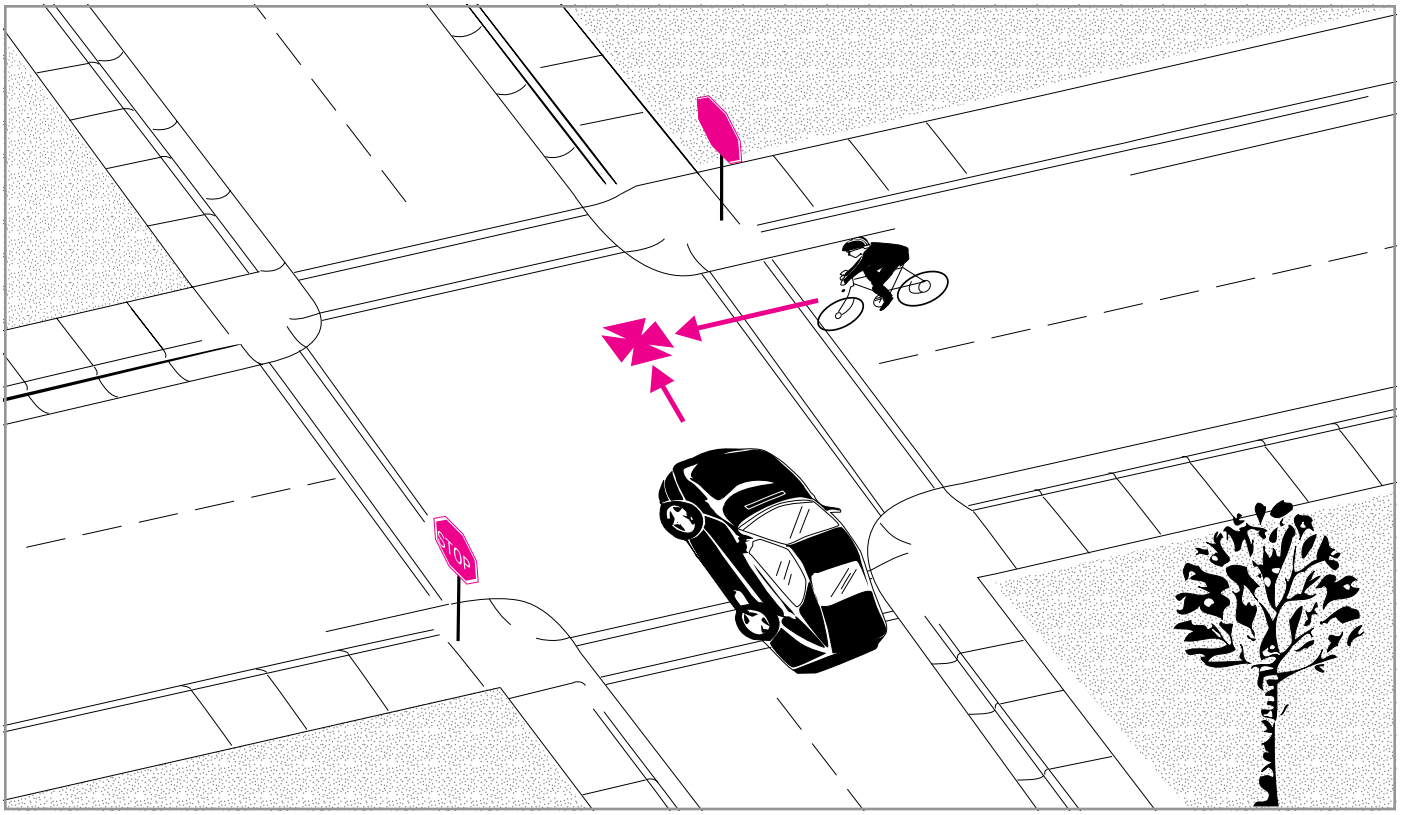
Chapter 3 – Selecting Improvements for Bicyclists



Identification of High-Crash Locations

Bicycle Crash Typing

Definitions of Bicycle Crash Types

Crash-Related Countermeasures

Performance Objectives

Program of Improvements

Deciding on a set of treatments that will provide the greatest safety and mobility benefits for bicyclists requires transportation and land-use planners, engineers, law enforcement officials, and community leaders to engage in problem-solving. In most cases, a two-pronged approach is required. The first prong involves an examination of the bicycling crash problem through a review of historical crash data. Two specific types of crash analyses that are detailed in this chapter include:

- The identification of high-crash or hazardous locations
- The detailed examination of pre-crash maneuvers that lead to bicycle-motor vehicle collisions

However, many of the problems faced by bicyclists either do not involve crashes or the crashes are not reported. Thus, the second prong is more broad-based and focuses on performance objectives that will lead to changes in behavior that, in turn, will result in a safer and more accessible environment for bicyclists.

IDENTIFICATION OF HIGH-CRASH LOCATIONS

A first step in the problem-solving process of improving bicycle safety and mobility is to identify locations or areas where bicycle crash problems exist and where engineering, education, and enforcement measures will be most beneficial. Mapping the locations of reported bicycle crashes in a neighborhood, campus, or city is a simple method of identifying sites for potential bicycle safety improvements. One method of analyzing crash locations is through computerized Geographic Information Systems (GIS) software. This type of map can help transportation engineers and planners focus safety improvements on intersections, corridors, or neighborhoods where bicycle crashes have occurred.

Several issues should be considered when creating GIS maps of reported crash locations. First, the volumes of bicycle and motor vehicle traffic that use each location will affect reported crash density. Second, bicycle crashes may not be reported frequently enough to establish a pattern of unsafe bicycling locations. In either case, other steps may improve the identification of unsafe locations for bicycling. These include:

- Using bikeability checklists.[1]
- Noting bicycle and driver behavior and examining roadway and bicycling characteristics at specific sites.
- Observing and recording the number of bicycle-motor vehicle conflicts at specific sites.[2]
- Mapping locations known to have a high potential for bicycle crashes in an area.
- Calculating a bicycle level of service.[3]

In regard to conflicts, a number of studies have been performed using bicycle-motor vehicle conflicts as a study variable in lieu of crash data.[2] A conflict is usually defined as a sudden change in speed or direction by either party to avoid the other. In regard to bicycle level of service, one popular tool is the Bicycle Compatibility Index, where a user inserts values for several easily obtained variables to determine the comfort level (level of service) for bicyclists on a midbock section of a street or roadway.[3] An intersection level of service for the bicycle through movement has also been developed.[4] Another intersection rating tool is under development for the Federal Highway Administration (FHWA) for both bicyclists and pedestrians. The bicyclist portion considers the through movement, right turns, and left turns.[5]

BICYCLE CRASH TYPING

The development of effective roadway design and operation, education, and enforcement measures to accommodate bicyclists and prevent crashes is hindered by insufficient detail in computerized state and local crash files. Analysis of these databases can provide information on where bicycle crashes occur (city, street, intersection, two-lane road, etc.), when they occur (time of day, day of week, etc.), and characteristics of the victims involved (age, gender, injury severity, etc.). Current crash files cannot provide a sufficient level of detail regarding the sequence of events leading to the crash.

In the 1970s, methods for typing pedestrian and bicycle crashes with motor vehicles were developed by the National Highway Traffic Safety Administration (NHTSA) to better define the sequence of events and precipitating actions leading to pedestrian- and bicycle-motor vehicle crashes.[6,7,8] These methodologies were applied by Hunter et al. in a 1996 study to more than 8,000 pedestrian and bicycle crashes from six states.[9] The results provided a representative summary of the distribution of crash types experienced by pedestrians and bicyclists. Some of the most frequently occurring bicycle crash types include:

- A motorist failing to yield (21.7 percent of crashes)
- A bicyclist failing to yield at an intersection (16.8 percent of crashes)
- A motorist turning or merging into the path of the bicyclist (12.1 percent of crashes)

- A bicyclist failing to yield at a midblock location (11.7 percent of crashes)
- A motorist overtaking a bicyclist (8.6 percent of crashes)
- A bicyclist turning or merging into the path of the motorist (7.3 percent of crashes)

The crash-typing methodology described above has evolved over time and has been refined as part of a software package known as the Pedestrian and Bicycle Crash Analysis Tool (PBCAT).[10] The development of PBCAT was sponsored by FHWA and NHTSA. Those interested may register for the PBCAT software and user's manual from the Pedestrian and Bicycle Information Center Web site at http://www.bicyclinginfo.org/bc/pbcat.htm. An update of this software will soon be available on the Web site.

PBCAT is a software product intended to assist state and local pedestrian and bicycle coordinators, planners, and engineers with the problem of lack of data regarding the sequence of events leading to a crash. PBCAT accomplishes this goal through the development and analysis of a database containing details associated with crashes between motor vehicles and pedestrians or bicyclists. One of these details is the crash type, which describes the pre-crash actions of the parties involved. The more than 70 specific bicyclist crash types used in PBCAT may be collapsed into 20 crash-typing groups. Several of these groups (including rarer or unusual crash types) have been further combined into 14 BIKESAFE groups for purposes of selecting treatments. A few PBCAT types that include rarer or difficult to remedy crashes that cannot be very specifically defined are not treated in the Crash Matrix. Some of these types of crashes are discussed in group 14 in the text that follows. Examining the closely-related crash groups for countermeasures could be helpful, as well as using the Performance Objectives Matrix to identify appropriate countermeasures. (See Chapter 4 for more information on the Crash and Performance Objectives matrices.)

DEFINITIONS OF BICYCLE CRASH TYPES

Provided below are the definitions of the 14 crash groups included in the BIKESAFE application (13 are included in the interactive crash matrix). These definitions are adapted from the PBCAT software.[10] For any crash group, there are multiple problems or possible causes that may have led to the crash. The following section provides examples of a few possible causes and problems for each group and some of the countermeasures within BIKESAFE that may be applicable. At the end of each potential solution is the countermeasure number in parentheses, which can be used to quickly locate the countermeasure description in Chapter 5.

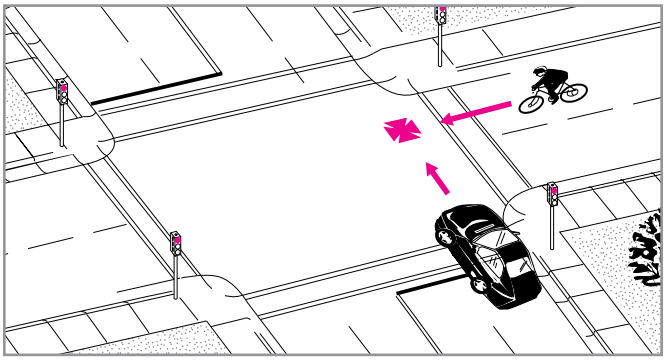
Neither the list of problems and possible causes nor the suggested countermeasures are to be considered comprehensive. Practitioners will still be required to supplement the analysis and recommendations with their own investigations and knowledge of local policies and practices. A number of potential countermeasures have, however, been identified for each group of crashes. The user is intended to think broadly initially, and develop their own narrower list of suitable options based on particular crash problems, detailed site conditions and other local circumstances. The countermeasures selection tool in the BIKESAFE software application (described in Chapter 4) is intended to aid in this process.

