Santa Maria Active Transportation Plan
Design Elements Toolkit List

The Santa Maria Design Elements Toolkit List includes safety treatments, or “tools,” that may be incorporated into future roadway safety projects to improve active transportation within the City. All improvement types were reviewed and approved by the City of Santa Maria for consideration in the Active Transportation Plan update.

This Toolkit is organized into the following categories:

• Signal Modifications
• Intersection Treatments
• Bicycle Facility Treatments

Some of the tools may overlap categories. For example, Signal Modifications may also be considered Intersection Treatments.

Relevant design resources and guides referenced include:

• Caltrans Complete Streets Elements Toolbox v2.0
• National Cooperative Highway Research Program (NCHRP) Guidance to Improve Pedestrian & Bicyclist Safety at Intersections
• NACTO Urban Street Design Guide and Urban Bikeway Design Guide
• FHWA Guide for Improving Safety at Uncontrolled Intersection

Each tool includes a brief description of the safety treatment, including:

• Design Contexts – Applicable location and additional factors to consider for implementing.

• Rating – A Crash Modification Factor (CMF) is a measure or rating of effectiveness of a design element. A CMF of less than 1.0 indicates that a treatment has the potential to reduce crashes. A Crash Reduction Factor (CRF) is the percentage crash reduction that might be expected after implementing a given countermeasure at a specific site. The Caltrans Local Roadway Safety Manual Version 1.4 provides CRF for projects that are HSIP funded. The CRF/CMF listed for each tool will cite the research authors when applicable.

• Estimated Cost – A cost range is provided for each tool as of the time of writing. Estimated costs will vary according to several factors.
SANTA MARIA ACTIVE TRANSPORTATION PLAN

SIGNAL MODIFICATION

Exclusive Pedestrian Phase

An exclusive pedestrian phase, also known as a “Barnes Dance,” pedestrian scramble, or all-walk phase, is a phase at signalized intersections that allows pedestrians to cross in any direction. Vehicles at all approaches to the intersection are stopped while pedestrians are given the “WALK” signal. This low-cost treatment can increase pedestrian safety by separating pedestrians in time from vehicles and may improve the efficiency of intersections with heavy pedestrian volumes. It is particularly advantageous in situations where other intersection treatments are cost prohibitive or unable to be implemented due to insufficient right of way.

Figure 1. Pedestrian Scramble (Source: Wikimedia Commons)

Design Contexts

- Densely populated urban areas, often in downtowns
- Signalized intersections with high instances of turning vehicle-pedestrian conflicts
- High pedestrian volumes and either: 1) low to moderate vehicle volumes, or 2) high turning vehicle volumes

CMF / Rating

0.66 for vehicle-pedestrian crashes (ITE 2004).

Estimated Cost

$ = <$2,500
$$ = $2,500–$49,999
$$$ = $50,000–$150,000
$$$$ = >$150,000
Leading Bicycle Intervals (LBIs) provide bicyclists an opportunity to enter an intersection before vehicles are given a green indication. LBIs can be easily programmed into existing signals to give bicyclists an advanced green signal a minimum of three to seven seconds before motorists can proceed through the intersection. This extra time provides through-bicyclists with an opportunity to establish their presence in, or to clear an intersection before motorists start turning. This “head start” increases the percentage of motorists who yield the right of way to bicyclists and can minimize conflicts between bicyclists crossing a roadway and turning motorists. If this treatment is used with a bicycle signal, an agency should request permission to experiment from FHWA. Leading bicycle intervals can be provided automatically with each phase or provided only when actuated (actively or passively). Active detection requires bicyclists to use a pushbutton. Pushbuttons should be placed in such a way that bicyclists do not have to dismount or leave the roadway to activate the signal. Passive bicycle detection is the preferred option (see passive bicycle signal detection).

