PAVED SHOULDER CLIMBING LANES

- Constrained roadways
- Steep grades
  - Ok to offset shoulder to one side to provide climbing lane

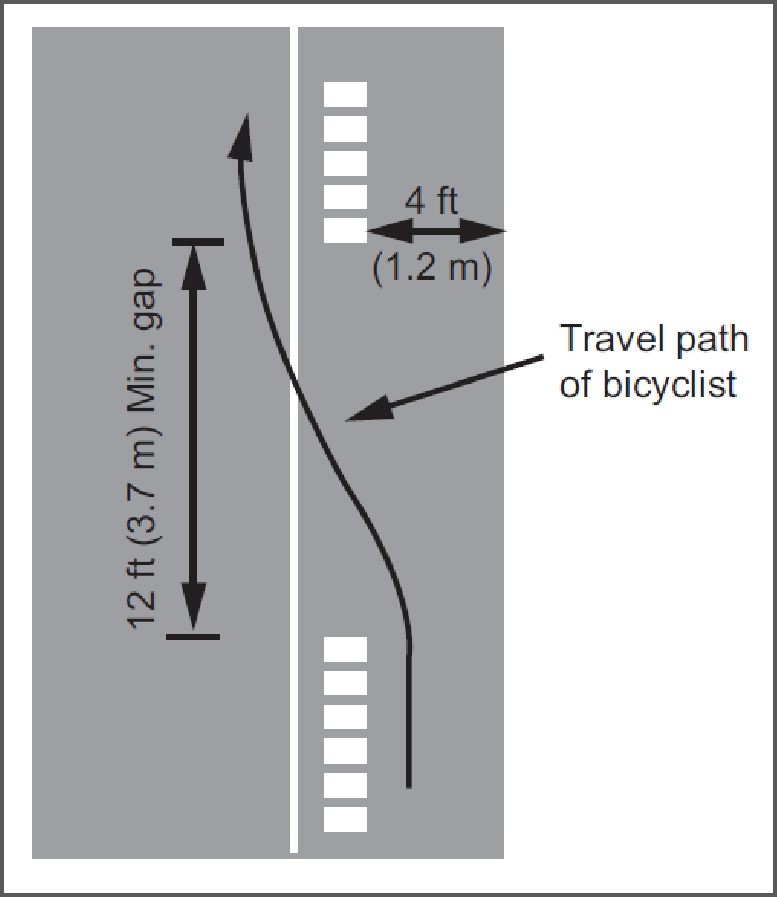
PAVED SHOULDER SPOT WIDENING

- Constrained roadways
- Spot widening can improve safety:
  - on inside of horizontal curves
  - over crest of steep vertical curves

Source: http://vermonthills.wordpress.com/

RUMBLE STRIPS

- Maintain a 4-foot minimum clear path width with no curb present; 5-foot with curb
- Use gaps to allow cyclists to move across rumble strips as needed
- Centerline rumble strips may lead motorists to shy away from the centerline and move closer to bicyclists



MARKED SHARED LANES
(SLM, SHARROWS)

- Shared Lane Marking applications:
  - Adjacent to parking to position cyclist outside of door zone
  - In wide lanes to position away from curb
  - Middle of narrow lanes
  - Multi-lane roads with no room for bike lanes

MARKED SHARED LANES

- Not appropriate on paved shoulders or bike lanes
- May not be appropriate on roadways with speed limits over 35mph
- Have not been studied to determine if they improve BLOS

SHARED LANE MARKINGS

- Indicate "practical path of travel under typical conditions" to guide positioning of cyclist on roadway

Minimum Distance From Curb to Center of Symbol	
With On-Street Parking	**11 feet from curb**
With No Parking	**4 feet from curb**
With No Room For Side-by-Side Operation	**Centered in lane**

Place immediately after intersections, not more than 250 feet apart

MARKED SHARED LANES ADJACENT TO PARKING

- Minimum of 11 feet to curbface
- Consider moving further left into lane where:
  - Travel lanes <14 feet
  - Steep grades where bike speeds are higher
  - Parking turnover is high or dooring is major concern

CLIMBING LANES

Marked shared lane downhill

Bike lane uphill

If bike speeds are high it may be appropriate to not mark bike lane downhill

CLIMBING LANES

Bike Lane

Bike Lane

SHARED LANE AND BICYCLE LANE

SHARED LANE MARKINGS TO GUIDE

SLM

SHARED LANE MARKINGS DURING CONSTRUCTION

SHARED LANE MARKING IN RT TURN LANE

BRIDGES, VIADUCTS, AND TUNNELS

- All should accommodate bicycles unless the roadway prohibits bicycle travel
  - True even if approach roadway does not accommodate bikes

BRIDGES, VIADUCTS, AND TUNNELS

- On long, (1/2 mile) bridges consider providing a shared-use path on each side separated by concrete barriers

BRIDGES, VIADUCTS, AND TUNNELS

- Limited access freeways may need to provide limited "appropriate access" to the bridge, viaduct or tunnel