1. MOTORIST FAILED TO YIELD—SIGNALIZED INTERSECTION

The motorist enters an intersection and fails to stop at a traffic signal, striking a bicyclist who is traveling through the intersection on a perpendicular path. Typically, no turning movements are made by either party, except for a possible right turn on red. Many of these crashes involve bicyclists who are riding the wrong way against traffic, either in the roadway or on the sidewalk approaching the intersection.

Possible Cause/Problem #1

Motorist drives through a red signal without stopping. The motorist could be speeding and unable to stop in time, trying to get through the intersection on a yellow or amber signal indication, disregarding the signal, or failing to see the red signal.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Reduce number of lanes (9).

c. Reduce lane width (10).

d. Install roundabouts (17).

e. Add/improve intersection markings (18).

f. Improve sight distance at intersection (19).

g. Install mini traffic circles (25).

h. Add chicanes or other traffic calming to slow motor vehicle speeds (26, 27).

i. Provide raised intersection (30).

j. Provide trail intersection treatments for shared-use paths crossing the roadway at the intersection (32).

k. Provide trail intersection warnings/advance treatments for shared-use paths crossing the roadway (33).

l. Optimize signal timing or improve signal visibility (35).

m. Make sign improvements (37).

n. Improve pavement markings (38).

o. Make school zone improvements (39).

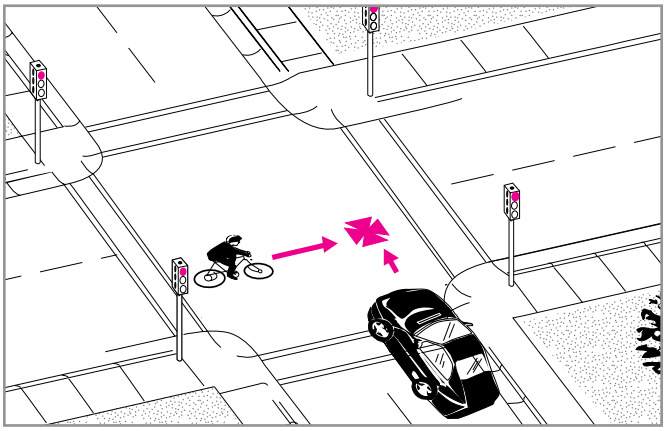
p. Provide law enforcement (40).

q. Provide bicyclist education on wrong-way riding and riding on the sidewalk (41).

r. Provide motorist education (42).

Possible Cause/Problem #2

The motorist drives out after stopping for a red signal, into the path of an oncoming bicyclist. The motorist may be making a right turn on red and fails to look to the right to see an approaching bicyclist. The bicyclist could be riding the wrong way in either the roadway or on the sidewalk.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Reduce curb radii to slow motor vehicle speeds (16).

c. Install roundabouts (17).

d. Add/improve intersection markings (18).

e. Provide intersection sight distance improvements (19).

f. Restrict right-turn-on-red (20).

g. Provide trail-roadway intersection treatments for shared-use paths adjacent to the roadway (32).

h. Provide trail intersection advance warning treatments for shared-use paths adjacent to the roadway (33).

i. Make sign improvements (37).

j. Provide bicyclist education (41).

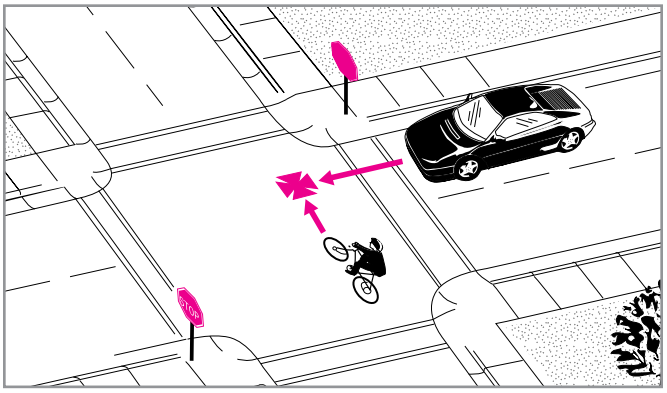
k. Provide motorist education (42).

2. MOTORIST FAILED TO YIELD—NON-SIGNALIZED INTERSECTION

The motorist enters an intersection without properly stopping or yielding at a stop sign, yield sign, or uncontrolled location, striking a bicyclist who is traveling through the intersection on an initial perpendicular path. Many of these crashes also involve bicyclists who are riding the wrong way against traffic, either in the roadway or on the sidewalk approaching the intersection.

Possible Cause/Problem #1

Motorist fails to stop at a stop sign or yield at a yield sign or uncontrolled intersection. The motorist could be speeding or otherwise fail to observe correct right-of-way, including flagrantly violating sign control.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Reduce number of lanes (9).

c. Reduce lane width (10).

d. Reduce curb radii to slow motor vehicle turning speeds (16).

e. Install roundabout (17).

f. Add/improve intersection markings (18).

g. Improve intersection sight distance (19).

h. Redesign merge area (21).

i. Install mini traffic circle at intersection (25).

j. Add chicanes or other traffic calming to reduce vehicle speeds (26, 27).

k. Provide raised intersection and other traffic calming treatments (30).

l. Provide path intersection treatments for shared-use paths crossing the roadway (32).

m. Provide path intersection warnings/advance treatments for shared-use paths crossing the roadway (33).

n. Install traffic signal (35). If signal is installed, add bike detection/activation (36).

o. Make sign improvements (37).

p. Improve pavement markings (38).

q. Make school zone improvements (39).

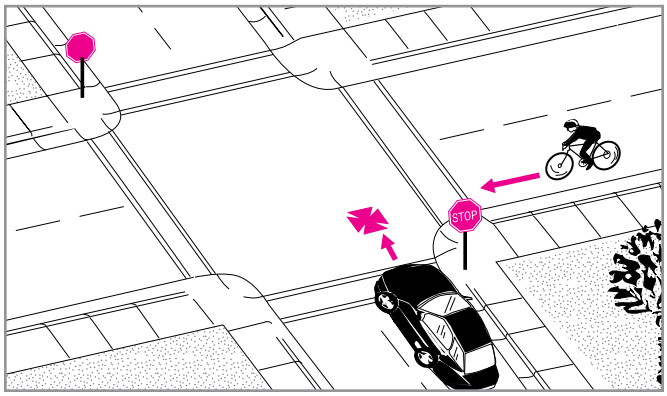
r. Provide law enforcement (40).

s. Provide bicyclist education on wrong-way riding and riding on the sidewalk (41).

t. Provide motorist education (42).

Possible Cause/Problem #2

The motorist pulls out into the path of a bicyclist traveling through the intersection after first stopping (or slowing). The bicyclist could be riding the wrong way or on the sidewalk or both and ride into the intersection in the pedestrian crosswalk area. The motorist may pull out and fail to check or notice the bicyclist approaching (particularly from the right). The motorist may be turning right.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Reduce curb radii to slow turning speeds (16).

c. Install roundabout (17).

d. Add/improve intersection markings (18).

e. Improve sight distance (19).

f. Install mini traffic circle (25).

g. Provide raised intersection (30).

h. Provide path intersection treatments for shared-use paths crossing the roadway (32).

i. Provide trail intersection warnings/advance treatments for shared-use paths adjacent to the roadway (33).

j. Make school zone improvements (39).

k. Provide bicyclist education (41).

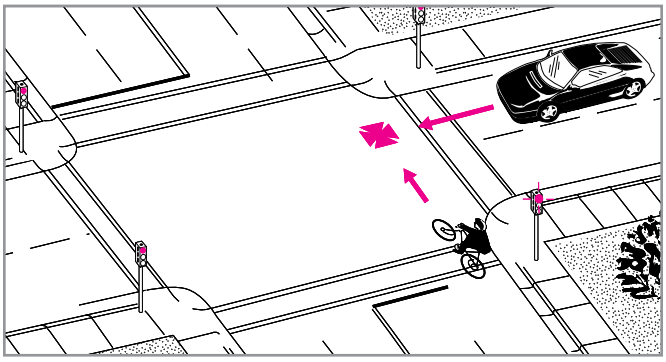
l. Provide motorist education (42).

3. BICYCLIST FAILED TO YIELD—SIGNALIZED INTERSECTION

The bicyclist enters an intersection on a red signal or is caught in the intersection by a signal change, colliding with a motorist who is traveling through the intersection. This group of crashes could involve a lack of understanding of the signal or inexperience for a young bicyclist or flagrant disregard for the signal by an older bicyclist. In many of these crashes, the bicyclist is likely to be riding on the sidewalk or riding the wrong way, against traffic, and fail to notice the signal indication.

Possible Cause/Problem #1

The bicyclist rides into the intersection through a red signal without stopping. The bicyclist may be trying to rush through on an amber signal indication, fail to see the red signal, or choose to disregard the signal. The bicyclist may not want to interrupt momentum or stop for a signal with an excessively long delay or that does not detect bicyclists' presence. Inexperience could also contribute to this type of crash. The signal may be more difficult to observe if the bicyclist is traveling wrong-way or riding on the sidewalk.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Install roundabout (17).

c. Add/improve intersection markings (18).

d. Improve sight distance (19).

e. Provide path intersection treatments for shared-use paths crossing the roadway (32).

f. Provide path intersection advance warning treatments for shared-use paths crossing the roadway (33).

g. Install/optimize signal timing (35).

h. Install bike-activated signals (36).

i. Make sign improvements (37).

j. Improve pavement markings (38).

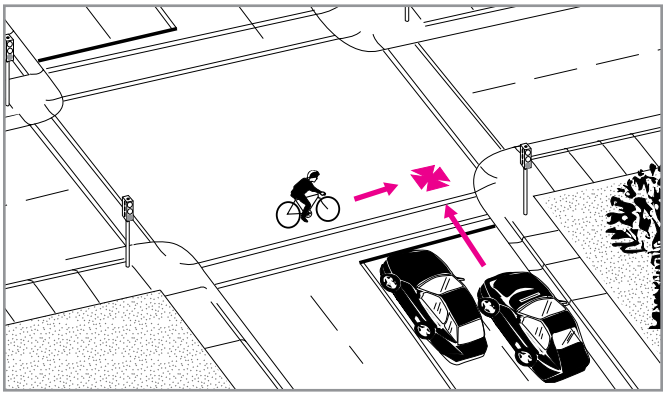
k. Make school zone improvements (39).

l. Provide law enforcement (40).

m. Provide bicyclist education (41).