**Design Contexts**
- Intersections with high bicycle volumes and high turning vehicle volumes
- Locations where a highly-used bicycle route (including shared-use path) must cross a major, signalized intersection to connect users to the rest of the route
- Intersections with contraflow bike lanes or separated bike lanes

**Estimated Cost**
- $ = < $2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = > $150,000

**CMF / Rating**
A CMF rating has not yet been determined; initial research indicates this treatment is promising (Kading 2016).
Leading pedestrian intervals (LPIs) provide pedestrians an opportunity to enter an intersection before vehicles are given a green indication. LPIs can be easily programmed into existing signals to give pedestrians the WALK signal a minimum of three to seven seconds before motorists are allowed to proceed through the intersection. This extra time provides pedestrians with an opportunity to establish their presence in the crosswalk before motorists start turning and provides additional crossing time for those who need it. This head start increases the percentage of motorists who yield the right of way to pedestrians and can minimize conflicts between pedestrians crossing a roadway and turning vehicles. Leading pedestrian intervals can be provided automatically with each phase (i.e., set to “recall”) or provided only when actuated (actively or passively).

**Design Contexts**
- Signalized intersections
- Medium to high turning vehicle volumes and pedestrian volumes

**CMF / Rating**
0.41 for vehicle-pedestrian crashes (Fayish and Gross 2010). A leading pedestrian interval is recognized by FHWA as a Proven Safety Countermeasure.

**Estimated Cost**

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In most communities, right-turn-on-red is a default condition of existing laws. To restrict it, a sign must be posted at the signalized intersection for each approach where the restriction is desired. The purpose of this treatment is to eliminate conflicts between turning vehicles and pedestrians and/or bicyclists during a concurrent walk (or bike signal) phase. Motorists are advised of this restriction with the posting of “No Turn on Red” signs (MUTCD R10-11 series) which may be static or dynamic. Dynamic signs can be used to restrict turns during certain times of day or during certain signal phases; for example, vehicle right turns may be restricted during a bike signal phase. Preliminary research indicates that dynamic signs may be more effective than static ones at inducing motorists to stop before turning right on red (Thomas et al. 2016).

**Design Contexts**
- Signalized intersections
- High volumes of right-turning vehicles and high volumes of bicyclists and/or pedestrians

**CMF / Rating**

0.97 for all crashes (Harkey et al. 2008). This treatment is not well-studied; it is possible that it would result in safety improvements for pedestrians and bicyclists.

**Estimated Cost**

- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = >$150,000
Pedestrian signals and countdown signals provide guidance to pedestrians regarding the permitted signal interval to cross a street and prohibit pedestrian crossings when conflicting traffic may impact pedestrian safety. Ideally, every signalized intersection should have a pedestrian signal head. Countdown signals are indications designed to begin counting down at the beginning of the clearance interval (flashing “DON’T WALK”) and can be set to fixed-time, push button operation, or passive pedestrian detection. They indicate to the pedestrian how much time is left in the crossing phase. The MUTCD requires countdown pedestrian indications for all newly installed traffic signals where pedestrian signals are installed.

Design Contexts
- Any time a new pedestrian signal is installed
- Crossings with exclusive pedestrian phases
- Signalized intersections spanning wide streets
- Crossings with medium to high volumes of pedestrians

CMF / Rating
- 0.30 (Van Houten et al. 2012)
- −0.75 (Markowitz et al. 2006) for vehicle pedestrian crashes; some research has shown no effect or a slightly negative effect (Camden et al. 2012).

Estimated Cost
- $ = <$2,500
- $$ = $2,500−$49,999
- $$$ = $50,000−$150,000
- $$$$ = >$150,000

Figure 5. Pedestrian Countdown Signal
Protected signal phases at intersections provide a way to separate vehicular traffic from pedestrian and/or bicyclist movements in time and space, particularly for left turns when concurrent phasing would result in a conflict with crossing pedestrians and left-turning vehicles, and right-turns when concurrent phasing would result in a conflict with through bicyclists and right-turning vehicles.