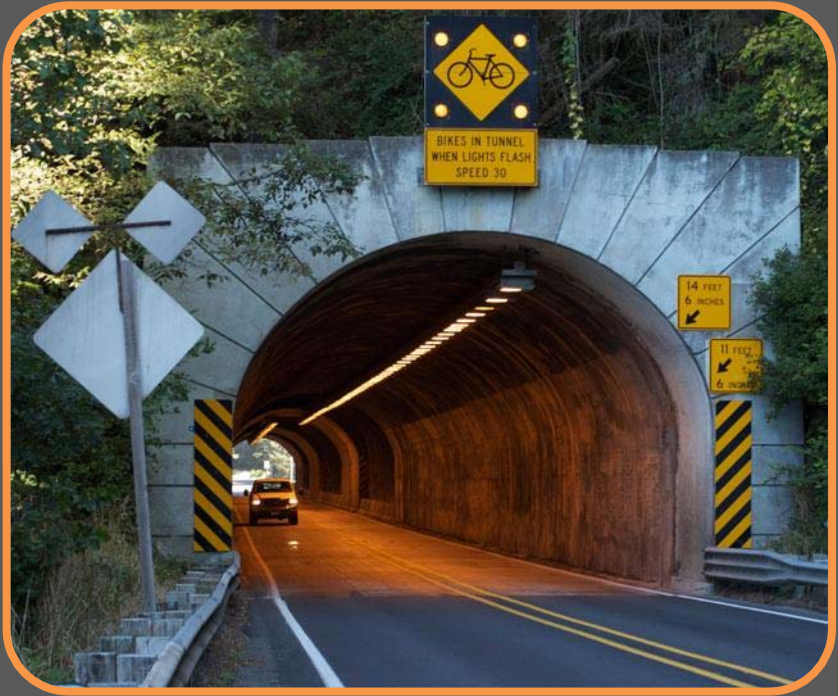
BRIDGES, VIADUCTS, AND TUNNELS

BRIDGE, VIADUCT, AND TUNNEL RETROFITS

- Widened sidewalks
- Widened shoulders
- Grating fill or replacement
- Shared lane markings on roadway with signs

