





Bicycle Facility Design

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January 2007 edition (expanded)

What Is a "Bicycle Facility"?





-  Bicycle Facility: Improvements and provisions to accommodate or encourage bicycling
-  Any roadway not specifically prohibited to cycling is a bicycle facility

However...



-  Not all existing roadways necessarily make good bicycle facilities
-  How can we improve conditions for bicyclists?

Operating Characteristics


-  Bicyclists are not pedestrians
-  Bicycles cannot turn instantly - turning radius is based on speed
-  Bicycles are only 2 feet wide - but require 4 to 6 feet of clear width (for "shy distance")
-  Bicycles cannot stop instantly - stopping distance is based on speed

Bicyclist Characteristics




 Skilled Cyclists

 Basic Cyclists

 Child Cyclists

 When accommodating less skilled cyclists, do not make conditions more difficult for skilled cyclists

Where are real dangers?

- 
-  Motor vehicle/bicycle crashes can have high severity
 - ...but comprise less than 1/3 of all bike crashes
 -  Facilities that are perceived to be safer can actually increase overall crash risks for cyclists

FHWA Crash Studies



Injuries to Pedestrians & Bicyclists: An Analysis Based on Hospital Emergency Department Data

<http://www.tfhrc.gov/safety/pedbike/research/99078/contents.htm>

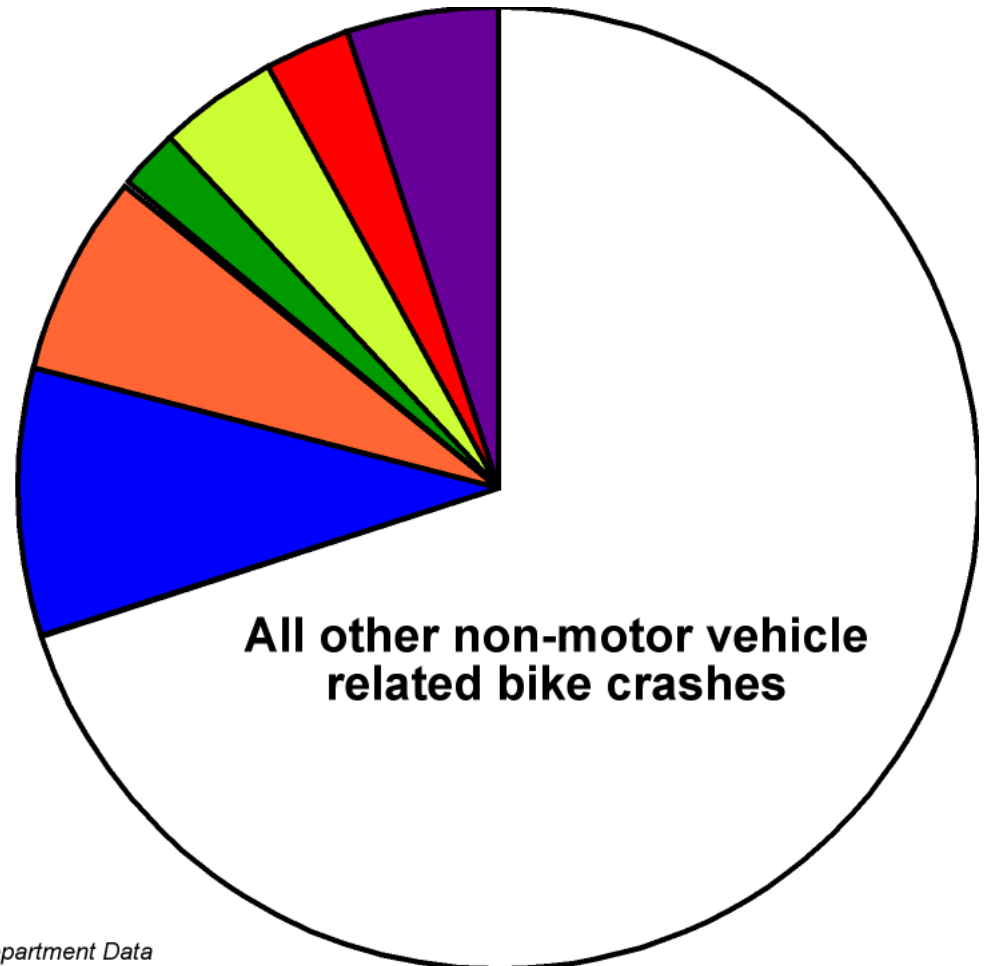


Bicycle Crash Types: A 1990's Informational Guide




http://www.bicyclinginfo.org/rd/pdf/Pr1_Doc5.pdf

Bicycle Crash Types

- All non-MV related bike crashes - 69%
- Bicyclist failed to yield - 9%
- Motorist failed to yield - 7%
- Bicyclist turn/merge into motorist - 2%
- Motorist turn/merge into bicyclist - 4%
- Motorist overtaking bicyclist - 3%
- Other circumstances - 6%





Non-Roadway Crashes

-  Almost 2/3 of non-roadway bicycle-motor vehicle collisions occurred on sidewalks
 -  typically at driveway & parking lot entrances/exits
-  Most remaining non-roadway bicycle-motor vehicle collisions occurred in parking lots





Non-Motor-Vehicle Crashes



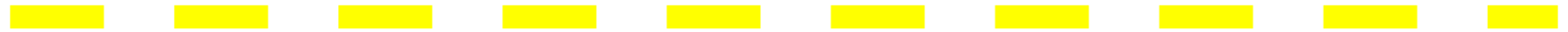
-  31% of injury crashes happened in non-roadway locations
-  55% of on-road bicyclist injuries did not involve a motor vehicle

Non-Motor-Vehicle Crashes



-  Half of bicycle-only non-roadway crashes occurred on sidewalks
-  1/4 on trails or paths
-  2/3 of bicycle-bicycle collisions occurred on the roadway
 -  most of the remainder on trails/sidewalks

Non-Motor-Vehicle Crashes







Bicycle-Pedestrian Crashes:

 40% on roadway

 60% on sidewalks




Good Bicycle Facility Design:



-  Treats bicyclists as operators of vehicles
-  Encourages operation in accordance with traffic flow and traffic law
-  Connects destinations in a continuous network
-  Accommodates cyclists without inconvenience or extra travel distance/time




Good Bicycle Facility Design

DOES NOT:

-  Treat bicyclists like "wheeled pedestrians"
-  Require bicyclists to operate in an unpredictable, unexpected, or unsafe manner
-  Encourage bicyclists to violate traffic laws

Design References



-  AASHTO Guide to Development of Bicycle Facilities
-  Manual on Uniform Traffic Control Devices (MUTCD), Part 9
-  Other References

guide for the development of bicycle facilities









american association
of state highway and
transportation officials

1999



AASHTO Guide

- 
-  Considered the "definitive" US guideline
 -  Consensus-based development process
 -  Only includes accepted best practices
 -  Consistent with MUTCD
 -  Thoroughly reviewed by several AASHTO subcommittees

AASHTO Guide



 Most recent edition: 1999

 Sections on:

- Planning
- Design
- Operation

AASHTO Guide Update



 NCHRP Project 15-37







 Contractor will develop content

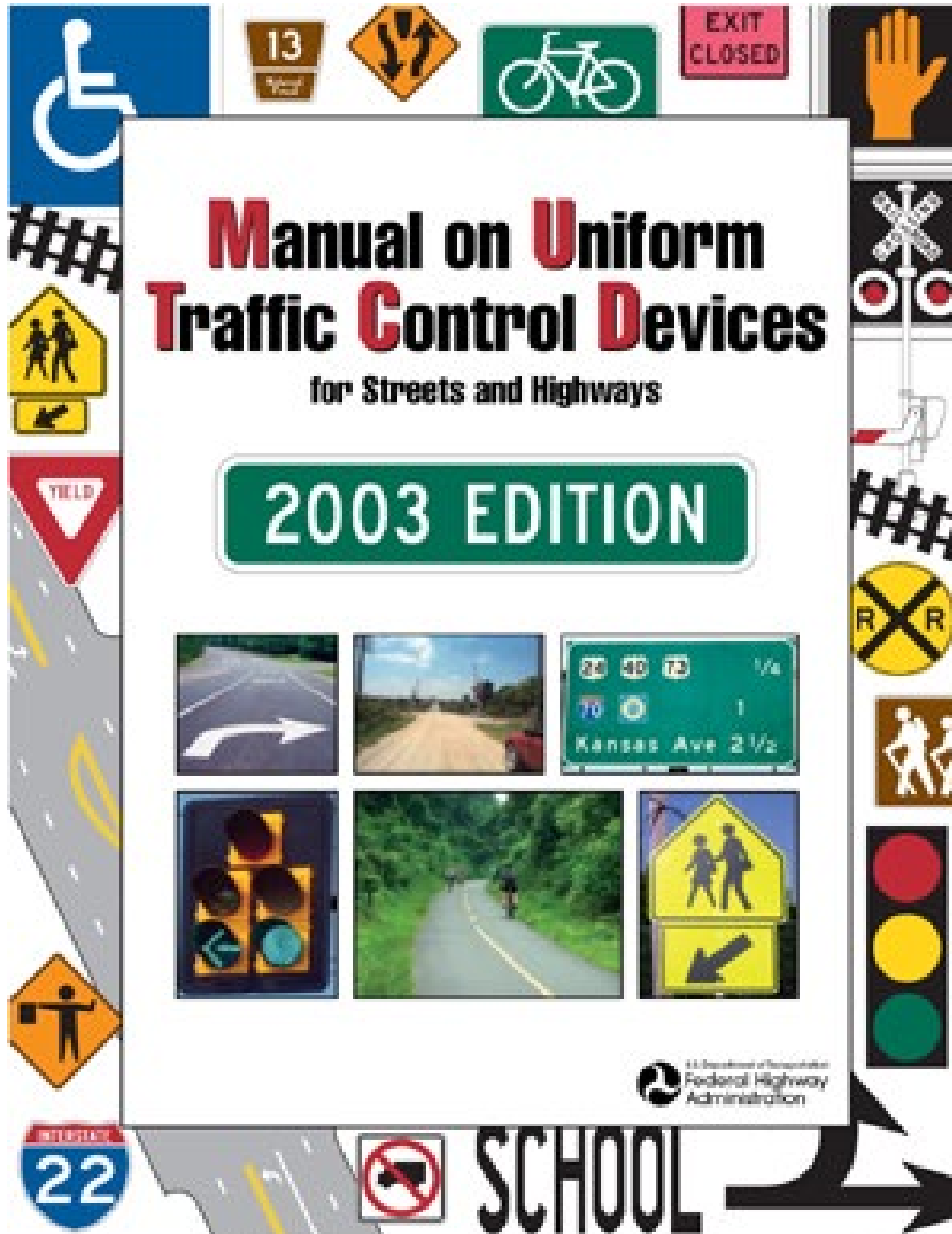
 Based on:

 Changes & improvements in current accepted practice

 New & ongoing research

AASHTO Guide Update

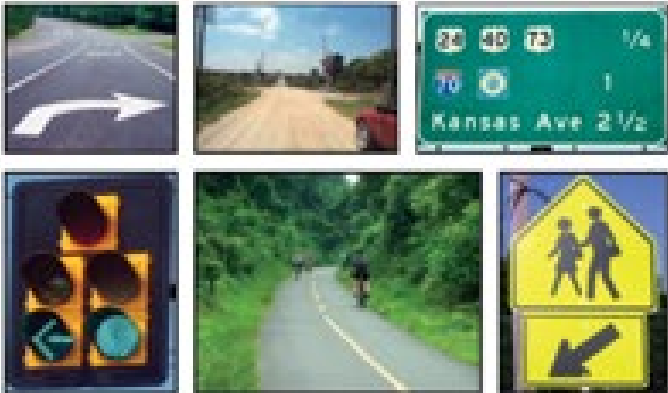
-  Panel will review content & progress
-  AASHTO committees will review & vote on draft final document
 -  Geometric Design
 -  Traffic Engineering
 -  Non-Motorized Transportation
-  Approval by AASHTO after (successful) balloting sometime in 2009-2010



Manual on Uniform Traffic Control Devices

for Streets and Highways

2003 EDITION



U.S. Department of Transportation
Federal Highway
Administration

SCHOOL

MUTCD

Manual on **U**niform **T**raffic **C**ontrol **D**eveloped

 Applies to all public roads in US

 Defines standards & guidelines for:

 Signs

 Markings

 Traffic signals

 Work zones & other temporary controls

 Railroad crossings

Manual on Uniform Traffic Control Devices

 Ensures similar situations are treated in similar manner for all road users

 Improves traffic flow

 Improves safety

 No "surprises"!

 MUTCD defines uniformity of

 Color

 Shape

 Legend

 Placement



Parts of MUTCD



- 1 - General
- 2 - Signs
- 3 - Markings
- 4 - Traffic Signals
- 5 - Low Volume Roads
- 6 - Temporary Traffic Control
- 7 - School Areas
- 8 - Railroad Crossings
- 9 - Bicycle Facilities
- 10 - Light Rail

MUTCD Part 9 - Bicycle Facilities



 Section that deals specifically with bicyclists

...although the rest of the MUTCD still applies to bicycle traffic as well

 Covers:

 Shared roadways & bike routes

 Bike lanes

 Shared-use paths

MUTCD Experimental Process

 Outlined in MUTCD Section 1A.10

 FHWA approval required for:

- New symbols or combination of symbols

- New colors or application of colors

- Non-compliant devices







 Advantages of FHWA oversight:

- Protection from liability

- More likely for FHWA to accept results





- Expert review / oversight

MUTCD Update Process

-  5 year cycle (approximately)
-  Proposed changes published in Federal Register and on MUTCD website
-  6 month public comment period
-  FHWA collects, reviews, & analyzes comments (12-18 months)
-  Final Rule published in Federal Register
-  States have 2 years to adopt




Next MUTCD



-  All content to FHWA by February 2007
-  Draft MUTCD out for review in late summer or fall 2007
-  Public comment for 6 months (fall 2007 - spring 2008)
-  Next edition published sometime in **2009**

NCUTCD

National **C**ommittee on **U**niform **T**raffic **C**ontrol **D**eVICES

-  Nonprofit corporation
-  Provides expert input to FHWA on MUTCD
-  Nearly 300 technical members from across US

<http://www.ncutcd.org/>

NCUTCD



39 voting members from 21 sponsoring organizations

American Association of State Highway & Transportation Officials (8 seats)

Institute of Transportation Engineers (8 seats)

National Association of County Engineers (3 seats)

American Public Works Association (3 seats)

Advocates for Highway & Auto Safety

American Automobile Association

American Association of Motor Vehicle Administrators

American Highway Users Alliance

American Public Transportation Association

American Railway Engineering & Maintenance of Way Association

American Road & Transportation Builders Association

American Traffic Safety Services Association

Association of American Railroads

Human Factors Resources

International Association of Chiefs of Police

International Bridge, Tunnel, and Turnpike Association

International Municipal Signal Association








League of American Bicyclists

National Association of Governors' State Highway Representatives








National Committee on Uniform Traffic Laws & Ordinances

National Safety Council

NCUTCD Technical Committees

-  Regulatory & Warning Signs (RWSTC)
-  Guide & Motorist Information Signs (GMITC)
-  Markings (MTC)
-  Signals (STC)
-  Temporary Traffic Control (TTC)
-  Railroad & Light Rail Crossings (RRLRTC)
-  **Bicycle (BTC)**

NCUTCD Process

- 
-  Technical Committees develop proposed devices & application language
 -  Sponsor organizations review proposals & provide comments & input
 -  Committees revise proposals based on input
 -  Council votes on revised proposal
 -  If approved, proposal is forwarded to FHWA
 -  FHWA then includes proposed device in next MUTCD (usually...)