**Design Contexts**
- Urban areas, particularly in downtown locations
- Intersections with high volumes of pedestrians or bicyclists and turning vehicles
- Intersections with low to medium vehicle volumes

**CMF / Rating**
0.64 for exclusive pedestrian phase for vehicle-pedestrian crashes (ITE 2004).

**Estimated Cost**

- $ = <$2,500
- $$ = $2,500–$49,999
- $$ = $50,000–$150,000
- $$$$ = >$150,000
Curb extensions (also known as “bulb-outs” or “neck downs”) decrease the width of a roadway through the physical extension of a curb line or sidewalk. Curb extensions may enhance pedestrian safety in several ways: by making pedestrians, bicyclists and motorists more visible to each other; by keeping motor vehicles from parking too close to crossings and blocking sight lines; by reducing crossing distance and thereby exposure; and by narrowing radii at intersections, which may slow right-turning traffic. Curb extensions also tend to allow for better placement of curb ramps and prevent ramps from being blocked by vehicles that park at the corner (Thomas et al. 2016). At signalized locations, it is possible that curb extensions may reduce motorist delay by reducing the amount of signal time that must be devoted to the pedestrian phase due to the shorter crossing distance. Consideration for concrete curb extensions include the presence of storm water inlets and adequate drainage around the curb extension. Detached concrete curb extensions can also be applied which leave existing drainage in place. Detached curb extensions should consider the installation of grates to prevent tripping hazards within the gutter pan gap. Temporary curb extensions can also be installed using low-cost materials (paint, bollards, or even rubberized platforms) for demonstration and evaluation purposes.

**Design Contexts**
- Locations with permanent on-street parking

**CMF / Rating**
A CMF has not yet been determined; initial research indicates this treatment may be effective at increasing driver yielding and improving pedestrian safety (Johnson et al. 2005).

**Estimated Cost**

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**Figure 8. Curb Extension with Stormwater Planting**
Continuous raised medians or hardened centerlines are roadway design treatments designed to provide access management and to separate opposing directions of motor vehicle travel at intersections and midblock locations. They can be extended across an intersection or a driveway, creating a continuous median to provide access management restricting motorists’ turning or crossing movements. Where crosswalks are provided, they must be at least 6 feet in width to provide a pedestrian refuge (see crossing islands) or 8 feet to provide a bicycle refuge. Where used as an access management strategy, they can simplify and improve safety for pedestrians and bicyclists by eliminating motorist left turns. When used at intersections and the hardened centerline or median extends up to or beyond crosswalks, they reduce left turning motorist speeds.

**Design Contexts**
- Locations with permanent on-street parking

**CMF / Rating**
0.54 for all crashes (Bahar et al. 2007); 0.69 for vehicle-pedestrian crashes for raised medians (Zegeer et al. 2017). A raised median is recognized by FHWA as a proven Safety Countermeasure.

**Estimated Cost**
- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = >$150,000
High-visibility crosswalk markings, such as continental or ladder-style, are preferred over parallel line markings to improve visibility to approaching motorists. High-visibility crosswalk markings reinforce legal crosswalks at intersections and create legal crossings at non-intersection locations. These crosswalk markings warn motorists to expect pedestrian crossings and clarify that motorists are expected to yield right-of-way to crossing pedestrians. At uncontrolled locations, high-visibility crosswalk markings identify a preferred crossing location for pedestrians.

Design Contexts
- Uncontrolled locations that meet the requirements listed in MUTCD Section 3B.18 (2009)

CMF / Rating
0.52 for vehicle-pedestrian crashes (Chen et al. 2012).

Estimated Cost

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**INTERSECTION TREATMENT**

**In-Street Pedestrian Crossing Signs**

This treatment involves placing Yield to Pedestrian signs (MUTCD R1-6) in the roadway at the centerline of an uncontrolled crosswalk.

![In-Street Pedestrian Crossing Sign](Source: Jacqui Swartz, LADOT)

**Design Contexts**
- Uncontrolled crossings of multi-lane roadways

**CMF / Rating**

A CMF has not yet been determined, however initial evidence indicates this treatment is promising. This treatment is associated with increased driver yielding and slight reductions in vehicle travel speeds when placed at marked crosswalks (Zegeer et al. 2017).