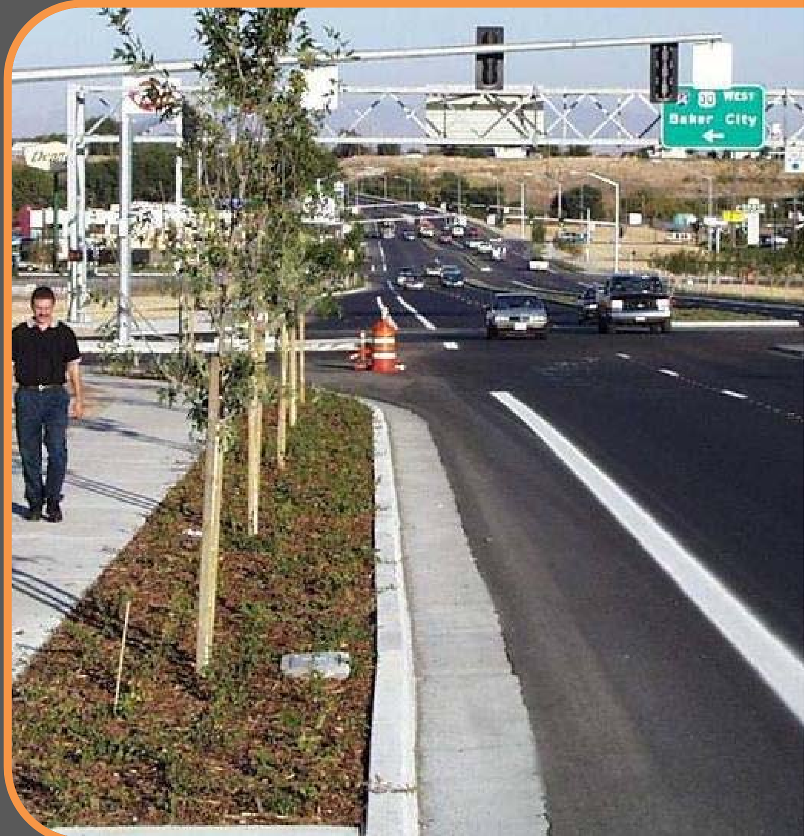
BRIDGE, VIADUCT, AND TUNNEL RETROFITS

- Markings
- Activated warning sign and beacons
- Adequate lighting



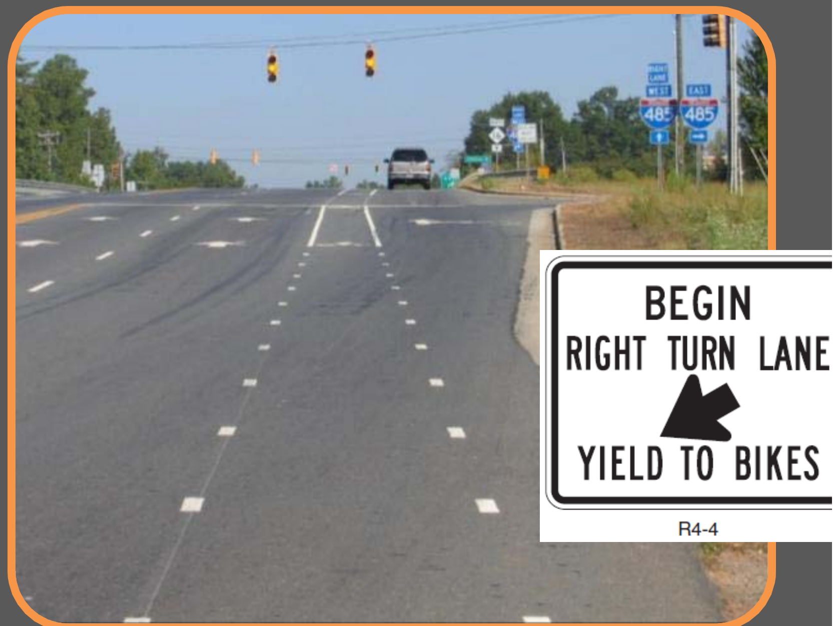
BICYCLE TRAVEL ON FREEWAYS

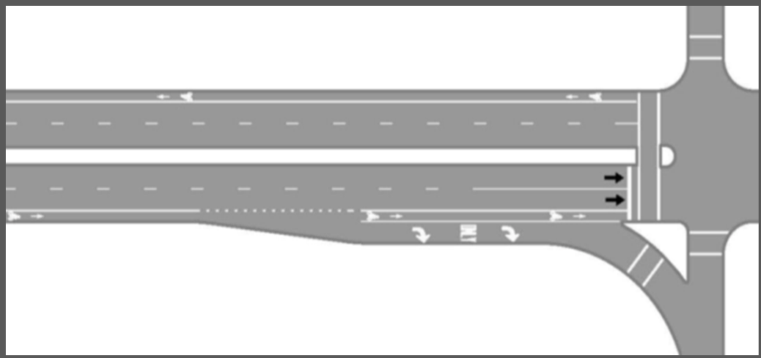
- Urban/Suburban Area Design Principles:
  - use Bicycle LOS to determine appropriate width
  - Ensure motorists and bicyclists are aware of conflict area
  - Provide continuous facility on both sides



BICYCLE TRAVEL AT RAMPS/INTERCHANGES

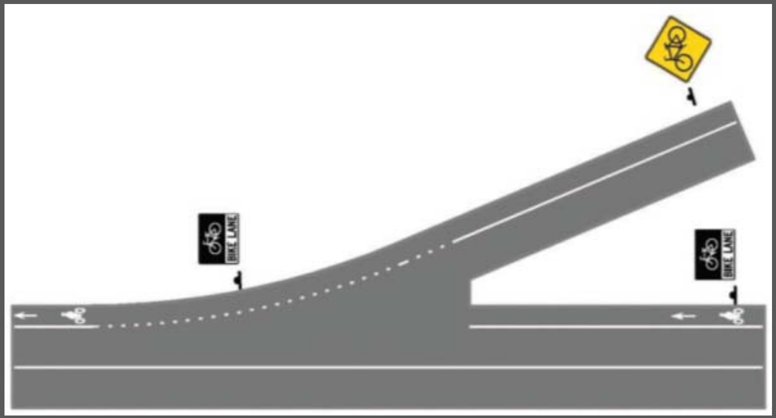
- Provide bike lanes or paved shoulder on both sides
- Create obvious and logical travel path for bicyclists
- Encourage motorists to slow or require them to stop
  - Create right-turn lane for entrances
  - Design junctions as right angles or roundabouts
- Avoid high speed merge designs





MERGING RAMPS

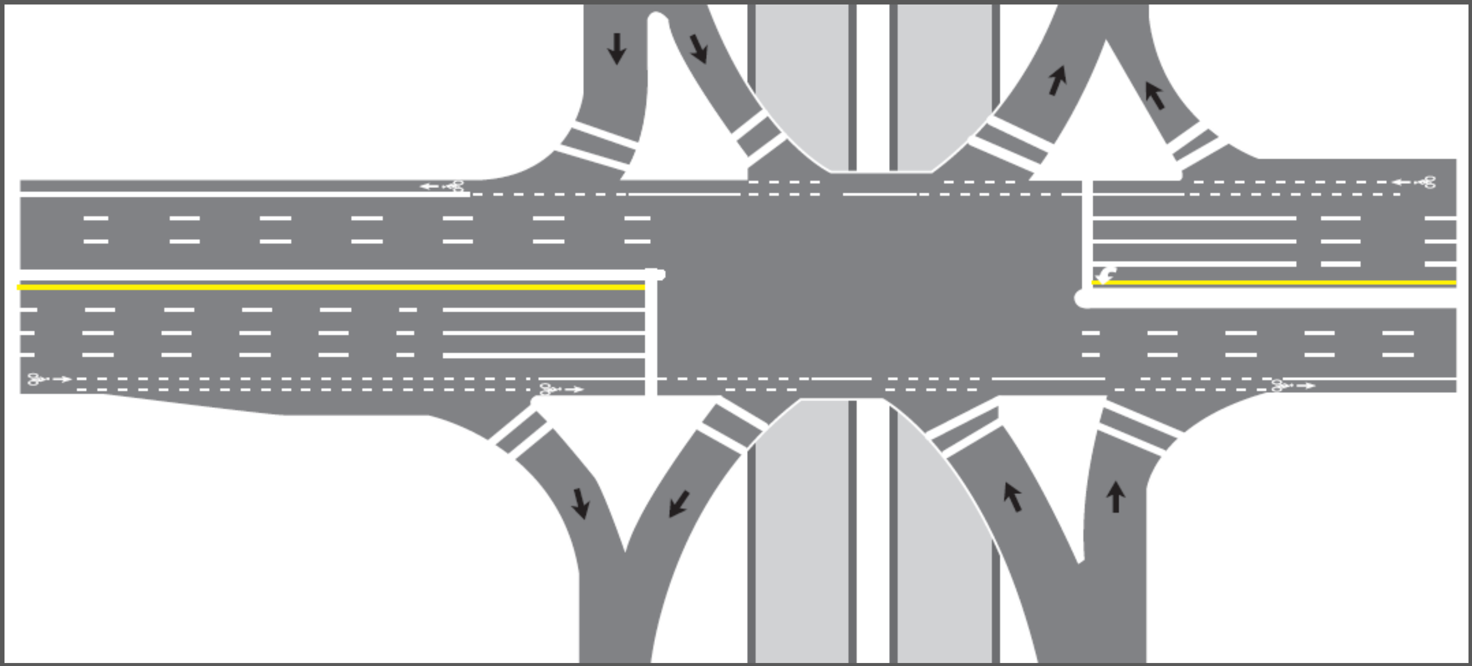
- Option 1 – allow bicyclists to choose their own merge



- Option 2 – Direct bicyclists to cross where crossing distance is short and drivers' attention is focused