Possible Cause/Problem #2

The bicyclist enters the intersection on a green or amber traffic signal indication but fails to clear the intersection when the traffic signal changes to green for the cross-street traffic. A multiple threat crash can also occur when the signal changes to green for the cross-street traffic and the bicyclist is struck by a motor vehicle whose view was obstructed by standing or stopped traffic in an adjacent lane.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Reduce the number of traffic lanes (9).

c. Reduce the width of traffic lanes (10).

d. Install roundabout (17).

e. Add/improve intersection markings (18).

f. Improve sight distance at the intersection (19).

g. Add traffic calming treatments to slow motor vehicle speed (25, 26, 27, and 30).

h. Provide path intersection treatments for shared-use paths crossing the roadway (32).

i. Provide path intersection warnings/advance treatments for shared-use paths crossing the roadway (33).

j. Optimize signal timing (35).

k. Install bike-activated signal (36).

l. Make school zone improvements (39).

m. Provide bicyclist education (41).

n. Provide motorist education about multiple threat (42).

Possible Cause/Problem #3

The bicyclist rides into the intersection after stopping for a red signal and into the path of a motorist. The bicyclist may ride out after waiting for a green indication if there is no provision for bicycle detection or the delay is excessive.

General Countermeasures

a. Install a modern roundabout (17) or mini traffic circle (25) (depending on street function and volumes).

b. Improve signal timing (35).

c. Add bike-activation to the traffic signal (36).

d. Enforce traffic laws (40).

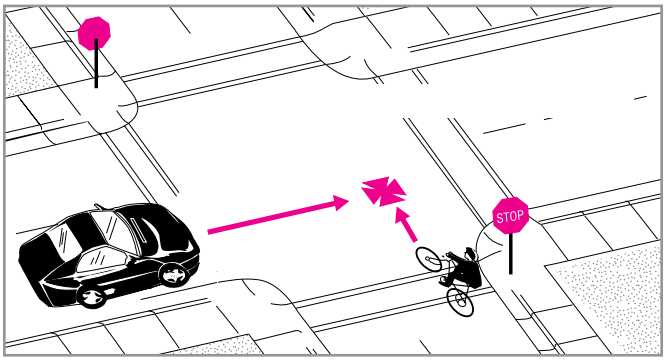
e. Provide bicyclist education (41).

4. BICYCLIST FAILED TO YIELD—NON-SIGNALIZED INTERSECTION

The bicyclist enters an intersection and fails to stop or yield at a non-signalized intersection (typically controlled by a stop sign), colliding with a motorist who is traveling through the intersection. This group of crashes could involve a lack of understanding of the sign control or inexperience for a young bicyclist, or flagrant disregard for the sign by an older bicyclist.

Possible Cause/Problem #1

Bicyclist fails to yield at a stop sign, yield sign or uncontrolled intersection. Sidewalk or wrong-way riding may exacerbate



the problem by increasing the chances the bicyclist will not notice and obey sign control. Younger bicyclists tend to be disproportionately involved in this crash type.

General Countermeasures

a. Add/improve lighting (4).

b. Install roundabouts (17).

c. Improve sight distance at intersection (19).

d. Install mini traffic circle (25).

e. Provide path intersection treatments (32).

f. Provide path intersection warnings/advance treatments (33).

g. Install traffic signal (35) and bike-activated signal (36).

h. Make sign improvements (37).

i. Improve pavement markings (38).

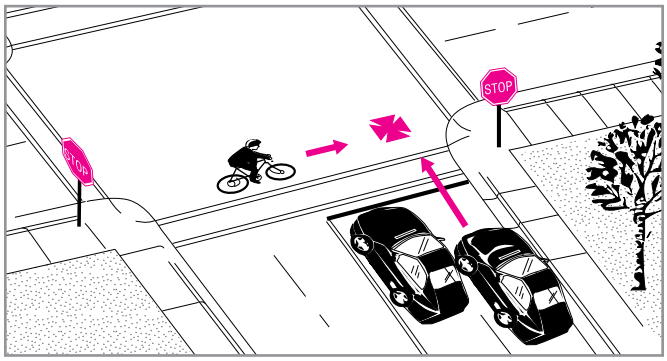
j. Make school zone improvements (39).

k. Provide law enforcement (40).

l. Provide bicyclist education (41).

Possible Cause/Problem #2

The bicyclist rides out after stopping (or slowing). At a yield or two-way stop, the motorist could be speeding, the bicyclist may underestimate the time needed to start-up and get through the intersection, or the bicyclist may not detect an approaching motorist. At a four-way stop, the bicyclist may not understand right-of-way rules. A multiple threat situation can also occur at a non-signalized location.



General Countermeasures

a. Add/improve lighting (4).

b. Reduce the number of traffic lanes (9).

c. Recuce the width of traffic areas (10).

d. Install roundabout (17).

e. Implement special intersection markings (18).

f. Improve sight distance at the intersection (19).

g. Redesign merge area (21).

h. Install mini traffic circle (25).

i. Install chicanes or other traffic calming measures to slow motorist speeds (26, 27, 30).

j. Install speed tables, humps, or cushions (27).

k. Install raised intersection (30).

l. Install traffic signal (35) and bike-activated signal (36).

m. Provide bicyclist education (41).

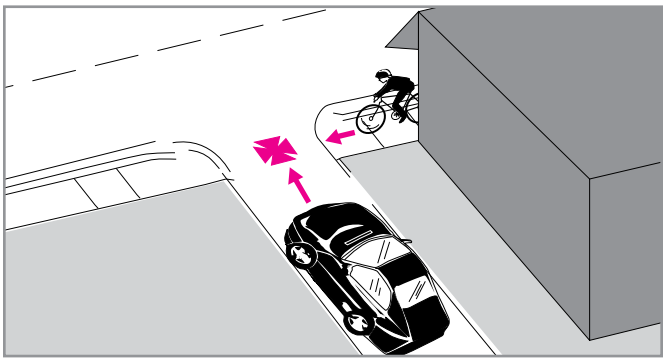
n. Provide motorists education about multiple threat and child bicyclists (42).

5. MOTORIST DROVE OUT—MIDBLOCK

The motorist typically pulls out of a driveway or alleyway and fails to yield to a bicyclist riding along the roadway or on a parallel path or sidewalk. Two-thirds of these types of crashes typically involve a bicyclist who is riding the wrong way against traffic, either on the sidewalk or on the roadway.

Possible Cause/Problem

The motorist pulls out of a residential or commercial driveway or alleyway and fails to yield to a bicyclist riding along the roadway, on the sidewalk, or on a parallel shared-use path. Visibility may be obscured by buildings, parked cars, trees and shrubs, signal control boxes, sign posts and a host of other things that can be found along the sidewalk or edge of the roadway. The motorist may also fail to look right before pulling out or fail to detect higher-speed bicyclists or those traveling wrong-way on the roadway or sidewalk.



General Countermeasures

a. Make parking improvements to increase sight distance (5).

b. Make driveway improvements (7).

c. Improve access management (8).

d. Provide path intersection treatments for shared-use paths adjacent to the roadway (32).

e. Provide path intersection warning treatments for shared-use paths adjacent to the roadway.

f. Optimize signal timing to create gaps mid-block (35).

g. Make sign improvements (37).

h. Improve pavement markings (38).

i. Provide law enforcement (40).

j. Provide bicyclist education (41).

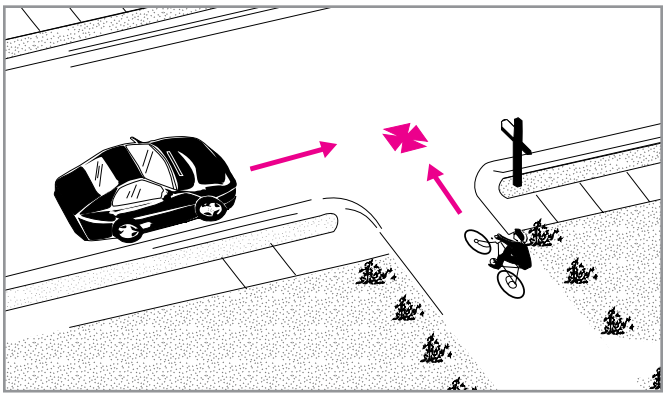
k. Provide motorist education (42).

6. BICYCLIST RODE OUT—MIDBLOCK

The bicyclist rides out from a residential driveway, commercial driveway, sidewalk, or other midblock location into the road and is struck by or collides with a motorist.

Possible Cause/Problem

The bicyclist rides out from a residential driveway, commercial driveway, sidewalk, or other midblock location into the road without stopping or yielding and is struck by a motorist. This crash type is a common one for young children who fail to stop and scan for vehicles before crossing the road or pulling out into traffic. Motorists speeding through neighborhood streets increase the risk of being unable to avoid this type of crash, so traffic calming measures may be appropriate.



General Countermeasures

a. Make parking improvements to increase visibility (5).

b. Install medians or crossing islands (6).

c. Make driveway improvements (7).

d. Improve access management (8).

e. Reduce number of lanes (9).

f. Reduce lane width (10).

g. Install traffic calming measures (26, 27, 28, 29).

h. Provide path intersection treatments for midblock roadway crossings (32).

i. Provide path intersection advance warnings treatments (33).

j. Optimize signal timing to create gaps mid-block (35).

k. If midblock signal is installed, add bike detection or activated signal (36).

l. Provide school zone improvements (39).

m. Provide law enforcement (40).

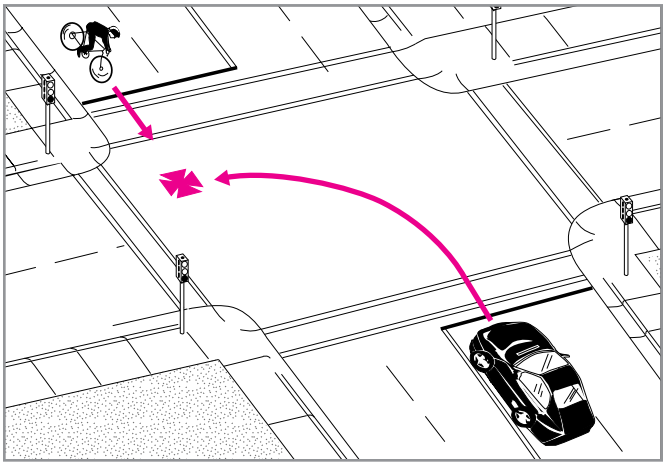
n. Provide bicyclist education (41).