**Estimated Cost**

- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = >$150,000
Mini traffic circles are a traffic-calming device that can take the place of, or supplement, an all-way stop controlled intersection. They may also be installed at intersections with no control or with all-way or 2-way stop or yield control. Mini-circles are raised circular islands constructed in the center of residential street intersections which require motorists to slow down to maneuver around them. They can eliminate left turns by requiring traffic to exit to the right of the circles. Due to the low-volume nature of the intersections where these are installed, mini traffic circles may be designed to allow larger vehicles to turn left in front of the circle to allow the circle to remain larger in size to provide the desired traffic calming benefits. Mini traffic circles are commonly landscaped, most often at locations where the neighborhood has agreed to maintain the plants. The islands in the center of the circle may be completely mountable for emergency vehicles to better navigate through the intersection.

**Design Contexts**
- Roadways with 30 mph or lower posted speeds
- Residential streets
- Neighborhood bikeways
- Stop-controlled intersections with high delay
- Intersections with one lane in each direction

**CMF/Rating**
A CMF has not yet been developed, however, existing studies indicate that mini-traffic circles can reduce vehicle speeds (Ewing 1999) and crashes (Thomas et al. 2015), improving safety for all road users.

**Estimated Cost**
- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = >$150,000

*Figure 14. Vegetated Mini Traffic Circle with Mountable Apron*
Pedestrian Hybrid Beacons (PHBs), also called HAWKs (high intensity activated crosswalk), are signals installed at unsignalized major street crossing locations to help pedestrians cross the street safely. PHBs may be used in locations where side-street volumes do not warrant a conventional traffic signal, or in situations where there are concerns that a conventional signal may encourage additional motor vehicle traffic on the minor street. PHBs may be effective at reducing multiple threat crashes. PHBs typically include the following elements:

- Overhead beacons with three sections (circular yellow signal indication centered below two horizontally aligned circular red signals) facing both directions on the major street
- Overhead signs labeled “CROSSWALK STOP ON RED” to indicate that the location is associated with a pedestrian crosswalk
- A marked crosswalk on the major street
- Countdown pedestrian signal heads to control pedestrian crossings at the crosswalk

**Design Contexts**

- Urban or suburban multi-lane roadways
- Higher speed roadways (particularly at or above 35 mph)
- Locations with high volumes of pedestrians and vehicles (AADT > 9,000); if higher volumes, 30 mph locations may be appropriate. (Blackburn et al. 2017)

**CMF / Rating**

0.70 for total crashes (Fitzpatrick et al. 2010); 0.31–0.45 for vehicle–pedestrian crashes (Zegeer et al. 2017). A pedestrian hybrid beacon is recognized by FHWA as a Proven Safety Countermeasure.

**Estimated Cost**

$ = <$2,500
$$ = $2,500–$49,999
$$$ = $50,000–$150,000
$$$$ = >$150,000
Pedestrian Refuge Islands (also known as Crossing Islands) are roadway treatments designed to provide refuge for pedestrians and bicyclists between motor vehicle travel lanes at intersections and midblock locations. To provide pedestrian refuge, they must be a minimum width of 6 feet to meet pedestrian accessibility requirements. To provide bicyclists refuge and to accommodate larger groups of pedestrians, the minimum should be increased to 8 feet.

They can improve safety for pedestrians and bicyclists by reducing crossing distances and creating a place of refuge to allow multiple-stage crossings. They are particularly beneficial at uncontrolled crossings, large signalized crossings, or complex intersections where people may have difficulty completing crossings, and they may be especially helpful for pedestrians who are unable to judge gaps in traffic accurately or who travel slower than the design pedestrian (typically walking at least 3.5 ft/s). Crossing islands can be designed with a Z-crossing to require people to face oncoming traffic which may increase visibility and eye contact. Crossing islands that extend up to or beyond crosswalks can also slow left turning motorists, providing the same benefit as hardened centerlines or medians. Temporary pedestrian refuge islands can be installed using low-cost materials (paint, bollards, or even rubberized platforms) for demonstration and evaluation purposes.