NCUTCD-Recommended Items For Next MUTCD

 Signs for skaters and equestrians on paths



 Signing improvements for multi-state bicycle routes




 M1-8a Numbered Bicycle Route Sign with logo




 Revision of W5-4a Sign



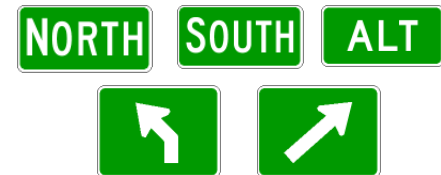
NCUTCD-Recommended Items For Next MUTCD

 Reference Location Signs
(mileposts) for paths



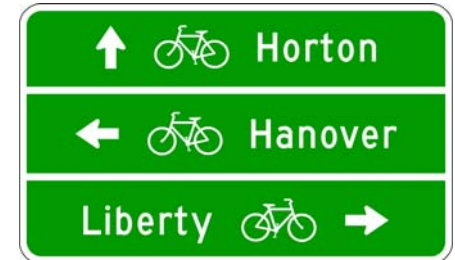
 Revision of use of Bike Lane
signs (no longer mandatory)

 New Route Marker Auxiliaries
for bicycle facilities



NCUTCD-Recommended Items For Next MUTCD

 Bicycle-specific direction & distance signing



 Sign height & offset changes for paths

 Shared Lane Marking



Other Design References

<http://www.bicyclinginfo.org>



"Official" site for FHWA bicycle info



Quality of information varies widely

- Some recommendations are inconsistent with established standards & guidelines found in MUTCD & AASHTO Guide
- Some design recommendations have not been fully tested or evaluated

Other Design References



ITE publications:

Traffic Control Devices Handbook

Traffic Engineering Handbook

~~Innovative Bicycle Treatments~~



TRB publications:

Transportation Research Record

State-Specific Guidelines

Critiques & Evaluations

<http://www.bikexpert.com>

-  Looks at reports & facilities from an experienced point of view
-  Not afraid to go after a few "sacred cows"

Facility Types




Two basic categories:

 **On-roadway**

 **Off-roadway**

On-Roadway Facilities




 Travel Lanes (narrow or wide)

 Shoulders

 Bike Lanes

 Bicycle Boulevards

 Sidewalks should never be considered to be an acceptable alternative to on-roadway accommodations

Off-Roadway Facilities



Pathways

Typically improved & paved facilities

Trails

Typically unimproved & unpaved

Facility Selection Factors

 Expected user types

 Expected user volumes

 Traffic Generators

 Barriers & impediments

Busy streets / highways / freeways

Rivers / canals

Mountains, canyons, other topography

Facility Selection Factors



Available corridors

Railroads (active or abandoned)

Utility corridors (power lines, pipelines)

Rivers/canals

Roads & streets (for on-street facilities)




Built environment & landscape may limit or dictate options



Politics shouldn't - but sometimes does

On-Roadway Facilities



 Travel Lanes (narrow or wide)



 Shoulders

 Bike Lanes






 Bicycle Boulevards

On-Road - For All Users?






-  Some less confident bicyclists may not feel comfortable riding on roadways
 - May prefer sidewalks or parallel paths
 - ...especially on higher-volume streets
-  However, studies indicate on-street facilities are safer overall than sidewalks or parallel pathways
 - Applies to all user types

Shared Travel Lanes

- 
-  Simplest, cheapest option
 -  Treats cyclists like other road users
 -  Serves greatest number of destinations
 -  Under higher speed & higher volume conditions, less confident cyclists may be reluctant to use the lane, and may instead use the sidewalk

Narrow (Non-Shareable) Lanes



-  Lanes less than 13-14 ft wide typically do not allow for side-by-side operation in the same travel lane
-  Faster traffic must wait until safe overtaking opportunities exist
-  Opposing traffic, sight distance constraints, and no-passing markings can complicate matters

Narrow Lanes



 Narrow travel lanes can still accommodate bicyclists in many situations, *depending on conditions*

 Examples:




Low-volume urban streets

Higher-volume but low-speed streets

Low-volume rural roads



Wide (Shareable) Lanes



-  Typically 14-16 ft wide from lane line to face of curb
-  Allows more convenient overtaking by faster traffic
-  More 'comfortable' for many bicyclists





Wide (Shareable) Lanes



-  Eliminate channelization problems at intersections (such as inherent in bike lanes or shoulders)
-  Less-confident bicyclists may not feel comfortable sharing a lane, even if wide





Shoulders



-  Create a place for cyclists to operate adjacent to travel lanes
-  Provide safety benefits to all road users
-  4 ft minimum clear width recommended for bicycle use
-  Usable by bicyclists on a wide variety of roadways - even rural freeways

Shoulders



-  Not typically used in urban areas
-  Can accumulate debris, parked vehicles, etc.
-  Can create conflicts between cyclists and turning vehicles
-  Striping changes at right turn lanes to reduce shoulder to right of turn lane & add "buffer zone" to left can mitigate turning conflicts
(similar to through bike lanes)

Shoulders & Rumble Strips



 Rumble strips can affect bicyclist travel

 3/8" or less rumble depth is much less jarring to bicyclists than 1/2" depth




Still provides effective rumble

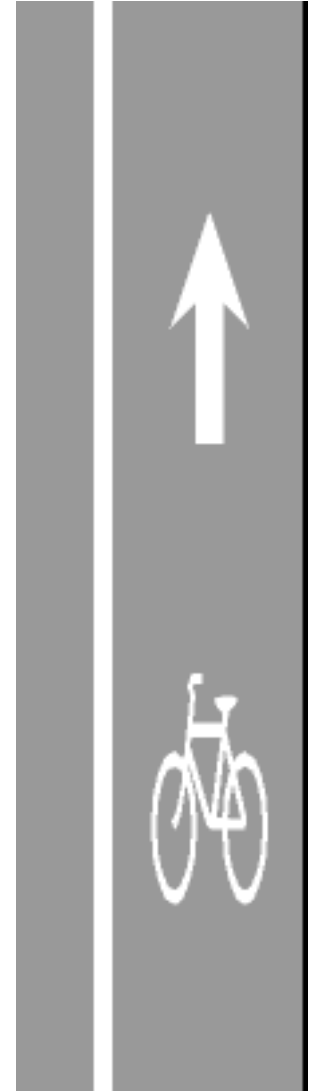
Used by several states

 Gaps in rumble pattern can allow for easy crossing by bicyclists






Bike Lanes



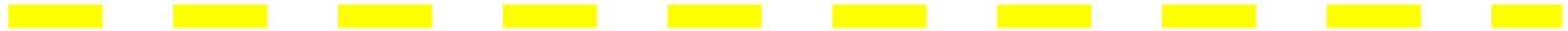
-  Typically used in urban & suburban areas
-  Create defined road space for cyclists
 - More "comfortable" for some cyclists than shared travel lanes
-  Can reduce sidewalk & wrong-way riding






Bike Lanes


-  Can accumulate debris & gravel if not frequently swept & cleaned
-  Prone to cracking & displacement
-  Should not be placed in "door zone" of parked cars
-  4 ft minimum clear width
-  5 ft or greater width preferable
 - 3 ft minimum outside gutter pan


Bike Lanes



-  Signs & markings for bike lanes defined in MUTCD
-  Widths, offsets, other details defined in AASHTO Guide
-  Be familiar with both these references!

Bicycle Boulevards



 "Bike-friendly"
streets parallel to
major travel
corridors

 Provide
convenient &
continuous route
of travel








Bicycle Boulevards







-  Intersection designs discourage "cut-through" traffic, but encourage through bicycle travel
-  Bike-specific signing & trailblazing provided for cyclist guidance & information

Roadway Retrofit Example

-  Existing roadway: urban arterial
-  60 ft wide + 2 x 2 ft gutters
-  Existing striping: 5 x 12 ft lanes
 - 2 lanes in each direction + TWLTL
-  Problem: 25% of all crashes on corridor involved bicyclists (75 out of 300 in 5 yr)
-  High percentage of wrong-way & sidewalk riders