7. MOTORIST TURNED OR MERGED LEFT INTO PATH OF BICYCLIST

The motorist turns left into the path of an oncoming bicyclist or turns or merges left across the path of a bicyclist who is traveling straight in the same direction as the motorist. This crash can also involve motorists or bus or delivery vehicles pulling out of parking spaces or stops.

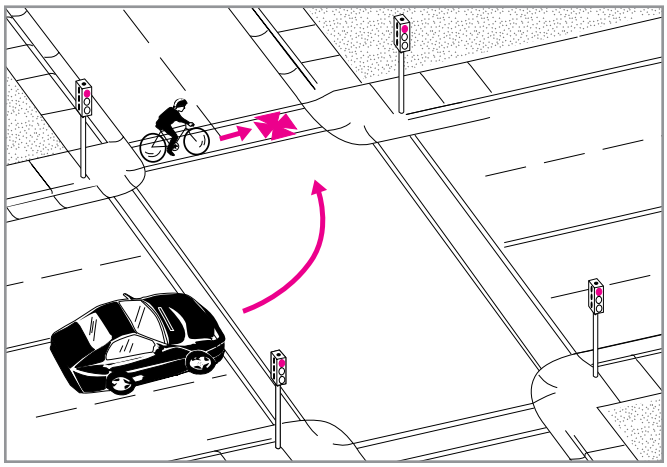
Possible Cause/Problem #1

The motorist turns left into the path of an oncoming bicyclist. The problem frequently occurs at signalized intersections on roads with four or more lanes, but may occur at driveways and other non-signalized junctions. The left-turning motorist is waiting for a gap in oncoming traffic and fails to look for, see, or yield to the oncoming bicyclist.



Possible Cause/Problem #2

A motorist turns or merges left across the path of a bicyclist who is traveling straight ahead in the same direction as the motorist. Many times this crash occurs at an intersection or driveway where the bicyclist is riding the wrong way against traffic or is riding the wrong way against traffic on the sidewalk. Reducing wrong-way riding would be a goal of bicyclist education and other countermeasures. Most general countermeasures are the same for these first two types of crashes.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Install medians or crossing islands (6).

c. Make driveway improvements (7).

d. Improve access management (8).

e. Provide bike lanes (11).

f. Provide paved shoulders (13).

g. Reduce curb radii or redesign skewed intersections (16).

h. Install roundabout (17).

i. Enhance intersection markings (18).

j. Make sight distance improvements at intersection (19).

k. Restrict left turns (20).

l. Implement mini traffic circle (25).

m. Install traffic diversion (29).

n. Install raised intersection (30).

o. Provide path intersection treatments for shared-use paths adjacent to the roadway (32).

p. Provide path intersection warnings/advance treatments for shared-use paths adjacent to the roadway (33).

q. Install or optimize signal timing (dedicated left turn) (35).

r. Add sign improvements (37).

s. Provide bicyclist education (41).

t. Provide motorist education (42).

Possible Cause/Problem #3

A motorist merges left across the path of a bicyclist traveling straight ahead at an on/off ramp or other merge or weave area.

General Countermeasures

a. Improve roadway lighting (4).

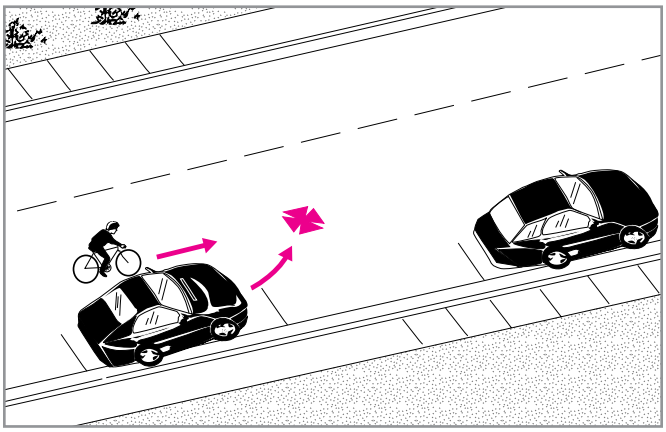
b. Enhance intersection markings (18) or make pavement marking improvements (38).

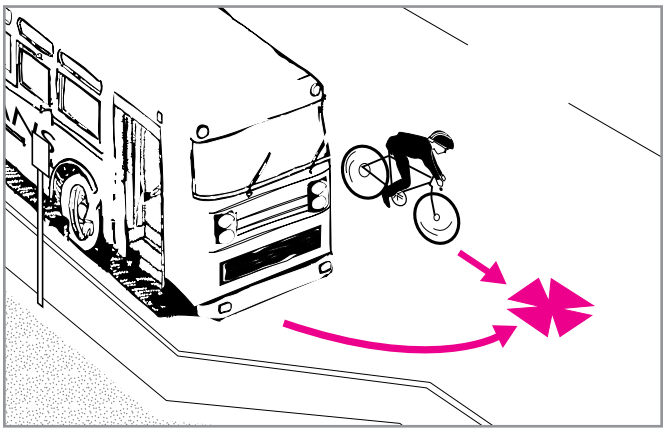
c. Add sign improvements (37).

d. Redesign merge area (21).

Possible Cause/Problem #4

A motorist, bus, or delivery vehicle strikes a bicyclist when pulling out of a parking space or stop.





General Countermeasures

a. Add/improve roadway lighting (4).

b. Provide parking treatments (5).

c. Provide transit stop treatments (covered under bike lanes) (11).

d. Provide combination lanes (14).

e. Provide bicyclist education (41).

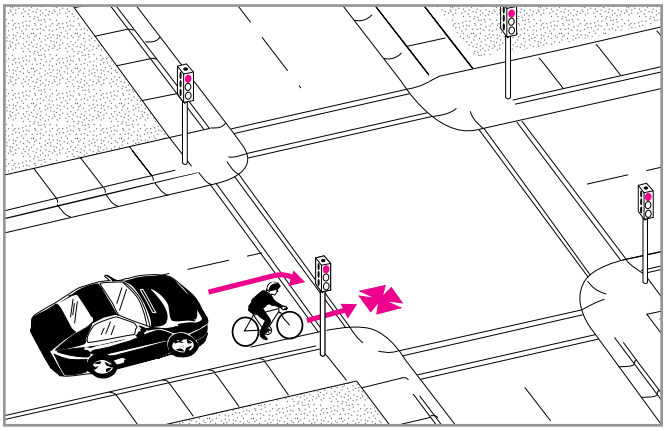
f. Provide motorist education (42).

8. MOTORIST TURNED OR MERGED RIGHT INTO PATH OF BICYCLIST

The motorist turns right into the path of a bicyclist traveling in the same direction or a motorist turning right strikes an oncoming bicyclist who is riding against traffic. This crash can also involve motorists pulling into parking spaces, bus or delivery vehicle pull-overs, or motorists making right turns on red.

Possible Cause/Problem #1

At an intersection, merge area, or driveway, the motorist turns or merges right across the path of a bicyclist who is traveling straight ahead in the same direction. The motorist may misjudge the speed of the bicyclist or believe (mistakenly) that the bicyclist should wait for them.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Provide parking treatments (5).

c. Make driveway improvements (7).

d. Improve access management (8).

e. Reduce number of travel lanes to slow motor vehicle speeds (9).

f. Reduce lane width to encourage bicyclists to take the lane (in low-speed areas) (10).

g. Provide bike lanes (11).

h. Provide paved shoulders (13).

i. Reduce curb radii (16).

j. Improve intersection markings (18).

k. Implement turning restrictions (20).

l. Redesign merge areas (21).

m. Install traffic diversion (29).

n. Add raised intersection (30).

o. Provide path intersection treatments for shared-use paths adjacent to the roadway (32).

p. Provide path intersection warnings/advance treatments for shared-use paths adjacent to the roadway (33).

q. Make sign improvements (37).

r. Improve pavement markings (38).

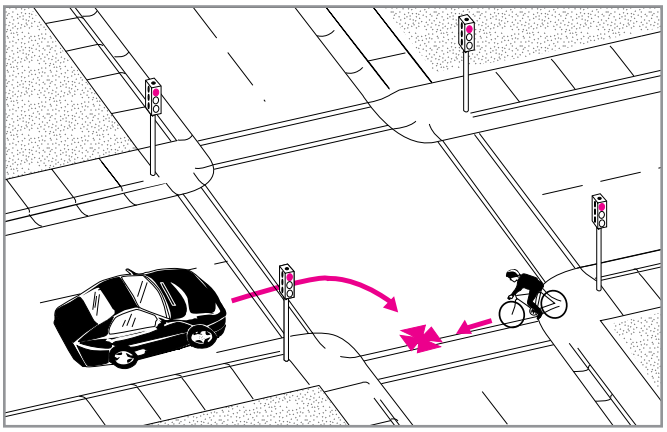
s. Provide law enforcement (40).

t. Provide bicyclist education (41).

u. Provide motorist education (42).

Possible Cause/Problem #2

A motorist turns right, striking a bicyclist approaching from the opposite direction. The bicyclist is most likely riding the wrong way, against traffic, but could be legally riding on the sidewalk or an adjacent shared-use path. This crash may involve a right-turn-on-red, with the bicyclist possibly violating a red signal since the crash type involves traveling on a parallel path to the motorist.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Make driveway improvements (7).

c. Implement turning restrictions (20).

d. Install traffic diversion (29).

e. Provide path intersection treatments for shared-use paths adjacent to the roadway (32).

f. Provide path advance of intersection warning treatments for shared-use paths adjacent to the roadway (33).

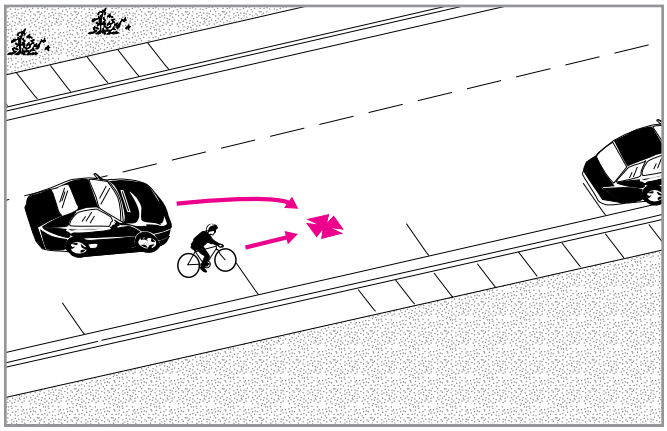
g. Make sign improvements (37).

h. Provide bicyclist education (41).

i. Provide motorist education (42).

Possible Cause/Problem #3

A motorist, bus, or delivery vehicle strikes a bicyclist when pulling into a parking space or stop.