SINGLE-POINT DIAMOND INTERCHANGE

- Check traffic signal timing for bikes
- Create separate right turn lanes for entrances
- Tight right turn geometry for exits/merges



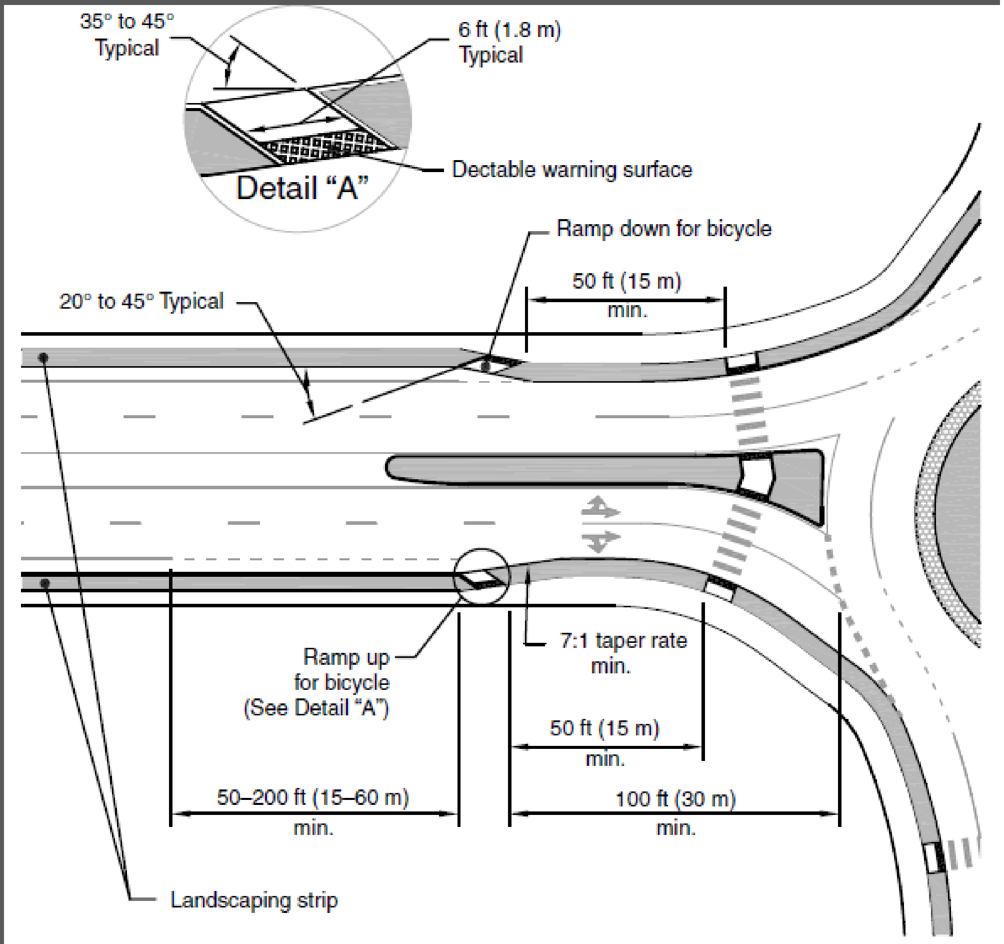
BICYCLES AT ROUNDABOUTS

- Crash reduction benefits for bicyclists if designed for slow speed
  - Single-lane are preferred
  - Design to widen to two lanes for "future traffic" if it comes
- Bicyclists should "take the lane" or use ramps to access the sidewalk

Source: Steven Vance, Flickr

BICYCLES AT ROUNDABOUTS

- *Taking the Lane*
  - End bike lane 100' in advance of edge of circulatory roadway
  - Use 7:1 taper (for 20 mph speed) to narrow the roadway
  - Dash bike lane for 50-200'
  - Add shared lane markings
  - Resume bike lane as soon as width is available



BICYCLES AT ROUNDABOUTS

- *Using the Sidewalk*
  - Used for multi-lane, high speed, and complex roundabouts
  - Provide wide sidewalks to function as shared-use path
    - Consider separate bicycle only path parallel to sidewalk
  - Provide ramp minimum of 50' prior to crosswalk
    - Angle (35-45 deg), steeper slope, and placement to reduce confusion to vision impaired pedestrians
  - Detectable warnings should be placed on the ramps
    - At top (sidewalk side) of ramp if buffer is present
    - At bottom of ramp (roadway side) if no buffer is present

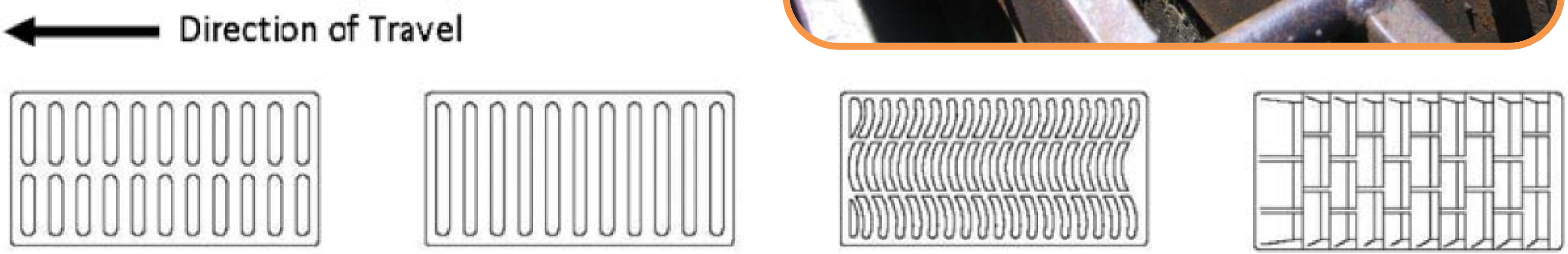
RAILROAD GRADE CROSSINGS

- Crossing angle
  - 60-90 degree angle
- Crossing surface
  - Smooth
  - Concrete is best
- Bikeway Width
  - 6' minimum
- Minimize flange opening