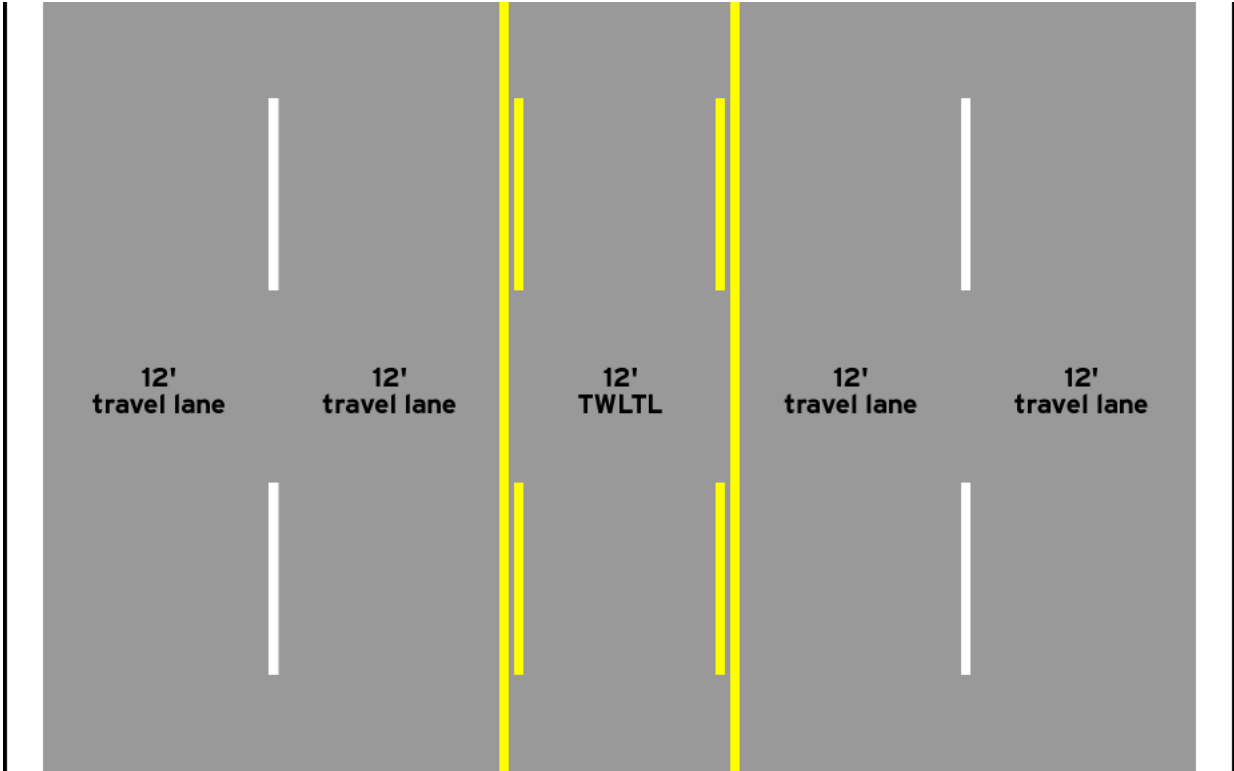
Roadway Retrofit Example



-  Question: How to encourage on-street bicycle operation in constrained width?
-  Proposed solution: Lane width reassignment
-  AASHTO Green Book allows use of 10 ft or 11 ft lanes in urban areas
-  Restriped to create wide outside lanes

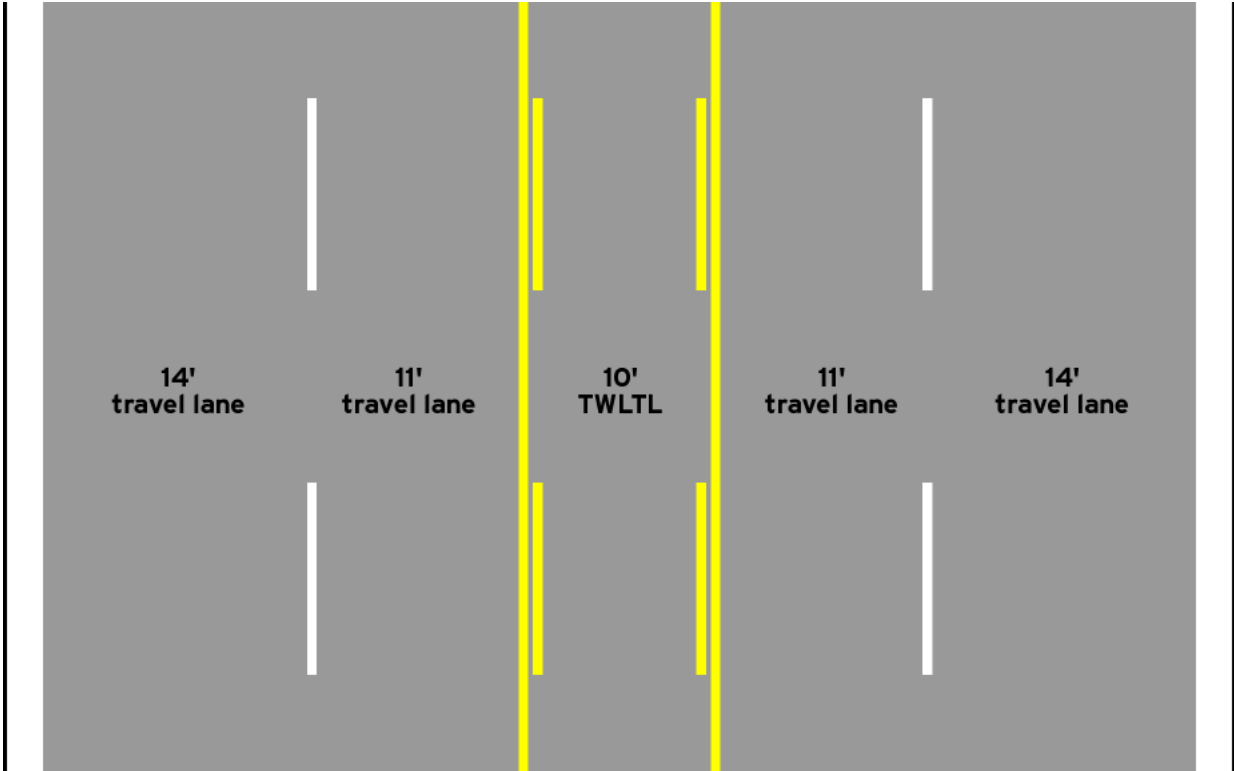
Roadway Retrofit Example

Before:



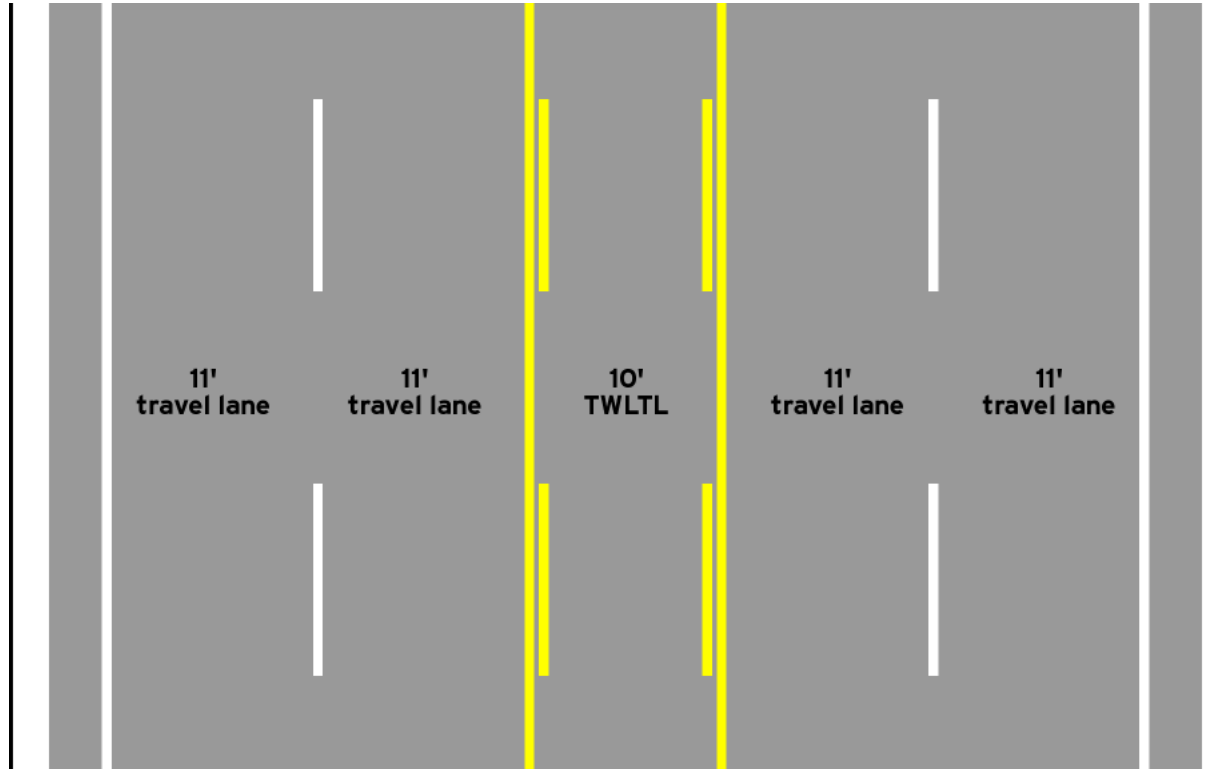
Roadway Retrofit Example

After:



Roadway Retrofit Example






Other Possible Options:



Off-Street Facilities



Paths & Trails

- 
-  Preferred by recreational cyclists
 -  Serve pedestrians and other users
 -  May be scenic and esthetically pleasing
 -  Can form valuable links in a transportation network when placed on independent alignments

Critical Design Issues



Bikes & On-Street Parking



Misperception of risks

Bicyclists "shy away" from moving traffic

Result: ride too close to parked vehicles

Bicyclists can't reliably see inside vehicles

Larger vehicle types

Headrests

Tinted windows

Bikes & On-Street Parking

- 🚲 Car door opens in 3/4 second
Too fast for human reaction

- 🚲 "Door zone" crashes can have severe or fatal results



Bike Lanes - Mitigating "Door Zones"

Wider bike lane

Bicyclists may still ride too close to parked vehicles

Buffer between bike lane & parking

More expensive to stripe/maintain

May not be understood by cyclists

Bike Lanes - Mitigating "Door Zones"

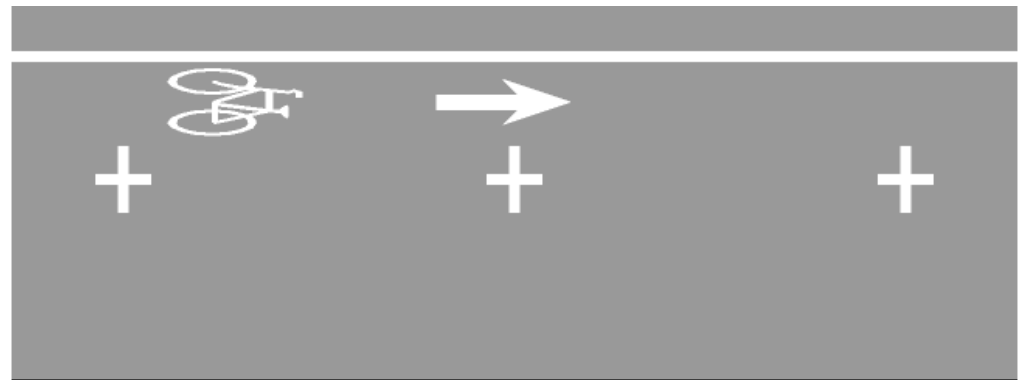
Wider parking lane

Vehicles still park close to curb

Leave more clear room on left side



Parking "crosses" (extended Ts)

Promising
results in
recent study



Bike Lanes & Intersections



-  Typically not a good idea to stripe a solid bike lane all the way to intersection
 - Encourages "cutting-off" movements
-  Recommend dashed (or dropped) bike lane 50-200 ft in advance of intersection


Bike Lanes & Intersections

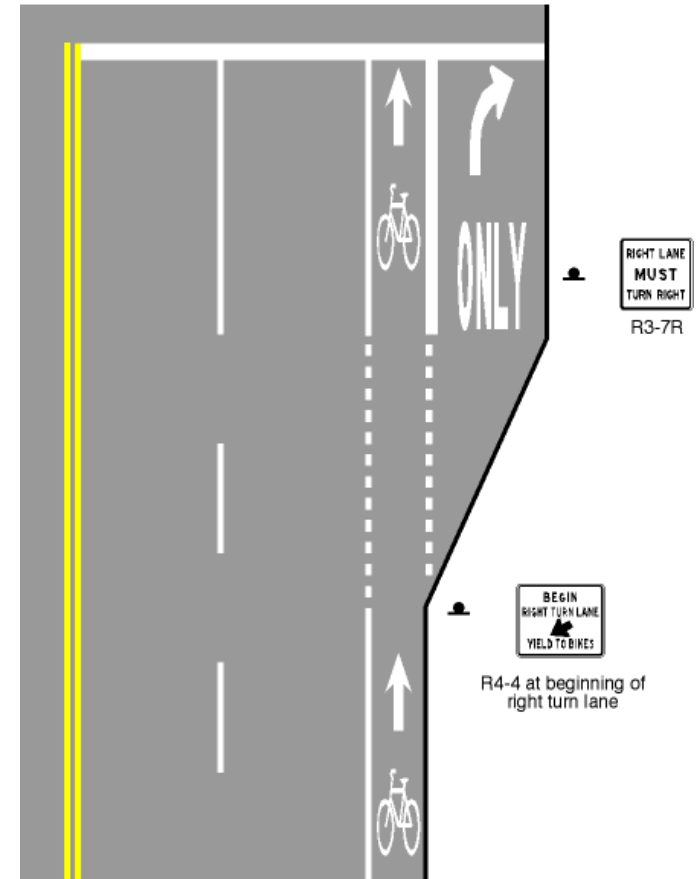
 2003 MUTCD:

A through
bicycle lane
shall not be
positioned to
the right of a
right turn only
lane







Bike Lanes & Intersections

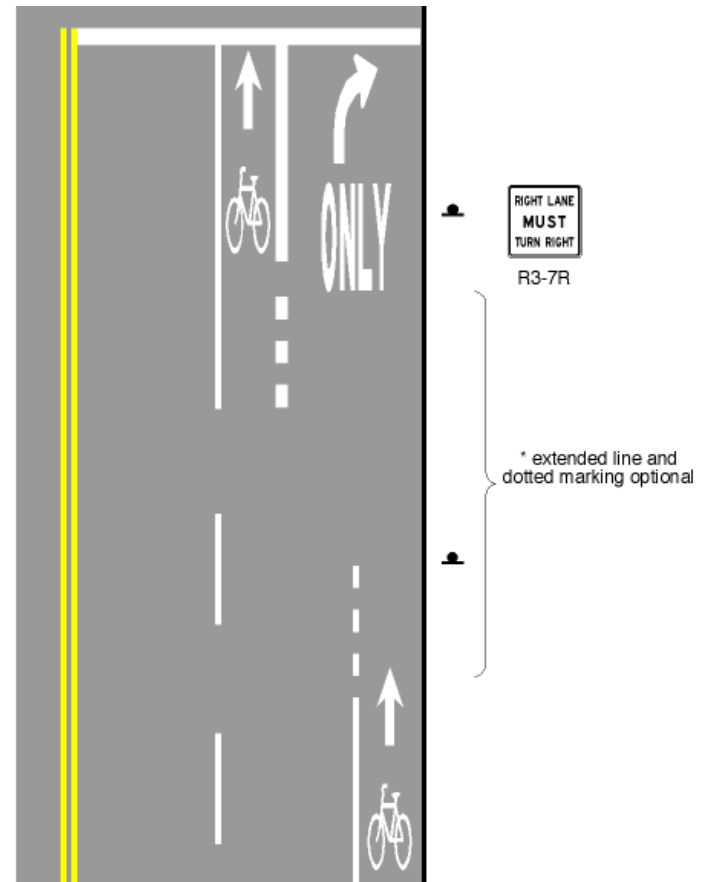
 Bike lane should be continued to the left of all right turn only lanes



Bike Lanes & Intersections




"Trap" right turn lanes:

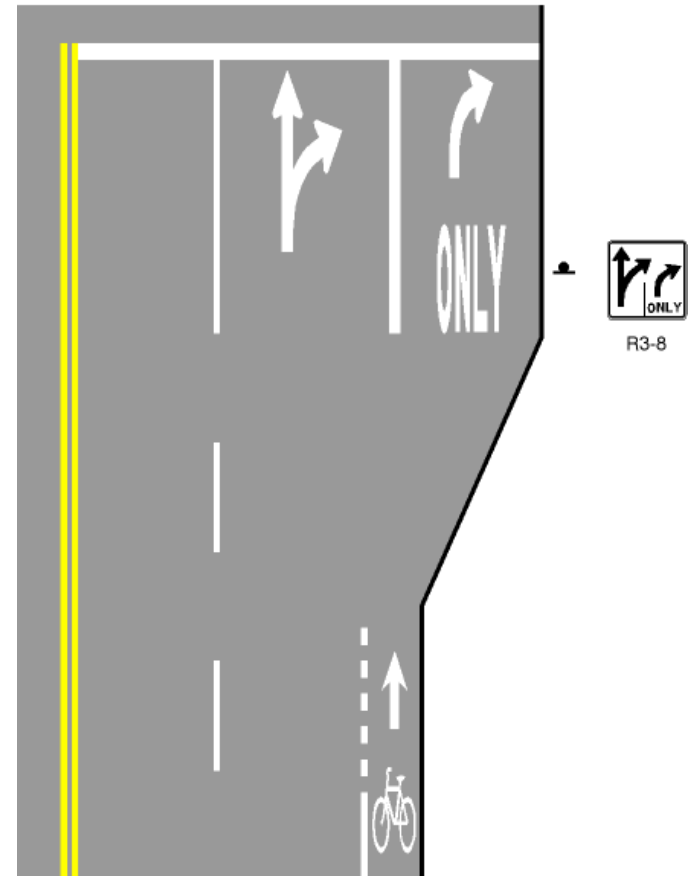
-  Cyclists should be encouraged to merge to left of turn lane
-  Best merging location will vary based on traffic volume, speed, platoons, etc.
-  Don't mark a single merging path veering across lane
-  Use "parallel lane" striping