**Design Contexts**
- Midblock or intersection crossing locations
- Preferable on all roadways with 2 or more lanes of through traffic in each direction and operating speeds over 30 mph
- Should be considered on all roadways where space is available to provide refuge, and particularly on roadways with medium to high speeds and medium to high vehicle volumes

**CMF / Rating**
- 0.54 for all crashes (Bahar et al. 2007); 0.69 for vehicle-pedestrian crashes for raised medians (Zegeer et al. 2017). A crossing island is recognized by FHWA as a Proven Safety Countermeasure.

**Estimated Cost**
- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = >$150,000
Rectangular Rapid Flashing Beacons (RRFBs) are placed on both sides of an uncontrolled crosswalk and are paired with a pedestrian crossing sign as well as an arrow pointing at the crosswalk. The beacons differ from standard flashing beacons by using a rapid flash frequency (approximately 190 times per minute), brighter light intensity, and ability to aim the LED flash. RRFBs can be actuated or pedestrian-actuated, and feature an irregular, eye-catching flash pattern to call attention to the presence of pedestrians.

Rectangular rapid flash beacons have been shown to significantly increase motorist yielding behavior at uncontrolled crosswalks, with motorist yield rates ranging from 34 percent to over 90 percent. Studies have also demonstrated reduced pedestrian-vehicle conflicts, increased stopping distance, and reductions in pedestrians trapped in the roadway while crossing (Thomas et al. 2016). These safety benefits likely extend to bicyclists crossing at RRFB locations as well.

**Design Contexts**
- Roadways with low to medium vehicle volumes
- Roadways with posted speeds less than 40 mph

**CMF / Rating**
0.53 for vehicle-pedestrian crashes (Zegeer et al. 2017).

**Estimated Cost**
- $ = < $2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$$$ = > $150,000
Roundabouts are circular intersections designed to eliminate left turns by requiring traffic to circulate around a central island. Roundabouts are typically installed in place of traffic signals to reduce vehicular speeds, improve safety at intersections by eliminating angle and higher-speed collisions, to allow more efficient traffic operations, and to reduce operation costs associated with signalized intersections. Further detail on potential applications are discussed in NCHRP Report 672, Roundabouts: An Informational Guide, Second Edition (Rodegerdts et al. 2010). NCHRP Report 834, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook, provides vital information on roundabout design for all pedestrians, including those with vision impairment (Schroeder et al. 2017).

Design Contexts

- Intersections where signals are not warranted or are unable to be installed
- Intersections of local, collector, or arterial roadways
- Intersections with high left-turning vehicle volumes
- Intersections that are part of a corridor treatment that includes access management and motor vehicle travel lane reductions
- Along corridors characterized by high vehicular speeds that are out of context with the area type

CMF / Rating

A CMF for vehicle-pedestrian crashes based on U.S. data has not been developed due to low incidence of reported pedestrian crashes (Ferguson et al. 2019). Roundabouts reduce motor vehicle speeds, which can create a safer environment for all road users (Rodegerdts et al. 2010, Ariniello 2005). The benefit of this tool is calculated using Caltrans procedure. The crash reduction factor is dependent on the ADT, project location (Rural/Urban) and the roundabout type (1 lane or 2 lanes). The benefit comes from both the reduction in the number and the severity of the crashes.

Estimated Cost

$ = < $2,500
$$ = $2,500–$49,999
$$$ = $50,000–$150,000
$$$$ = > $150,000
Advanced yield lines are pavement markings placed 20 to 50 feet in advance of an uncontrolled and unsignalized pedestrian or bicycle crossing. This treatment increases the distance between where drivers have stopped or yielded and the crosswalk or bicycle crossing, which improves the visibility of crossing pedestrians and bicyclists to motorists and helps to reduce multiple-threat crashes. Advanced yield lines also discourage drivers from encroaching into the crosswalk.