General Countermeasures

a. Add/improve roadway lighting (4).

b. Provide parking treatments (5).

c. Provide transit stop treatments (covered under bike lanes) (11).

d. Provide combination lanes (14).

e. Provide bicyclist education (41).

f. Provide motorist education (42).

Possible Cause/Problem #4

A motorist merges right across the path of a bicyclist traveling straight ahead at an on/off ramp or other merge/weave area..

General Countermeasures

a. Improve roadway lighting (4).

b. Enhance intersection markings (18) or make pavement marking improvements (38).

c. Add sign improvements (37).

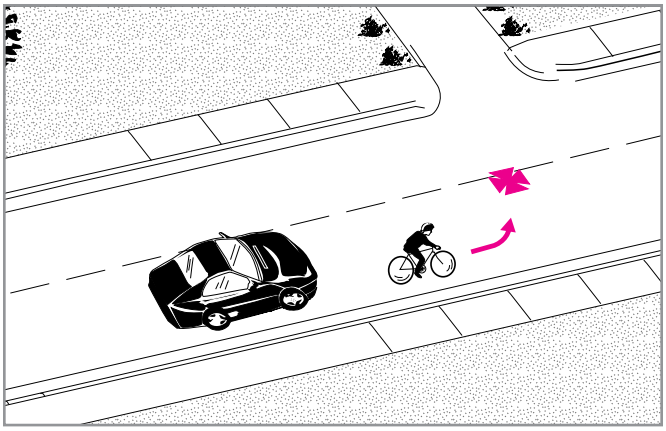
d. Redesign merge area (21).

9. BICYCLIST TURNED OR MERGED LEFT INTO PATH OF MOTORIST

The bicyclist turns or merges left into the path of an overtaking motorist who is traveling straight ahead in the same direction as the bicyclist, or a bicyclist turning left strikes an oncoming motorist. This crash can also involve a bicyclist riding out from a sidewalk or path beside the road. The bicycle and the motor vehicle are initially on parallel paths.

Possible Cause/Problem #1

The bicyclist turns or merges left from the right side of the roadway. The rider fails to see or yield to a motorist coming from behind and is hit by the overtaking motorist. The crash also could involve a bicyclist riding out from a sidewalk or path beside the road. Speed of overtaking vehicles may be a factor in this group of crashes. The motorist also may not see the bicyclist, or may not suspect that the bicyclist will turn in front in time to react.



General Countermeasures

a. Make roadway surface hazard improvements (1).

b. Add/improve roadway lighting (4).

c. Provide parking improvements (5).

d. Reduce number of lanes/road diet (9).

e. Reduce lane width in low-speed areas to encourage shared-lane use (10).

f. Install roundabout (17).

g. Improve intersection markings (18).

h. Perform repetitive and short-term maintenance to reduce surface hazards (22).

i. Perform major maintenance (23).

j. Institute a hazard identification program (24).

k. Install mini traffic circle (25).

l. Provide traffic calming treatments (26, 27, 28) to slow motor vehicle speeds.

m. Divert traffic (29).

n. Install raised intersection (30).

o. Provide path intersection treatments (parallel paths adjacent to the roadway) (32).

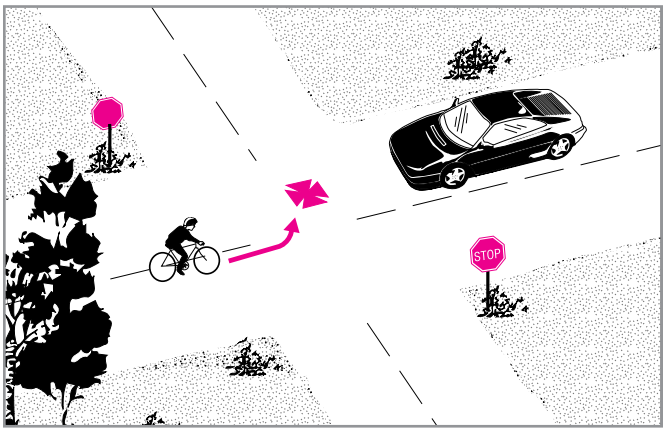
p. Provide path intersection warnings/advance treatments (33).

q. Make pavement marking improvements (38).

r. Provide bicyclist education (41).

Possible Cause/Problem #2

The bicyclist attempts to make a left turn and rides into the path of an oncoming motorist. The crash could occur at an intersection, a midblock driveway, or a shared-use path.



General Countermeasures

a. Install medians or crossing islands (6).

b. Improve driveways (7).

c. Improve access management (8).

d. Reduce number of lanes/road diet (9).

e. Reduce lane width (10).

f. Install roundabout (17).

g. Improve intersection markings (18).

h. Improve sight distance (19).

i. Install mini traffic circle (25).

j. Provide trail intersection treatments (32).

k. Provide trail intersection warnings/advance treatments (33).

l. Install/optimize signal timing (35).

m. Add bike activated signals (36).

n. Make pavement marking improvements (38).

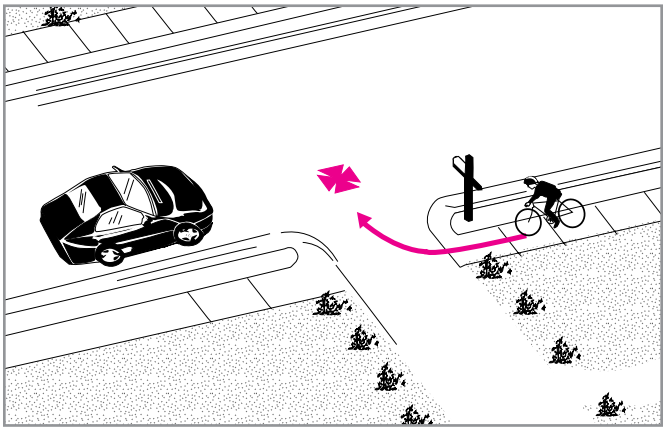
o. Provide bicyclist education (41).

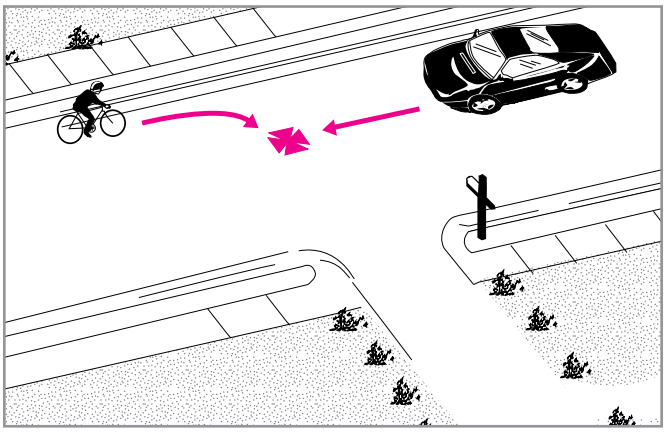
10. BICYCLIST TURNED OR MERGED RIGHT INTO PATH OF MOTORIST

The bicyclist turns or merges right into the path of an oncoming motorist, or a bicyclist turns right across the path of a motorist traveling in the same direction as the bicyclist. This crash can also involve a bicyclist riding out from a sidewalk or shared-use path beside the road. The bicycle and the motor vehicle are initially on parallel paths.

Possible Cause/Problem #1

The bicyclist turns or merges right into the path of an oncoming motorist. The crash could occur at an intersection or mid-block. The bicyclist may be riding out from an adjacent sidewalk or shared-use path or attempting to make a right turn from the wrong side of the roadway.





General Countermeasures

a. Reduce number of lanes/road diet to gain space for bike lanes (9).

b. Reduce lane width (10).

c. Install bike lanes on both sides of the street (11).

d. Provide/improve intersection markings (18).

e. Perform repetitive and short-term maintenance (22).

f. Perform major maintenance (23).

g. Institute a hazard identification program (24).

h. Add traffic calming treatments to slow motorist speeds (25, 26, 27, 28, 29, 30).

i. Provide path intersection treatments for shared-use paths adjacent to the roadway (32).

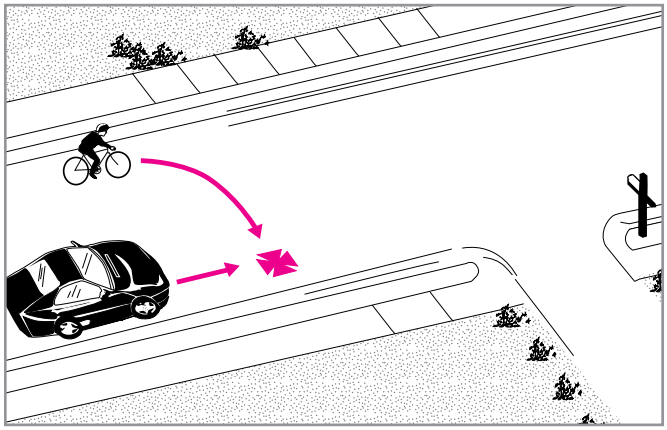
j. Provide path intersection warnings/advance treatments for shared-use paths adjacent to the roadway (33).

k. Make pavement marking improvements (38).

l. Provide bicyclist education on wrong-way riding (41).

Possible Cause/Problem #2

The bicyclist turns or merges right into the path of a motorist who is traveling straight ahead in the same original direction as the bicyclist. The bicyclist may be attempting to change lanes to make a right turn. This crash can also involve a bicyclist riding out from a sidewalk or shared-use path beside the road or changing from traveling facing traffic (wrong side of the street) to the correct side of the street.



General Countermeasures

a. Reduce number of lanes/road diet to gain space for bike lanes (9).

b. Reduce lane width to slow motor vehicle speeds (10).

c. Install bike lanes on both sides of the street (11).

d. Provide or improve intersection markings (18).

e. Institute good maintenance practices to reduce surface and other hazards (22, 23, 24).

f. Add traffic calming treatments (25, 26, 27, 28, 29, 30).

g. Provide trail intersection treatments for shared-use paths adjacent to the roadway (32).

h. Provide trail intersection warnings/advance treatments for shared-use paths adjacent to the roadway (33).

i. Make pavement marking improvements (38).

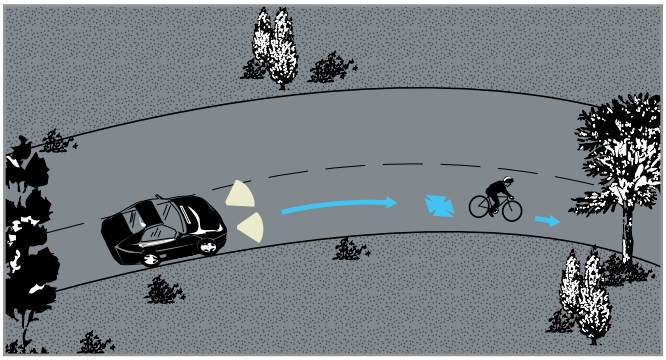
j. Provide bicyclist education on wrong-way riding and scanning behind (41).