Bike Lanes & Intersections

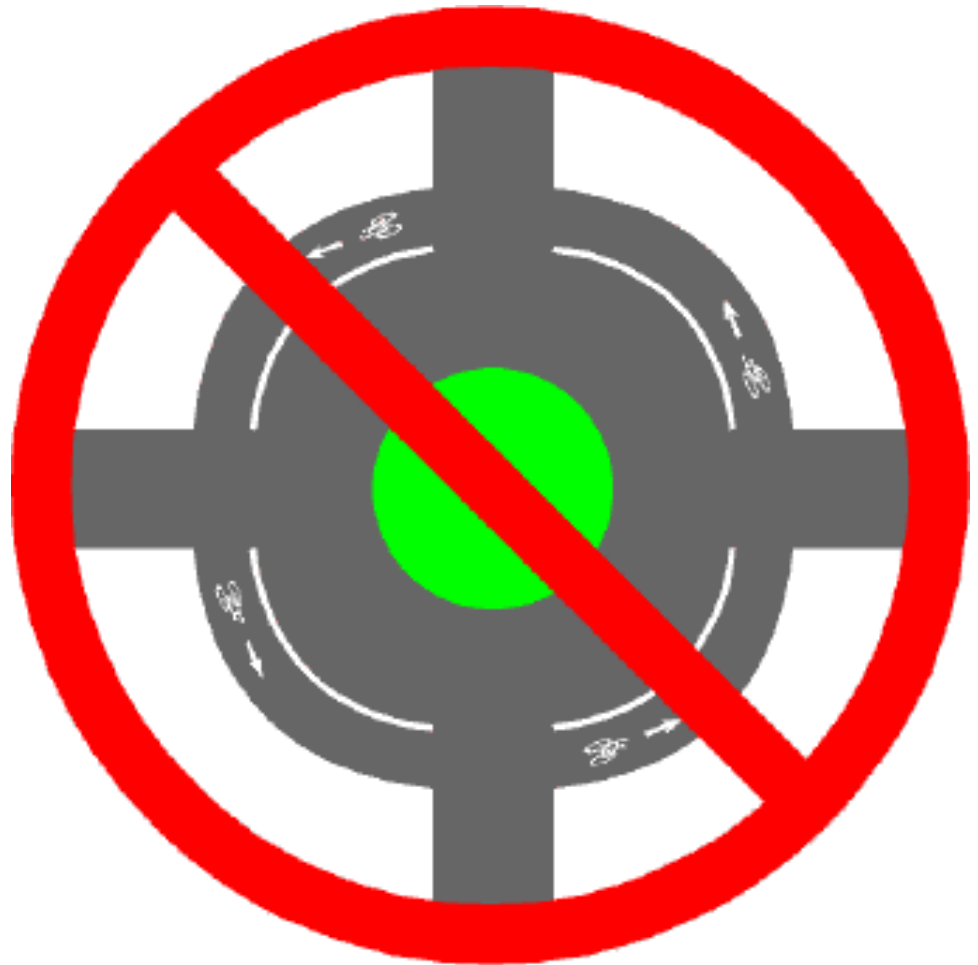
Multiple turn lanes:

-  There may not be any single best travel path through this intersection
-  Skilled cyclists will merge over & use center of thru/right lane
-  **MUTCD:** Don't use this where bikelanes exist unless justified by capacity analysis

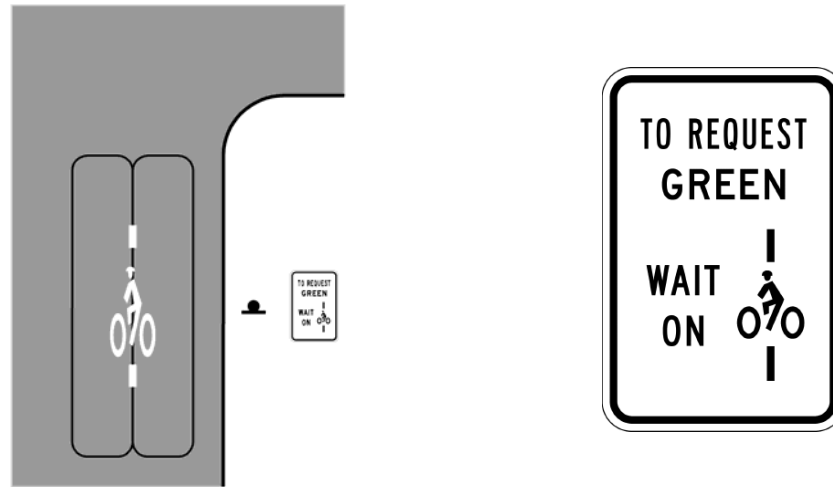





Bike Lanes & Roundabouts

 2003 MUTCD:
Bicycle lanes
shall not be
provided on the
circular
roadway of a
roundabout
intersection








Signal Actuation Sign/Symbol









-  In MUTCD (as of 2003 edition)
-  Indicates best location to actuate signal detector
-  R10-22 sign can be used to assist / educate


Pathway Issues

- 
-  Conflicts between different user types
 -  Users may be less attentive
 -  Crossings of roadways may cause problems
 -  Pathways parallel and adjacent to roadways create severe intersection and driveway conflicts

Good Pathway Design

- 
-  Place on independent alignment
 -  Provide adequate width for all users to "share nicely"
 -  Provide good sight distance
 -  Install all obstructions clear of traveled way
 -  Route roadway crossings away from other intersections





Pathway Design

 **Don't** install posts or bollards in traveled way of path unless there is a documented history of vehicle intrusion


Can cause severe crashes & injuries, even if marked or reflectorized



Path-Roadway Intersections

-  Path shouldn't always have to yield to road
-  Priority should be assigned based on:
 - Relative speeds - path vs. roadway
 - Relative volumes - path vs. roadway
 - Relative importance - path vs. roadway
-  It's appropriate to give right-of-way to a high-volume path crossing a low-volume street
-  STOP signs should not be used where YIELD signs would be acceptable