RAILROAD GRADE CROSSINGS

DRAINAGE GRATES AND UTILITY COVERS

- Small openings perpendicular to curb
- Existing grates can be modified by welding metal straps at 4" spacing
- Flush with pavement

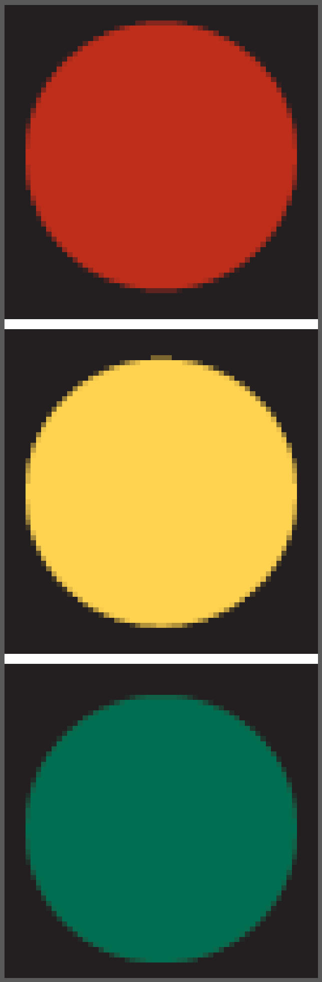


DRAINAGE CONSIDERATIONS WITH SHOULDERS

- Useable width of 4 feet is recommended
- Drainage grates
  - Reduce effective width of shoulder/bike lane
  - Use bicycle compatible grates
- Widen shoulder or relocate grate if the clear shoulder operating space falls below 4 feet

TRAFFIC SIGNALS

- Significantly expanded guidance
- Minimum green time & yellow change interval – similar guidance
- Red clearance interval & green extension time – updated guidance
- Additional information on detection
- Some guidance on signals for the exclusive use of bicyclists



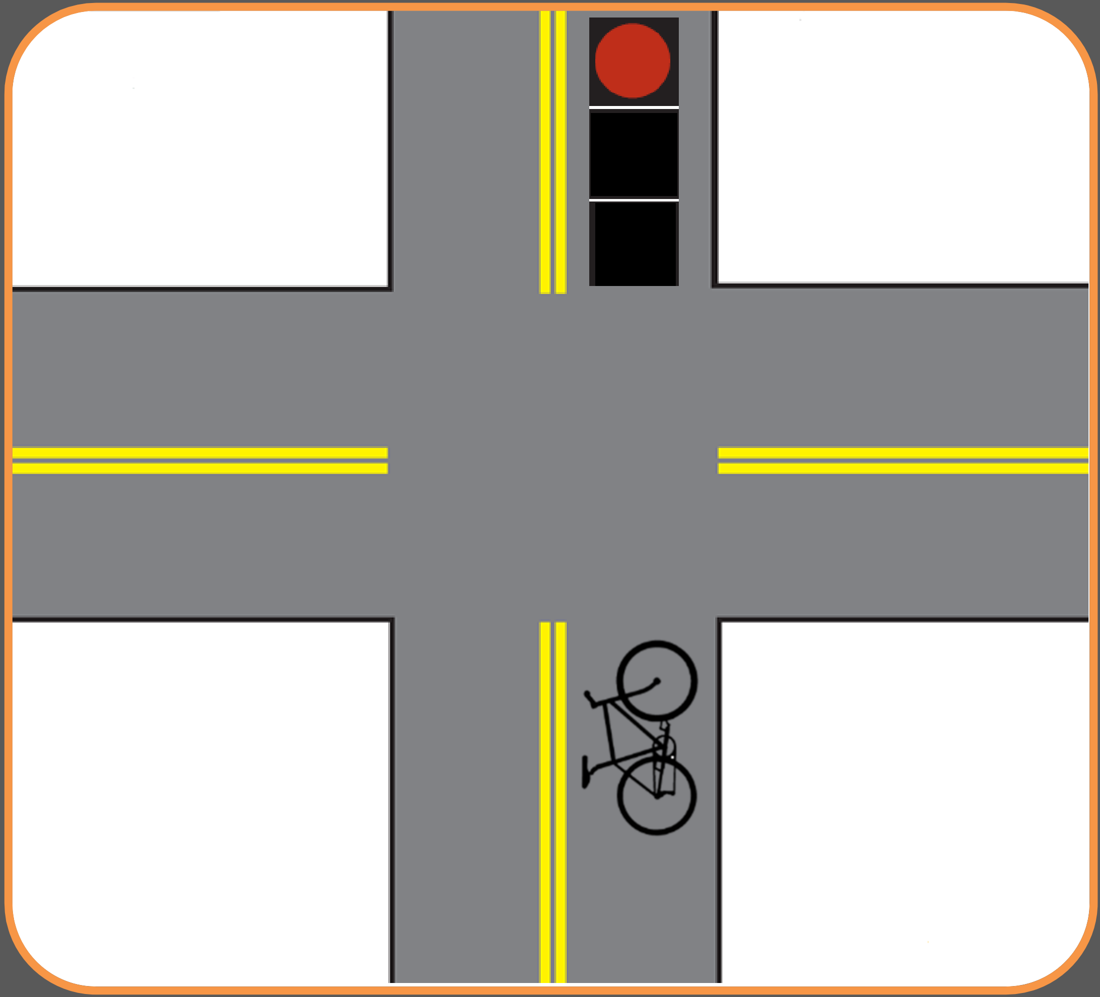
OPERATING CHARACTERISTICS

Speed: 25-55 mph
Deceleration: 10 ft/s^2
Perception-Reaction Time: 1 s

Speed: 10 mph
Deceleration: 5 ft/s^2
Perception-Reaction Time: 1 s

STANDING BICYCLE SCENARIO

- Used to determine:
  - Bicycle Minimum Green



STANDING BICYCLE CROSSING TIME

U.S. Customary

$$BCT_{standing} = PRT + \frac{V}{2a} + \frac{(W+L)}{V}$$

where:

$BCT_{standing}$	=	bicycle crossing time (s)
W	=	intersection width (ft)
L	=	typical bicycle length = 6 ft (see Chapter 3 for other design users)
V	=	attained bicycle crossing speed (ft/s)
PRT	=	perception reaction time = 1s
a	=	bicycle acceleration (1.5 ft/s²)

Standing bicycle crossing time ($BCT_{standing}$) =

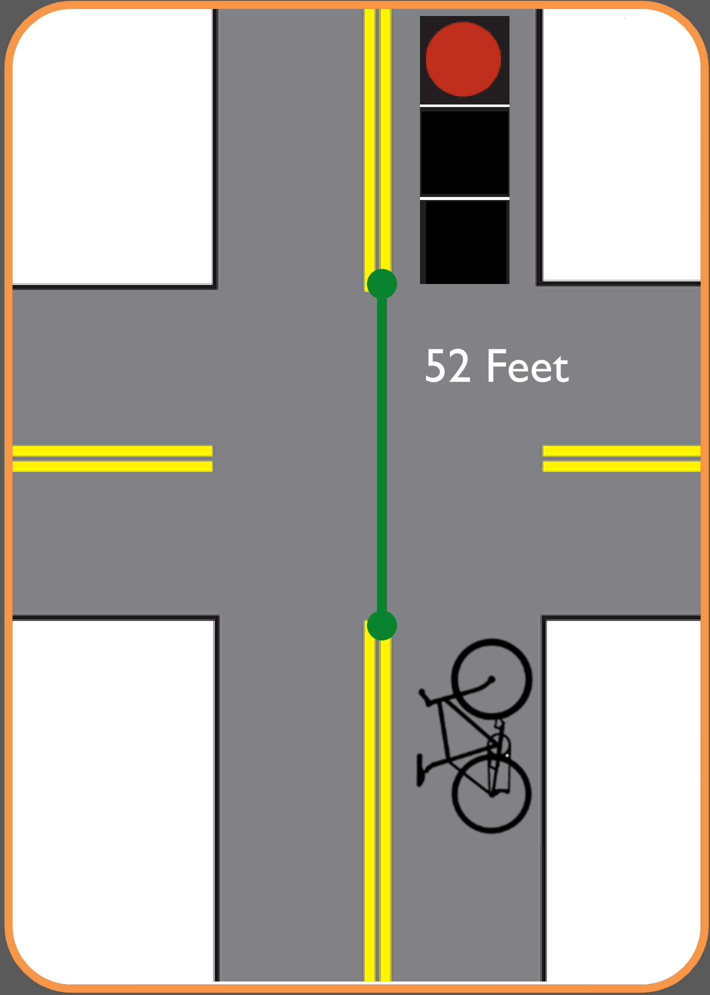
Bicycle minimum green

+ Yellow change interval

+ Red clearance interval

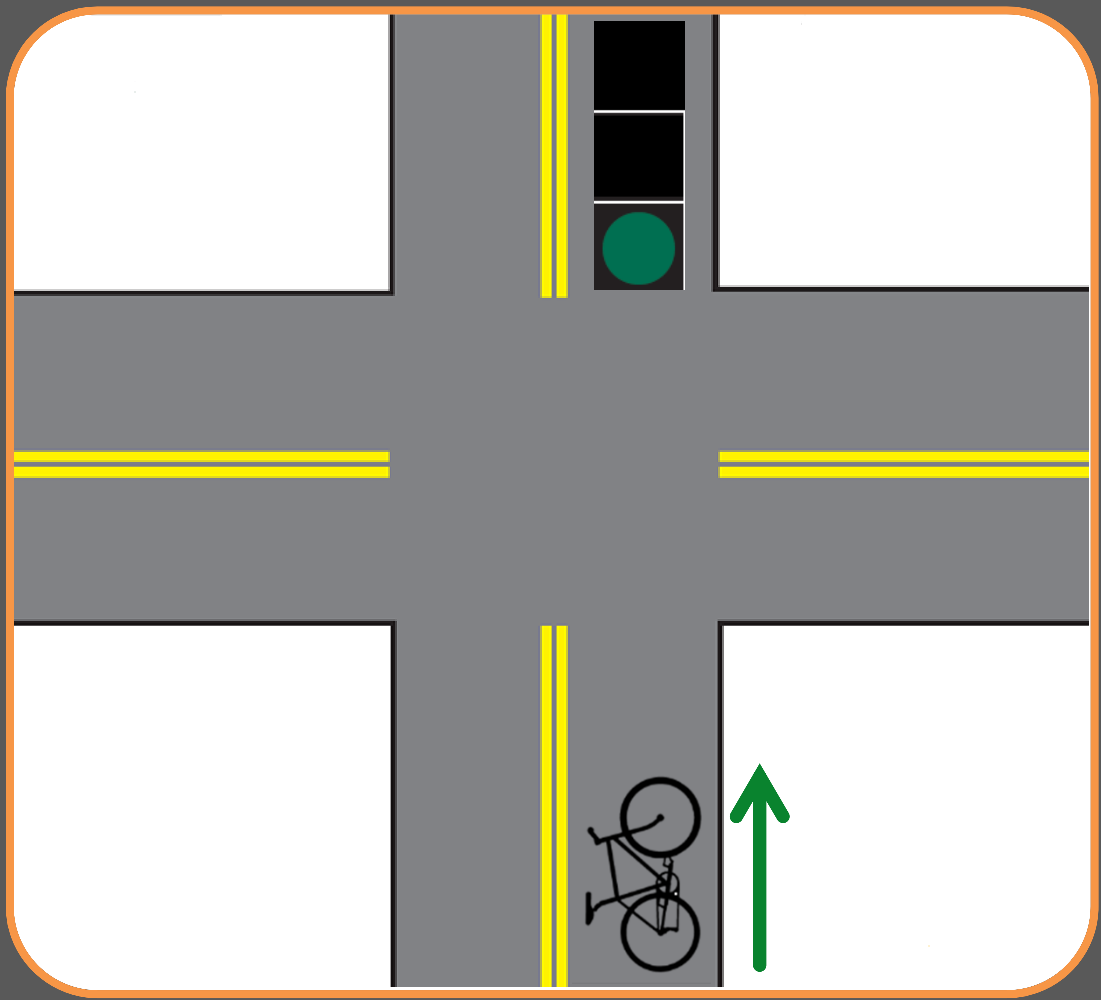
EXAMPLE: STANDING BICYCLE CROSSING TIME & MINIMUM GREEN