11. MOTORIST OVERTAKING BICYCLIST

The motorist is overtaking a bicyclist and strikes the bicyclist from behind. These crashes tend to occur because the motorist fails to detect the bicyclist, the bicyclist swerves to the left to avoid an object or surface irregularity, or the motorist misjudges the space necessary to pass the bicyclist.

Possible Cause/Problem #1

The motorist is overtaking and fails to detect a bicyclist, striking the bicyclist from behind. These crashes often occur at night, and one or both parties may have been drinking. The bicyclist may have inadequate lights or reflectors, or may not be using lights.



General Countermeasures

a. Provide space on bridges/overpasses (2).

b. Provide space and other measures in tunnels/underpasses (3).

c. Add/improve roadway lighting (4).

e. Provide space on roadway for bicyclists with bike lanes (11), wide curb lanes (12), paved shoulders (13), or combination lanes (14).

f. Provide chicanes or serpentine for low-speed, shared-lane situations (26).

g. Provide other traffic calming measures (27, 28, 29).

h. Provide a separate path or trail (31).

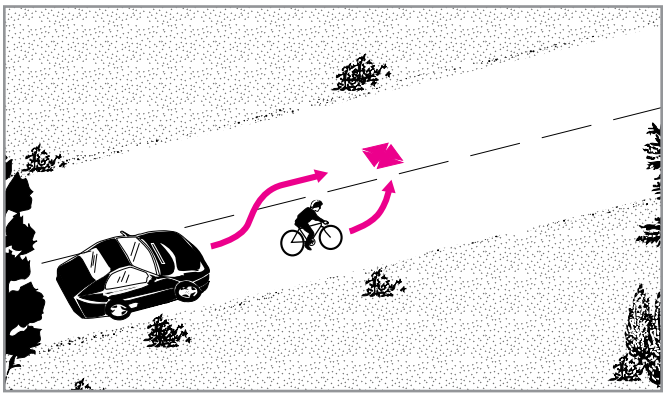
i. Make sign improvements (37).

j. Improve pavement markings (38).

k. Provide bicyclist education about conspicuity and riding at night (41).

l. Provide motorist education (42).

Possible Cause/Problem #2
The overtaking motorist strikes a bicyclist suddenly swerving to the left, possibly to avoid an object or surface irregularity, extended door of a parked car, or other obstacle.



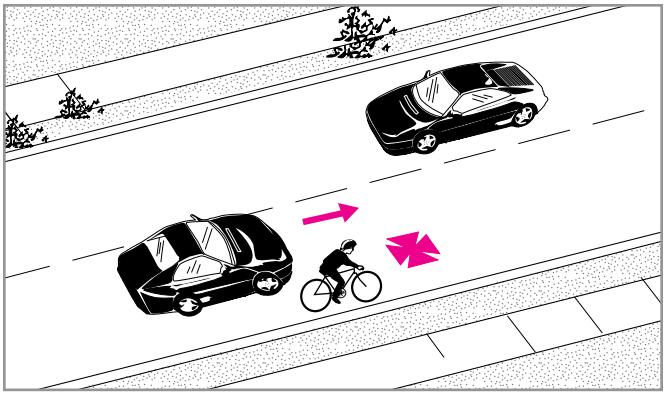
General Countermeasures

a. Make roadway surface hazard improvements (1).
b. Add/improve roadway lighting (4).
c. Provide parking improvements (5).
d. Make driveway improvements (7).
e. Provide bike lanes (11).
f. Provide wide curb lanes (12).
g. Provide paved shoulders (13).
h. Perform repetitive and short-term maintenance (22), major maintenance (23), and institute a hazard identification program (24).
i. Provide chicanes or serpentine design or other traffic calming measures (26, 27, 28, 29).
j. Provide a separate path or trail (31).
k. Make sign improvements (37).
l. Improve pavement markings (38).
m. Provide bicyclist education about avoiding objects and correct spacing from parked motor vehicles (41).
n. Provide motorist education (42).

Possible Cause/Problem #3
The overtaking motorist detects the bicyclist ahead but fails to allow enough space to safely pass the bicyclist.

General Countermeasures

a. Make roadway surface hazard improvements (1).
b. Provide space on bridges and overpasses (2).
c. Provide space and other measures in tunnels and underpasses (3).

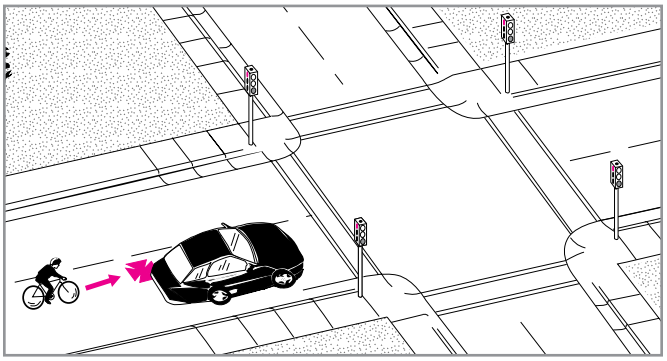


d. Add/improve roadway lighting (4).
e. Reduce lane width (on low speed roads) to encourage bicyclist to "take the lane" (10).
f. Provide space for bicyclists on high speed roadways with bike lanes (11), wide curb lanes (12), or paved shoulders (13).
g. Identify maintenance needs and perform routine and major maintenance (22, 23, 24).
h. Provide chicanes or chicane-like parking (26).
i. Provide a separate shared-use path (31).
j. Make sign improvements (37).
k. Improve pavement markings (38).
l. Provide bicyclist education (41).
m. Provide motorist education (42).

12. BICYCLIST OVERTAKING MOTORIST

The bicyclist is overtaking and strikes the motor vehicle from behind. These crashes tend to occur because the bicyclist tries to pass on the right or left, the bicyclist strikes a parked vehicle while passing, or the bicyclist strikes an extended door on a parked vehicle while passing.

Possible Cause/Problem #1
The overtaking bicyclist strikes a motor vehicle while attempting to pass on either the right or the left.



General Countermeasures

a Provide space for bicyclists with bike lanes (11), wide curb lanes (12), paved shoulders (13), or combination lanes (14).

b. Perform repetitive and short-term maintenance (22).

c. Perform major maintenance (23).

d. Institute a hazard identification program (24).

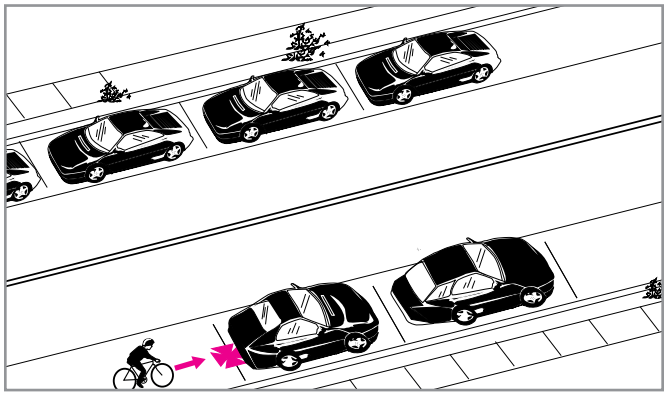
e. Provide a separate shared-use path (31).

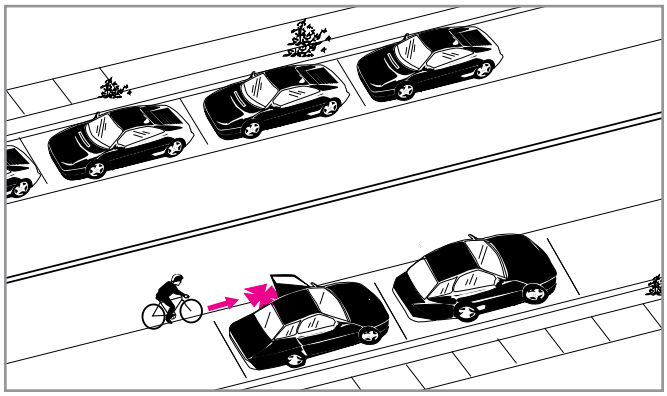
f. Improve pavement markings (38).

g. Provide bicyclist education (41).

Possible Cause/Problem #2

The overtaking bicyclist strikes a parked motor vehicle or extended door of a parked motor vehicle while attempting to pass on either the right or the left.





General Countermeasures

a. Implement parking treatments (5).

b. Provide bike lanes (11).

c. Provide wide outside lanes (12).

d. Provide paved shoulders (13).

e. Provide a separate shared-use path (31).

f. Improve pavement markings (38).

g. Provide bicyclist education (41).

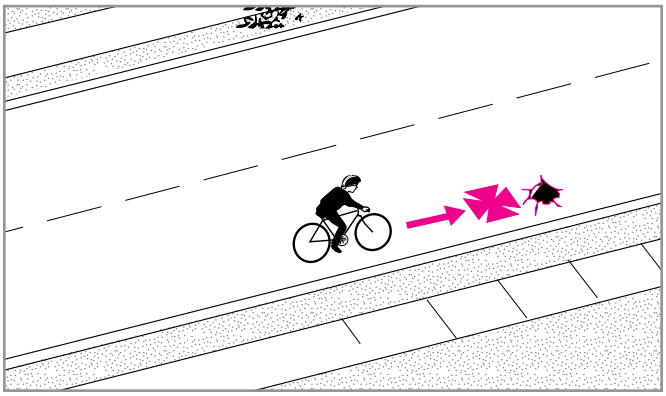
h. Provide motorist education (42).

13. NON-MOTOR VEHICLE CRASHES

These crashes do not involve a motor vehicle and can occur in a variety of ways, including falls from a bike, a collision between two bicycles, a collision between a bike and a pedestrian, or a bicyclist striking an object.

Possible Cause/Problem #1

The bicyclist loses control due to a pavement surface irregularity, debris, or other hazard.



General Countermeasures

a. Make roadway surface hazard improvements (1).

b. Improve bridge access and surfaces (2).

c. Improve tunnel access and surfaces (3).

d. Add/improve roadway lighting (4).

e. Make driveway improvements (5).

f. Perform repetitive and short-term maintenance (22).

g. Perform major maintenance (23).

h. Institute a hazard identification program (24).