**Design Contexts**

- Uncontrolled multi-lane crossings (at least two lanes in one direction) (Blackburn et al. 2017).

**CMF / Rating**

0.75 for vehicle-pedestrian crashes (Zegeer et al., 2017). The safety benefits of advance stop/yield lines at unsignalized bicycle crossings have not yet been studied.

**Estimated Cost**

- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$ = >$150,000

*Figure 19. Advance Yield Lines at a Midblock Pedestrian Crossing*
BICYCLE FACILITY TREATMENT

Bicycle Lane Extension through Intersection

Bicycle lane extension pavement markings through intersections are intended to provide bicyclists with a clear, highly visible pathway through an intersection. They also help to alert motorists to the presence of bicycle through-traffic and encourage turning motorists to yield to through moving bicyclists. The pavement within the bicycle lane extension can include green color. The color may be applied with paint, Durable Liquid Pavement Markings (DLPM), thermoplastic, or colored asphalt.

Design Contexts
- Locations with bicycle lanes or separated bike lanes where it is desired to delineate the bicycle crossing through an intersection
- Locations where right- or left-turning vehicles cross through moving bicyclists, especially at intersections along major bike routes
- At wide or complex intersections where the bicyclist path is unclear (NACTO 2012)

CMF / Rating
CMFs for this treatment have not been developed for the US context. Existing studies indicate that when used to highlight key conflict points this treatment may improve bicyclist safety via increased motorist yielding, reduced conflicts with turning vehicles, and increased predictability of bicyclist location (Hunter et al. 2000; Brady et al. 2010; Jensen 2008).

Estimated Cost

$ = < $2,500
$$ = $2,500–$49,999
$$= $50,000–$150,000
$$$$ = > $150,000

Figure 20. Bicycle Lane Extensions through Intersections Using Various Pavement Marking Strategies
BICYCLE FACILITY TREATMENT

Bicycle Signal

A bicycle signal is a traffic signal with a green, yellow, and red display intended to control bicycle movements. The display may include arrows or a bicycle symbol shape. Bicycle signals are necessary to indicate a leading or protected phase for bicycle movements. This may sometimes require an additional phase be added to the traffic signal cycle. Initial studies of bicycle signals indicate that their presence may increase signal compliance and improve safety. This treatment has been given interim approval to use by FHWA if used for protected bicycle phases but is not included in the 2009 MUTCD. FHWA requires an agency to request permission to experiment if using a bicycle signal to apply a leading phase.

Bicycle signals can be activated actively or passively. Active detection requires bicyclists to use a pushbutton. Pushbuttons should be placed in such a way that bicyclists do not have to leave the roadway to activate the signal.

Figure 21. Bicycle Signal

Design Contexts

- Signalized intersections with high bicycle volumes and high turning vehicle volumes
- Locations where a highly-used bicycle route (including shared-use path) must cross a major, signalized intersection to connect users to the rest of the route (sometimes requiring bicyclists to cross diagonally)
- Intersections with contraflow bike lanes or separated bike lanes
- Intersections where a bicycle facility transitions from a cycle track to a bicycle lane
- Complex intersections that may otherwise be difficult for bicyclists to navigate

CMF / Rating

0.75 for vehicle-pedestrian crashes (Zegeer et al., 2017). The safety benefits of advance stop/yield lines at unsignalized bicycle crossings have not yet been studied.

Estimated Cost

$ = <$2,500
$$ = $2,500–$49,999
$$$ = $50,000–$150,000
$$$$ = >$150,000
BICYCLE FACILITY TREATMENT

Bike Boxes

Bike boxes provide space for bicyclists to position themselves in front of vehicles while stopped at a signalized intersection. This treatment provides a predictable place for bicyclists to stop and wait at a signal, allowing them to get out ahead of traffic at the onset of a green signal. Bike boxes are intended to reduce the likelihood of a right- or left-hook collision at the onset of a green signal. In addition to increasing the visibility and predictability of bicyclists, bike boxes provide priority for bicyclists by allowing them to come to the front of the queue. A "No Right Turn on Red" sign can be installed to prevent vehicles from entering the bike box. Bike boxes can also be helpful for bicyclists making left turns who are uncomfortable or unable to merge to a left turn lane. This treatment has been given interim approval to use by FHWA but is not included in the 2009 MUTCD.