- *Crossing Distance:*
  52 feet
- *Standing Bicycle Crossing Time:*
  9.8 sec
- *Yellow & Red:*
  4.0 sec
- *Bicycle Minimum Green Time:*
  5.8 sec



ROLLING BICYCLIST SCENARIO

- Used to determine:
  - Red Time
  - Green Extension Time (if needed)



ROLLING BICYCLE CROSSING TIME

U.S. Customary

$$BCT_{rolling} = \frac{BD + W + L}{V}$$

$$BD = PRT \times V + \frac{V^2}{2a}$$

where:

$BCT_{rolling}$	=	bicycle crossing time (s)
W	=	intersection width (ft)
L	=	typical bicycle length = 6 ft (see Chapter 3 for other design users)
V	=	bicycle speed crossing an intersection (ft/s)
BD	=	breaking distance (ft)
PRT	=	perception reaction time = 1s
a	=	deceleration rate for wet pavement = 5 ft/s^2

Rolling bicycle crossing time ($BCT_{rolling}$) =

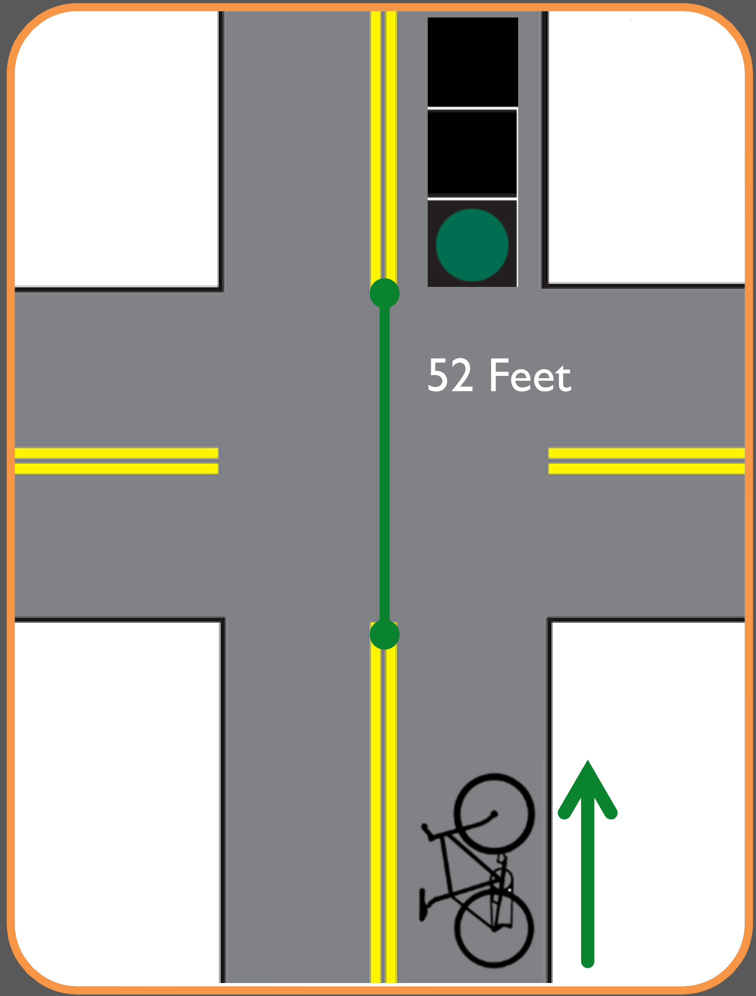
Green extension time

+ Yellow change interval

+ Red clearance interval

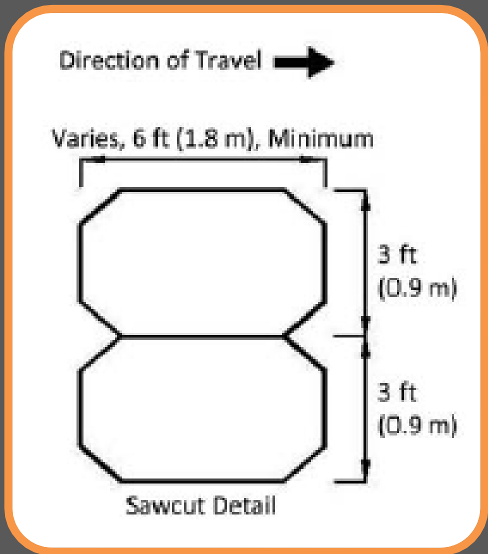
EXAMPLE: ROLLING BICYCLE CROSSING TIME & GREEN EXTENSION/RED TIME