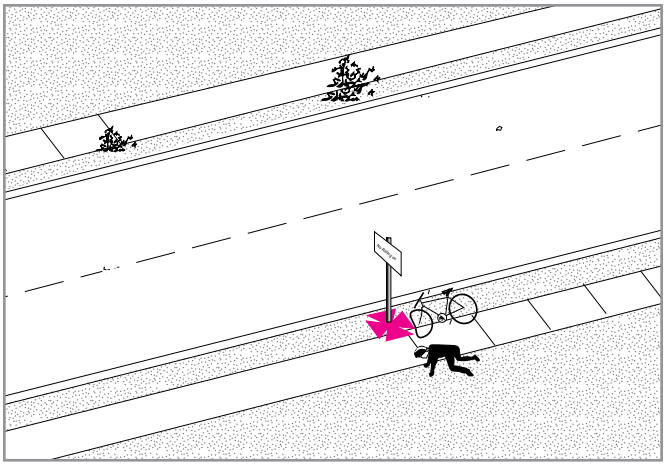
i. Implement "share the path" measures (34).

j. Improve pavement markings (38).

k. Provide bicyclist education (41).

Possible Cause/Problem #2

The bicyclist strikes a pedestrian, object or other bicyclist on a shared-use path, sidewalk, or roadway.



General Countermeasures

a. Make roadway surface hazard improvements (1).

b. Add/improve lighting (4).

c. Make parking improvements (5).

d. Implement maintenance countermeasures (22, 23, 24).

e. Provide path intersection treatments (32).

f. Provide path intersection advance warning treatments (33).

g. Implement "share the path" measures (34).

h. Improve pavement markings (38).

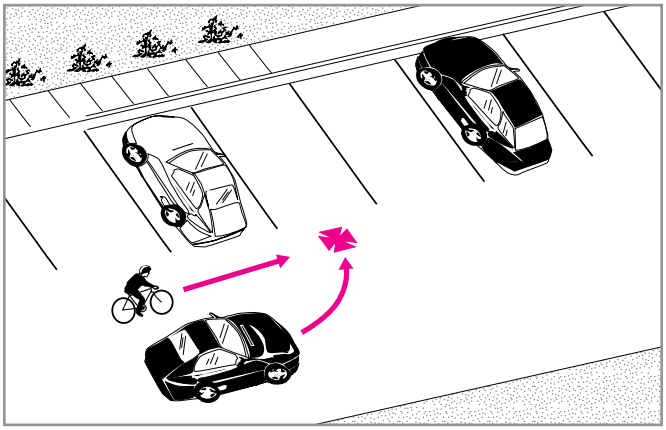
i. Provide school zone improvements (39).

j. Provide bicyclist education (41).

14. NON-ROADWAY AND OTHER CRASHES

Possible Cause/Problem #1 (Non-Roadway)

A motorist and bicyclist collide in a parking lot or driveway. The motor vehicle may be backing at the time of the crash.



General Countermeasures

a. Add/improve lighting (4).

b. Redesign parking (5).

c. Make driveway improvements (7).

d. Perform repetitive and short-term maintenance (22).

e. Perform major maintenance (23).

f. Institute a hazard identification program (24).

g. Provide speed tables, humps, or cushions (27).

h. Make sign improvements (37).

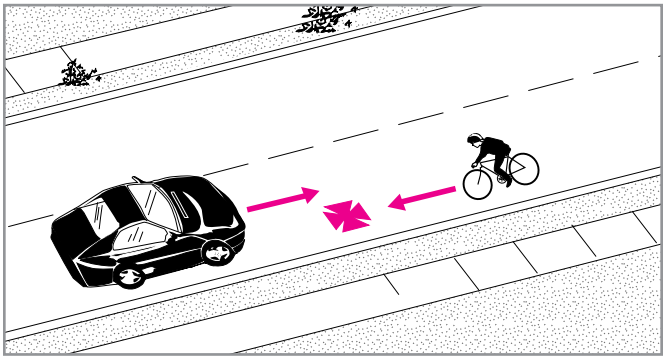
i. Improve pavement markings (38).

j. Provide bicyclist education (41).

k. Provide motorist education (42).

Possible Cause/Problem #2 (Other)

Either the bicyclist or the motorist was traveling in the wrong lane or direction and collided head-on with the other. The bicyclist could have been riding on the wrong side of the roadway or the motorist could have been passing another vehicle when the crash occurred.



General Countermeasures

a. Add or improve roadway lighting (4).

b. Provide bike lanes (11).

c. Provide paved shoulders (13).

d. Complete repetitive and short-term maintenance (general sight distance maintenance) (22, 24).

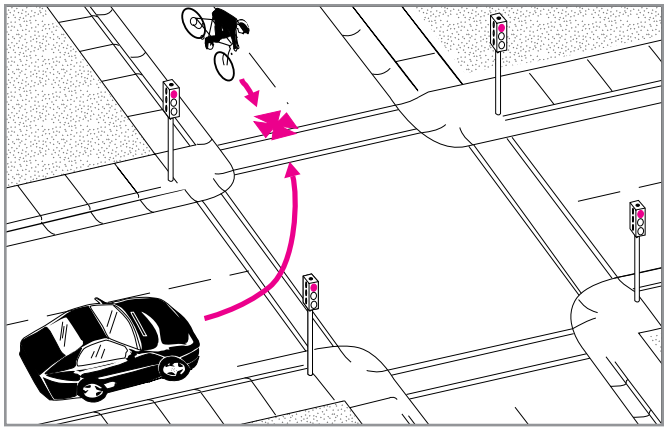
e. Provide law enforcement (40).

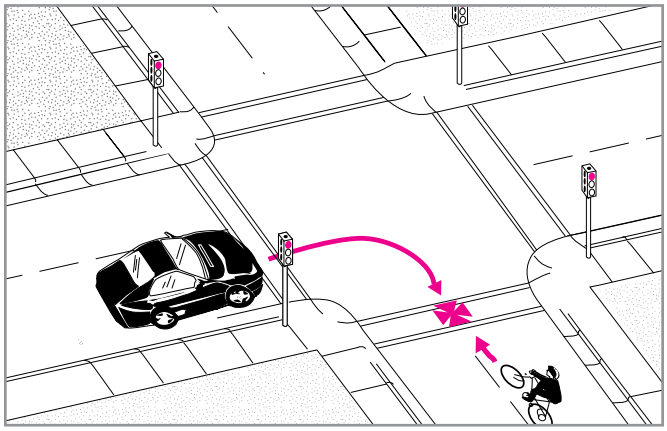
f. Provide bicyclist education about wrong-way riding and conspicuity and using lights at night (41).

g. Provide motorist education on safe passing (42).

Possible Cause/Problem #3 (Other)

Either the bicyclist or motorist made a turning error (swung too wide on a right turn or cut the corner on a left turn) and turned into the opposing lane or path of the other.





General Countermeasures

a. Install median divider (6).

b. Make driveway improvements (7).

c. Revise curb radii or re-align skewed intersections (16).

d. Install roundabout (17) or mini traffic circle (25) at intersection.

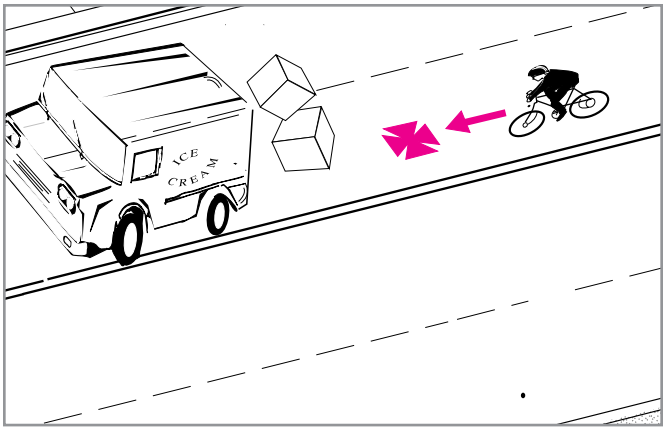
e. Add or improve intersection markings (18).

f. Impose turning restrictions (20).

g. Install raised intersection (30).

Possible Cause/Problem #4 (Other)

The bicyclist or motorist intentionally caused the crash, one or the other lost control due to impairment, mechanical problems, or other causes, or there were other unusual circumstances such as the bicyclist being struck by falling cargo. Few specific countermeasures can be identified for unusual or non-specific types of crashes other than educational and enforcement measures. To view general performance objectives and corresponding countermeasures to reduce crashes and encourage safer bicycling, go to the Performance Objectives section.



CRASH-RELATED COUNTERMEASURES

A total of 50 different bicyclist countermeasures are presented in Chapter 5 of this guide. To assist engineers and planners who may want further guidance on which measures are appropriate to address certain types of bicycle crashes, a matrix is provided on pages 32–33. The applicable treatments within the nine categories of countermeasures are shown for each of the 13 crash type groups.

To illustrate how to use the table, consider the sixth crash type group in the table ("Bicyclist Ride Out—Mid-block"). This is a crash involving a bicyclist riding out into the roadway from a location in the middle of the block, such as a residential driveway. This tends to be a right-angle crash and often involves younger bicyclists.

The chart shows that there are 17 potential countermeasures that may reduce the probability of this type of crash, depending on the site conditions. These countermeasures include shared roadway improvements, such as removal of parking to increase sight distance, traffic calming measures such as speed humps that could slow motor vehicle speeds and decrease the braking distance, and other possible countermeasures.

In Chapter 5, details are provided on each of the countermeasures listed. The quick reference index at the start of Chapter 5 can be used to easily locate the page containing the detailed description. The Web/CD-ROM application allows the list of countermeasures to be refined on the basis of site characteristics (see Chapter 4).

These charts are intended to give general information on candidate solutions that should be considered when trying to reduce a pattern of bicycle crashes at a specific location or roadway section. Many bicyclist crashes are the direct result of careless or illegal motorist behavior or unsafe bicyclist behavior. Many of these crashes can-

not necessarily be prevented by roadway improvements alone. In such cases, bicyclist and motorist education and enforcement activities may be helpful.

PERFORMANCE OBJECTIVES

Bicyclists face a variety of challenges when they ride along and across streets with motor vehicles. Communities are asking for help to "slow traffic down," and "make the street more inviting to bicyclists."

The following is a list of requests (objectives) that transportation professionals are likely to face when working to provide bicycle safety and mobility:

- Provide safe on-street facilities/space for bicyclists.
- Provide off-road paths or trails for bicyclists.
- Provide and maintain quality surfaces for bicyclists.
- Provide safe intersections for bicyclists.
- Improve motorist behavior/compliance with traffic laws.
- Improve bicyclist behavior/compliance with traffic laws.
- Encourage and promote bicycling.

Each of these objectives can be accomplished through a variety of the individual treatments presented in this chapter. Yet, most treatments will work best when used at multiple locations and in combination with other treatments.

In addition, many of the treatments will accomplish two or more objectives. The key is to make sure that the right treatments are chosen to accomplish the desired effect.

The matrix located on pages 34–35 shows which countermeasures are appropriate to consider for the seven performance objectives. In using the chart, it is important to remember that it is simply a guide. In all cases, good engineering judgment should be applied when making decisions about what treatment will be best for a specific location.