Pathway Design

 "Sidepaths" (pathways parallel & adjacent to roadways) can be very problematic




 **Why?**

 Intersections






 Driveways

Sidepath Issues

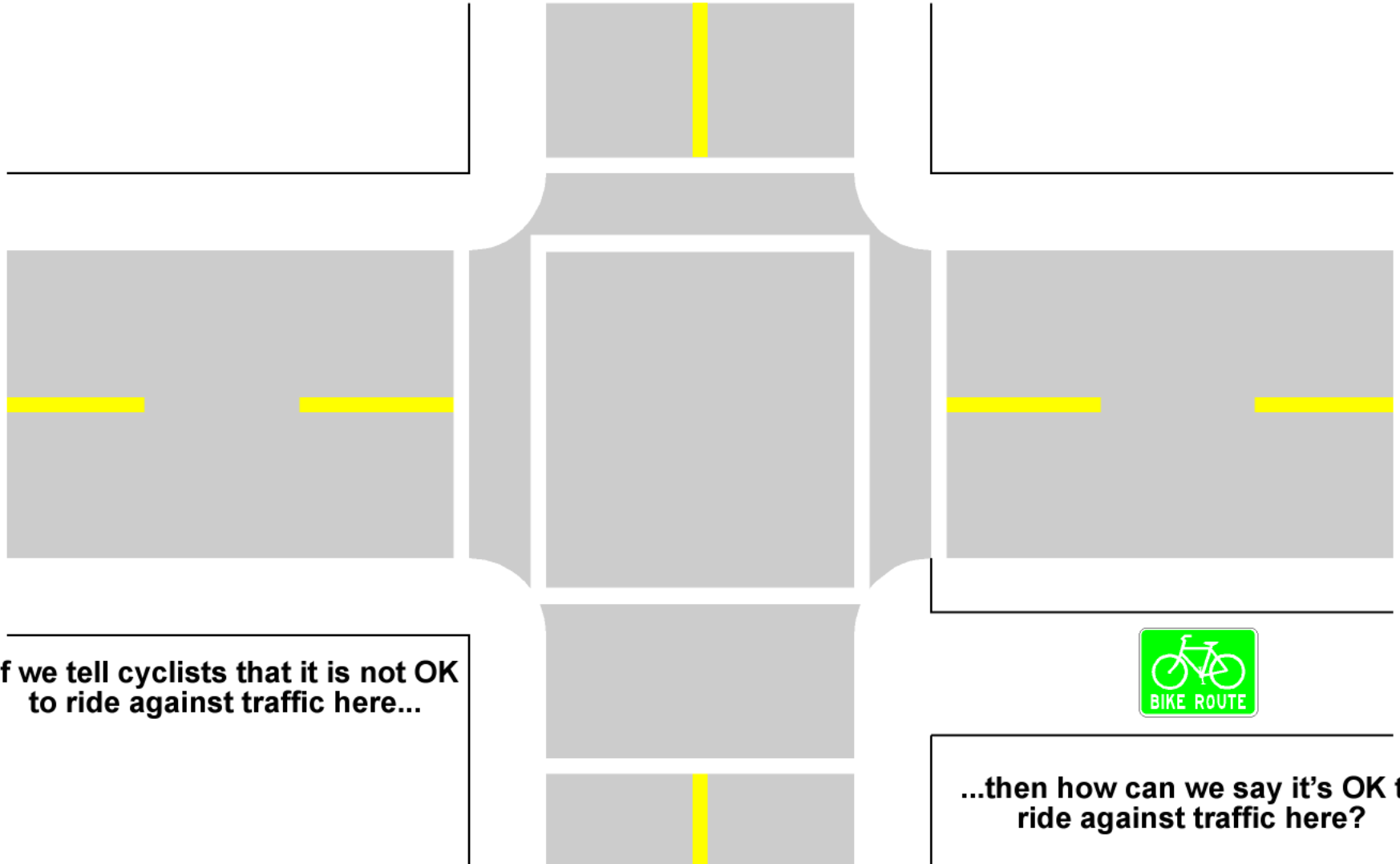


-  Offset between path and adjacent roadway does not ensure safety
-  Requiring cyclists to yield at intersections and driveways or operate at pedestrian speeds may not be feasible or reasonable
-  Two-way path on one side of street encourages wrong-way operation

Are Sidepaths Safer?

- 
-  Unless grade-separated, pathways still have intersection conflicts - often severe
 -  70% of bicycle/motor vehicle crashes occur at intersections and driveways
 -  Very few bicycle crashes involve overtaking vehicles
 -  Children are still at greater relative risk at intersections & driveways

Legal Issues - Sidepaths

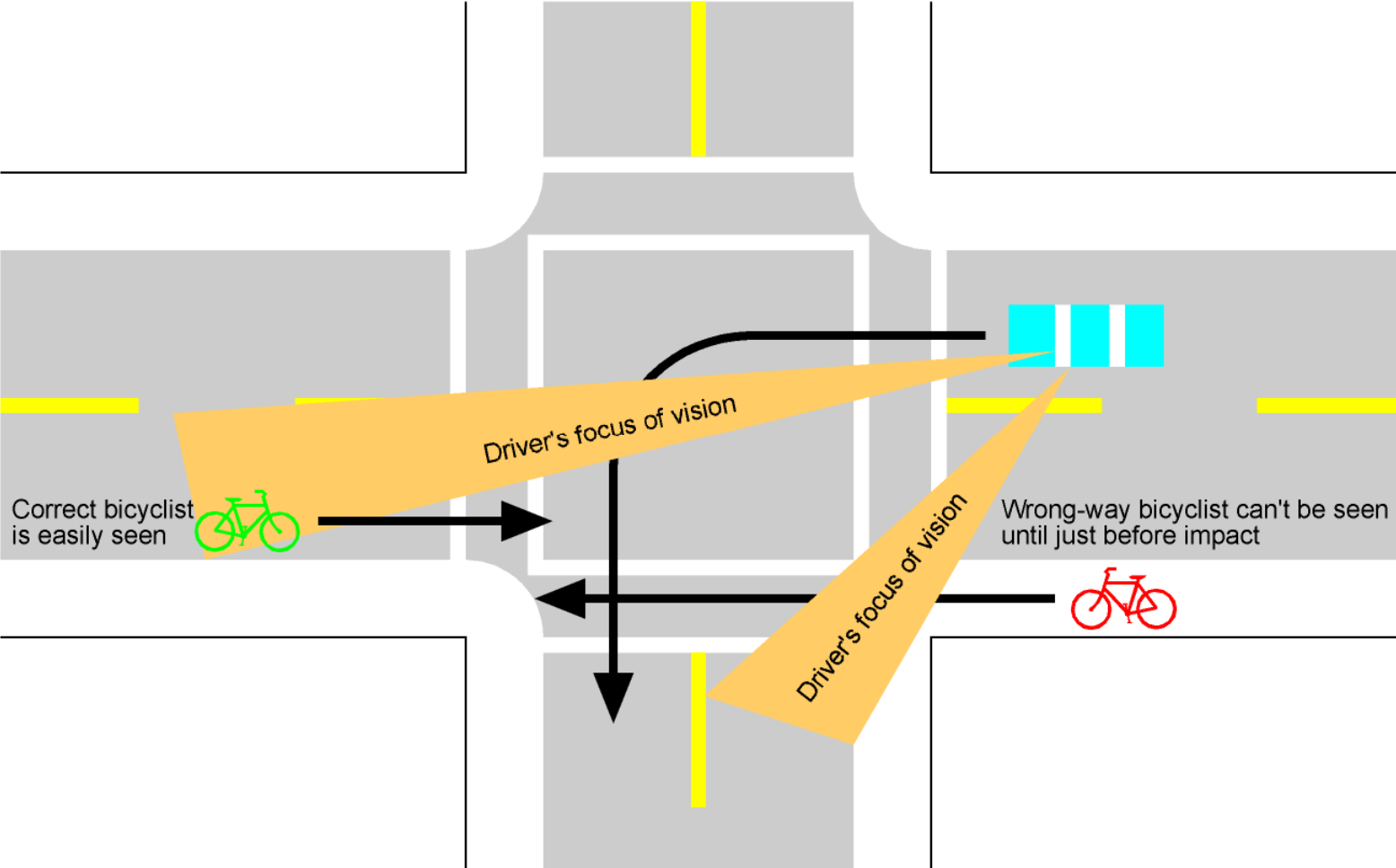


If we tell cyclists that it is not OK to ride against traffic here...