- *Crossing Distance:*
  52 feet
- *Rolling Bicycle Crossing Time:*
  6.4 sec
- *Yellow & Red:*
  4.0 sec
- *Additional Extension/Red Time:*
  2.4 sec

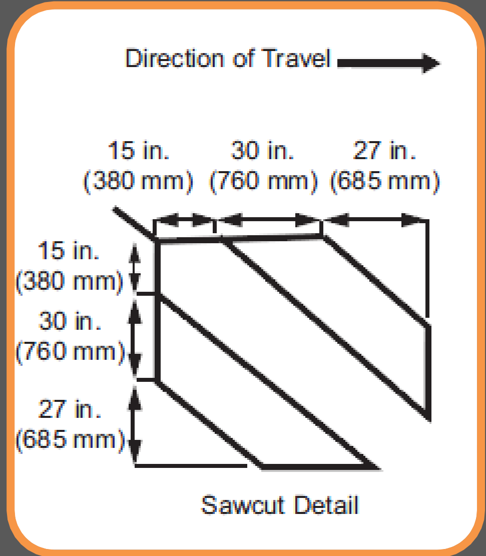


LOOP DETECTORS

Pavement Markings & Signing for Loop Detectors



Conventional Quadrupole Loop



Diagonal Quadrupole Loop

OTHER DETECTION SYSTEMS

- Video detection
- Microwave (radar) detection
- Magnetometer detection
- Bicycle Pushbuttons

BIKE SIGNALS

- Mentions instances where a separate bicycle signal may be appropriate
  - Contra-flow movement
  - Separate phasing
- Designating a "Bicycle Signal" okay with sign posting

BICYCLE BOULEVARD

- Mix and match design elements to:
  - Prioritize bicycle through travel
  - Create comfortable and safe intersection crossings
  - Reduce cyclist delay
  - Reduce or maintain low motor vehicle volumes/volumes
  - Create a logical, direct, and continuous route
  - Create access to desired destinations

BICYCLE BOULEVARDS

Consider Impact of Term

- “bicycle preferred streets”
- “bicycle friendly streets”
- “bike/walk streets”
- “slow streets”
- “neighborhood greenways”
- “neighborways”

BICYCLES AND TRAFFIC CALMING

- Bicycle should be the "design vehicle"
- If traffic calming features work well for bicycles, they should achieve other stated goals

NARROW (VERY SLOW SPEED) STREETS

- "Queuing streets"
  - 26-28 feet with parking on both sides
  - 20 feet with parking on one side
- Positive effect on bicycling if operating speeds are reduced to 15-25mph

VERTICAL DEFLECTIONS

- Speed humps, speed tables, speed cushions, raised intersections, and raised crosswalks
- Avoid speed bumps
- Positive effect on bicycling

  if smooth transition provided

CURB EXTENSIONS

- Chokers, Neckdowns, Bulbouts
- Should not extend beyond parking lane
- Should be highly visible
- Positive effect on bicycling if they are highly visible

CHICANES

- Design goal:
  - Don't squeeze bicyclists
  - Maintain adequate sight lines
- Generally neutral effect on bicycling

Source: Scott Batson

MINI TRAFFIC CIRCLES

- Typically 12-16 feet in diameter
- Add deflection to travel lane
- Reduce long vistas
- Preferable to stop signs
- Positive effect on bicycling

MULTI-WAY STOPS

- Not a recommended traffic management technique:
  - slow traffic excessively
  - encourage drivers to accelerate to higher speeds
  - increase noise and air pollution
  - may increase crashes
- Often ignored
- Negative effect on bicycling

DIVERTERS AND CUL-DE-SACS

- May contradict other transportation goals such as an open grid system
- Provide pedestrian and bicy
- Positive effect if access to ne provided; Negative effect if n

BICYCLE GUIDE SIGNS/WAYFINDING

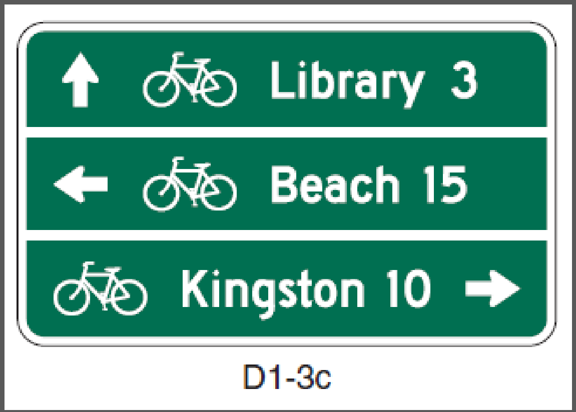
Used to:

- Provide wayfinding guidance
  - Designate a system of routes
  - Designate a continuous or preferred route
  - Provide location specific guidance

They are NOT a bike facility

BICYCLE GUIDE SIGNS/WAYFINDING

- D11-1 signs – preference is to replace "BIKE ROUTE" with a destination or route name
  - use to confirm route beyond intersections
- D-1 signs with arrows and mileage can simplify signing
  - use at intersections



D1-3c

D11-1/D1-3

BICYCLE GUIDE SIGNS/WAYFINDING

- M1-8/M1-8a signs are better for longer routes accompanied by a map

- M1-9 signs are only for AASHTO-approved U.S. Bicycle Routes

M1-8

M1-9

FUTURE WEBINARS

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THANK YOU!

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Questions?

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