PROGRAM OF IMPROVEMENTS

While some bicycle crashes are associated with deficient roadway designs, bicyclists and motorists often contribute to crashes through a disregard or lack of understanding of laws and safe driving or riding behavior.[9] Because most crashes are a result of human error, crashes will not be completely eliminated as long as bicyclists and motor vehicles share the same space. The consequences of these crashes are exacerbated by speeding, failing to yield, or failing to check both directions for traffic, so new education, enforcement, and engineering tools are needed to manage the conflicts between bicyclists and drivers.

A complete program of bicyclist safety improvements includes:

- Shared roadway accommodations, such as provision of roadway surface improvements or lighting where needed.
- Provision of bicyclist facilities, such as bike lanes, wide curb lanes and separate trails.
- Provision of intersection treatments, such as curb radii revisions and sight distance improvements.
- Maintenance of roadways and trails.
- Use of traffic calming treatments, such as mini circles and speed control measures.
- Adequate signs, signals, and markings, particularly as pertains to intersections and share-the-road philosophies.
- Programs to enforce existing traffic laws and ordinances for motorists (e.g., obeying speed limits, yielding to approaching bicyclists when turning, traffic signal compliance, obeying drunk-driving laws) and bicyclists (e.g., riding in the same direction with traffic, obeying traffic signals and signs).
- Encouraging bicyclists to use reflective clothing and appropriate lighting when riding at night.
- Encouraging and educating bicyclists in proper helmet use.
- Education programs provided to motorists and bicyclists.
- Providing support facilities, such as bicycle parking and events, such as ride-to-work days or fundraisers to support bicycling.

Roadway improvements can often reduce the likelihood of a bicycle-motor vehicle crash. Physical improvements are most effective when tailored to an individual location and traffic problem. Factors to consider when choosing an improvement include: location characteristics, bicycle and motor vehicle volume and types, motor vehicle speed, design of a given location, city laws and ordinances, and financial constraints. Many of these factors are included for consideration in the BIKESAFE Selection Tool (see Chapter 4).

It is important to remember that overuse or unjustified use of any traffic control measure is not recommended, since this may breed disrespect for such devices. While facilities and shared roadway accommodations for bicyclists can, in many cases, reduce the risk of collisions, crash reduction is not the only reason for providing such accommodations. Other benefits include improved access to destinations by riding, better air quality due to less dependence on driving, and improved personal health. Traffic and transportation engineers have the responsibility

for providing facilities for all modes of travel, including bicycling (and walking).

COUNTERMEASURES ASSOCIATED WITH SPECIFIC CRASH GROUPS

Crash Type	Shared Roadway	On-Road Bike Facilities	Intersection Treatments	Maintenance
1) Motorist failed to yield – signalized intersection	· Lighting Improvements · Reduce Lane Number · Reduce Lane Width		· Curb Radii Revisions · Roundabouts · Intersection Markings · Sight Distance Improvements · Turning Restrictions	·
2) Motorist failed to yield – non-signalized intersection	· Lighting Improvements · Reduce Lane Number · Reduce Lane Width		· Curb Radii Revisions · Roundabouts · Intersection Markings · Sight Distance Improvements · Merge and Weave Area Redesign	
3) Bicyclist failed to yield – signalized intersection	· Lighting Improvements · Median/Crossing Island · Reduce Lane Number · Reduce Lane Width		· Roundabouts · Intersection Markings · Sight Distance Improvements	
4) Bicyclist failed to yield – non-signalized intersection	· Lighting Improvements · Reduce Lane Number · Reduce Lane Width		· Roundabouts · Intersection Markings · Sight Distance Improvements · Merge and Weave Area Redesign	
5) Motorist drive out – midblock	· Parking Treatments · Driveway Improvements · Access Management			
6) Bicyclist ride out – midblock	· Parking Treatments · Median/Crossing Island · Driveway Improvements · Access Management · Reduce Lane Number · Reduce Lane Width			
7) Motorist turned or merged left into path of bicyclist	· Lighting Improvements · Parking Treatments · Median/Crossing Island · Driveway Improvements · Access Management · Reduce Lane Number	· Bike Lanes · Paved Shoulders · Combination Lanes	· Curb Radii Revisions · Roundabouts · Intersection Markings · Sight Distance Improvements · Turning Restrictions · Merge and Weave Area Redesign	
8) Motorist turned or merged right into path of bicyclist	· Lighting Improvements · Parking Treatments · Driveway Improvements · Access Management · Reduce Lane Number · Reduce Lane Width	· Bike Lanes · Paved Shoulders · Combination Lanes	· Curb Radii Revisions · Intersection Markings · Turning Restrictions · Merge and Weave Area Redesign	
9) Bicyclist turned or merged left into path of motorist	· Roadway Surface Improvements · Lighting Improvements · Parking Treatments · Median/Crossing Island · Driveway Improvements · Access Management · Reduce Lane Number · Reduce Lane Width		· Roundabouts · Intersection Markings · Sight Distance Improvements	· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
10) Bicyclist turned or merged right into path of motorist	· Reduce Lane Number · Reduce Lane Width	· Bike Lanes	· Intersection Markings	· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
11) Motorist overtaking bicyclist	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access · Lighting Improvements · Parking Treatments · Reduce Lane Width	· Bike Lanes · Wide Curb Lanes · Paved Shoulders · Combination Lanes		· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
12) Bicyclist overtaking motorist	· Parking Treatments	· Bike Lanes · Wide Curb Lanes · Paved Shoulders · Combination Lanes		· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
13) Non-motor vehicle crashes	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access · Lighting Improvements · Parking Treatments · Driveway Improvements			· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program

Traffic Calming	Trails/Shared-Use Paths	Markings, Signs, Signals	Education and Enforcement
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/Cushions · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Bicyclist Education · Motorist Education
· Mini Traffic Circles · Chicanes · Visual Narrowing · Speed Tables/Humps/Cushions · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Bicyclist Education · Motorist Education
· Mini Traffic Circles	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Bicyclist Education · Motorist Education
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/Cushions · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Bicyclist Education · Motorist Education
	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Sign Improvements · Pavement Marking Improvements	· Law Enforcement · Bicyclist Education · Motorist Education
· Chicanes · Speed Tables/Humps/Cushions · Visual Narrowing · Traffic Diversion	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · School Zone Improvements	· Law Enforcement · Bicyclist Education
· Mini Traffic Circles · Traffic Diversion · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Sign Improvements · Pavement Marking Improvements	· Bicyclist Education · Motorist Education
· Traffic Diversion · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Sign Improvements · Pavement Marking Improvements	· Bicyclist Education · Motorist Education
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/Cushions · Visual Narrowing · Traffic Diversion · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · Pavement Marking Improvements	· Bicyclist Education
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/Cushions · Visual Narrowing · Traffic Diversion · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Pavement Marking Improvements	· Bicyclist Education
· Chicanes · Speed Tables/Humps/Cushions · Visual Narrowing · Traffic Diversion	· Separate Shared-Use Path	· Sign Improvements · Pavement Marking Improvements	· Bicyclist Education · Motorist Education
	· Separate Shared-Use Path	· Pavement Marking Improvements	· Bicyclist Education · Motorist Education
	· Path Intersection Treatments · Intersection Warning Treatments · Share the Path Treatments	· Pavement Marking Improvements · School Zone Improvements	· Bicyclist Education

COUNTERMEASURES ASSOCIATED WITH SPECIFIC OBJECTIVES

Objectives	Shared Roadway	On-Road Bike Facilities	Intersection Treatments	Maintenance
1) Provide safe on-street facilities/space for bicyclists.	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access · Lighting Improvements · Parking Treatments · Median/Crossing Island · Driveway Improvements · Access Management · Reduce Lane Number · Reduce Lane Width	· Bike Lanes · Wide Curb Lanes · Paved Shoulders · Combination Lanes · Contraflow Bike Lanes		· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
2) Provide off-road paths or trails for bicyclists.				· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
3) Provide and maintain quality surfaces for bicyclists.	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access			· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
4) Provide safe intersections for bicyclists.	· Lighting Improvements · Parking Treatments · Reduce Lane Number · Reduce Lane Width		· Curb Radii Revisions · Roundabouts · Intersection Markings · Sight Distance Improvements · Turning Restrictions · Merge and Weave Area Redesign	
5) Improve motorist behavior/compliance with traffic laws.	· Lighting Improvements · Parking Treatments · Driveway Improvements · Reduce Lane Width		· Curb Radii Revisions · Roundabouts · Intersection Markings · Sight Distance Improvements · Merge and Weave Area Redesign	· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
6) Improve bicyclist behavior/compliance with traffic laws.	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access · Parking Treatments	· Bike Lanes	· Intersection Markings · Sight Distance Improvements · Merge and Weave Area Redesign	· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program
7) Encourage and promote bicycling.	· Roadway Surface Improvements · Bridge and Overpass Access · Tunnel and Underpass Access · Lighting Improvements · Median/Crossing Island	· Bike Lanes · Paved Shoulders		· Repetitive/Short-Term Maintenance · Major Maintenance · Hazard Identification Program

Traffic Calming	Trails/Shared-Use Paths	Markings, Signs, Signals	Education and Enforcement	Support Facilities and Programs
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/ Cushions · Visual Narrowing · Traffic Diversion · Raised Intersection		· Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Practitioner Education	· Wayfinding · Aesthetics/Landscaping
	· Separate Shared-Use Path · Path Intersection Treatments · Intersection Warning Treatments · Share the Path Treatments	· Sign Improvements · Pavement Marking Improvements	· Bicyclist Education · Practitioner Education	· Wayfinding · Aesthetics/Landscaping
		· Pavement Marking Improvements	· Practitioner Education	
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/ Cushions · Raised Intersection	· Path Intersection Treatments · Intersection Warning Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Practitioner Education	
· Mini Traffic Circles · Chicanes · Speed Tables/Humps/ Cushions · Visual Narrowing · Traffic Diversion · Raised Intersection		· Install Signal/Optimize Timing · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Motorist Education	· Bike Maps · Events/Activities
· Mini Traffic Circles	· Path Intersection Treatments · Intersection Warning Treatments · Share the Path Treatments	· Install Signal/Optimize Timing · Bike-Activated Signal · Sign Improvements · Pavement Marking Improvements · School Zone Improvements	· Law Enforcement · Bicyclist Education	· Bike Maps · Events/Activities
	· Separate Shared-Use Path	· Bike-Activated Signal · School Zone Improvements	· Bicyclist Education · Motorist Education · Practitioner Education	· Bike Parking · Transit Access · Bicyclist Personal Facilitie · Bike Maps · Wayfinding · Events/Activities · Aesthetics/Landscaping