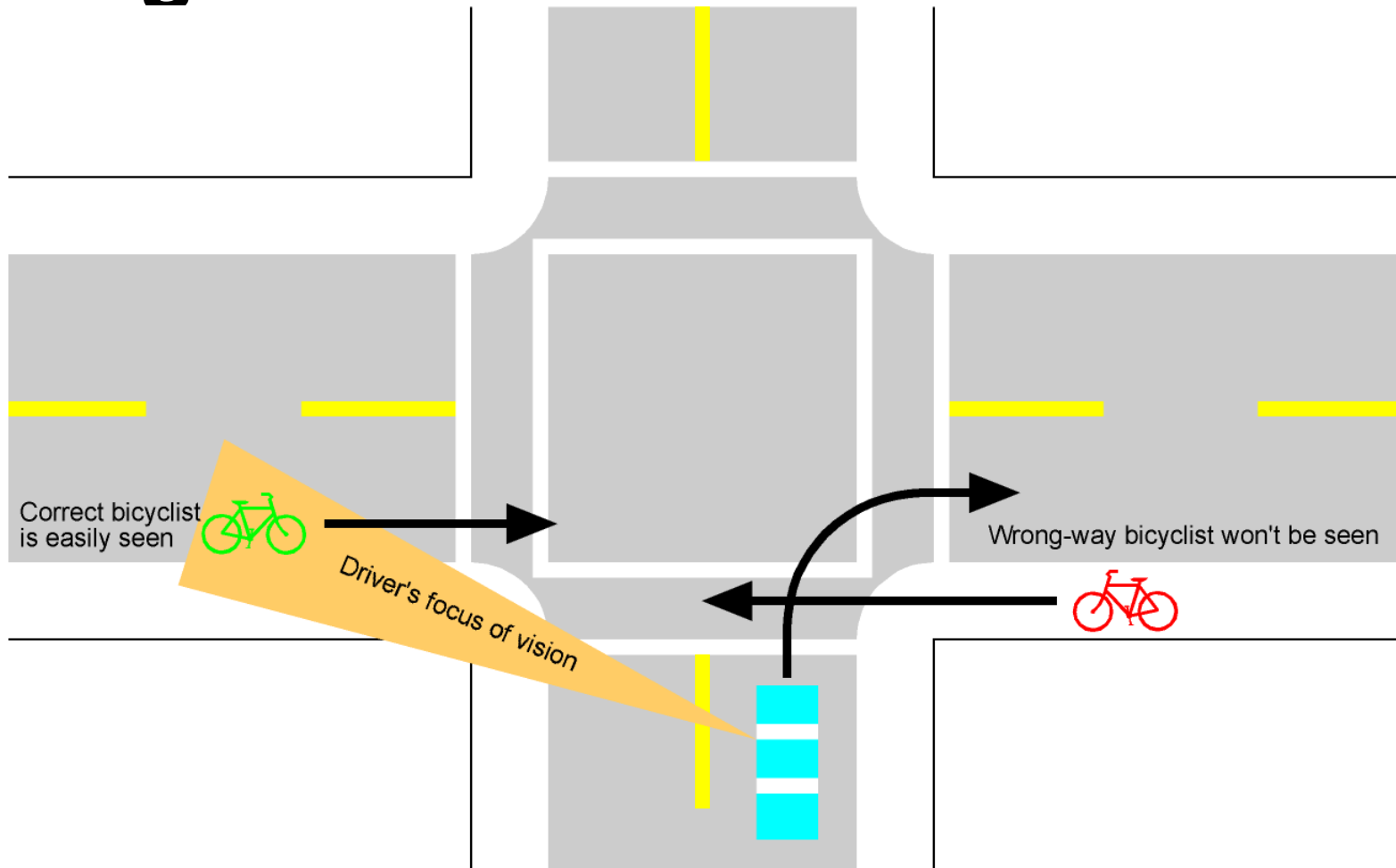


...then how can we say it's OK to ride against traffic here?

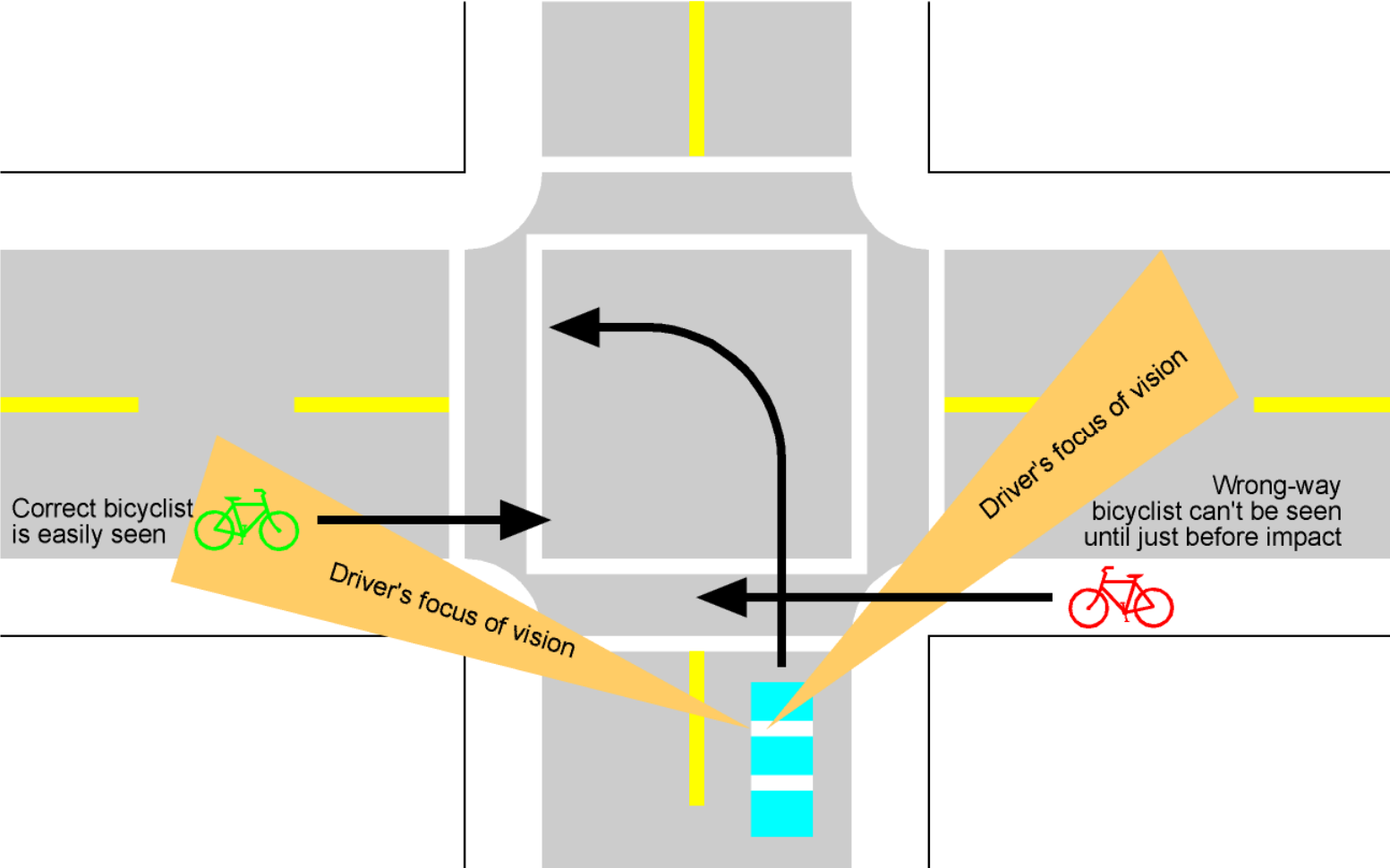
Wrong-Way Cycling Hazard - Left Turn From Parallel Road



Wrong-Way Cycling Hazard - Right Turn From Cross Road



Wrong-Way Cycling Hazard - Left Turn From Parallel Road



Other Cycling Improvements



 Guide & Informational Signing




 Bicycle Parking

 "Bikestations"

 **Education**

 **Enforcement**

Guide & Informational Signs

-  Low-cost, high-value improvement
-  Typically not done (well) in US
-  Signing can be provided for destinations frequently visited by cyclists
 - Local
 - Long-distance

Guide & Informational Signs

 Can use BIKE
ROUTE + info signs



 New series of signs
proposed for MUTCD



Bicycle Parking

- ❏ Lack of available parking can greatly discourage bicycle use
- ❏ Parking should be:
 - ❏ Convenient
 - ❏ Secure
- ❏ See www.apbp.org for recommendations



'Bikestations'

 Central location for:

Secure parking




Minor service

Clean-up/wash-up






 Either privately or publicly owned & operated






Education

- 
-  Education can be far more effective in improving behavior and safety than any facility type or traffic control device
 -  Education programs can be far cheaper than signs, markings, asphalt, & concrete

Education





- 
-  Education can be effective in reducing high-risk behaviors:
 -  Wrong-way cycling
 -  Sidewalk cycling
 -  Nighttime operation without lights

Education

- 
-  However, most cyclists do not take advantage of education, even if available
 -  Widespread perception: "I know how to pedal & stop - what else is there?"

Education Resources




League of American Bicyclists

-  Targeted programs for adults, kids, motorists, commuters
-  Certified instructors
-  Peer-reviewed national curriculum
-  Classroom & "hands-on" modules

<http://www.bikeleague.org/>

Enforcement



-  Enforcement can be very effective against high-risk behavior patterns
-  Targeted enforcement sweeps at high-ridership times & locations can have significant "halo effect"
-  Warnings (followed by citations if needed) can be effective without causing backlash

Enforcement



'Useful' enforcement:

Wrong-way riding

Failure to yield (running stop signs / signals)

Unlit operation at night







'Not-So-Useful' Enforcement:

Failure to make a full stop (but yielding)




Registration violations

Enforcement

- 
-  Build a good relationship with your local enforcement agency
 -  Try to overcome misconceptions & assumptions
 -  Focus on intercepting high-risk behavior

So, Finally...



-  There are many ways to accommodate bicyclists
-  It's extremely important to accommodate cyclists in reasonable, convenient, and safe ways
-  Select the correct type of facility, then design it properly