Figure 22. Bike Box

Design Contexts

• Signalized intersections with medium to high volumes of bicyclists and motor vehicles
• Intersections where large vehicles are common
• Intersections with high volumes of queuing bicyclists
• Intersections with high volumes of turning vehicles and bicyclists going straight

CMF / Rating

A CMF has not yet been determined; initial evidence indicates this treatment can improve bicyclist safety through improved visibility of bicyclists, increased awareness of bicyclists by motorists, increased motorist yielding, and a reduction in right-hook conflicts (Allen et al. 2005; Brady et al. 2010; Dill et al. 2012).

Estimated Cost

$ = <$2,500  
$$ = $2,500–$49,999  
$$$ = $50,000–$150,000  
$$$$ = >$150,000
BICYCLE FACILITY TREATMENT

Class I Bicycle Facilities

Class I bikeways (also known as bike paths or shared-use paths) are facilities with exclusive right of way for bicyclists and pedestrians, away from the roadway and with minimized cross flows by vehicle traffic. These facilities support both recreational and commuting opportunities, especially along rivers, shorelines, canals, utility rights-of-way, railroad rights-of-way, within school campuses, or within and between parks.

Figure 23. Shared-Use Path

Design Contexts
- Rural settings to provide access to users of all ages and abilities
- Along active and/or abandoned rail easements

CMF / Rating
A CMF has not yet been determined.

Estimated Cost
The cost per mile depends on several factors including facility width, materials used, etc.
Also known as bike lanes, Class II Bicycle Facilities are established along streets, defined by pavement striping and signage to delineate a portion of a roadway for bicycle travel. Bike lanes are one-way facilities, typically striped adjacent to vehicle traffic traveling in the same direction. Buffered bike lanes provide greater separation from an adjacent traffic lane or on-street parking by using painted chevrons or diagonal markings. Buffered bike lanes may be desirable on streets with higher vehicle speeds or volumes.

**Design Contexts**
- Bike lanes are most helpful on streets with ≥ 3,000 motor vehicle average daily traffic.
- Bike lanes are most helpful on streets with a posted speed ≥ 25 mph.
- On streets with high transit vehicle volume.
- On streets with high traffic volume, regular truck traffic, high parking turnover, or a speed limit > 35 mph,
  - consider treatments that provide greater separation between bicycles and motor traffic such as:
    - Left-side bike lanes on one-way streets
    - Buffered bike lanes
    - Separated bikeways

**Estimated Cost (per mile)**

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**CMF / Rating**
A CMF has not yet been determined.
Class III Bicycle Facilities, also known as bike routes, are designated routes shared with vehicles but not served by dedicated bikeways. Bike routes are established by placing signage and/or shared lane (sharrow) markings along roadways, and are therefore generally not appropriate for roadways with high vehicle speeds or volumes.

A Bicycle Boulevard or a Neighborhood Greenway is a type of bike route where bicycle travel is prioritized. These facilities are typically placed on residential streets where biking or walking is the primary mode of transportation. Traffic speed and non-local vehicle access is reduced for the safety of bicyclists and pedestrians.

**Figure 26. Bike Route with Sharrow**

**Figure 27. Bike Boulevard**

**Design Contexts**

- Streets with speeds at 25 mph or less
- Streets with traffic volumes less than 3,000 vehicles per day
- Streets with lower vehicle volumes and speeds that are parallel and near major streets, which have a similar level of connectivity and travel demand function

**Estimated Cost (per mile)**

- $ = <$2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
- $$ $$ = >$150,000

**CMF / Rating**

A CMF has not yet been determined.
Class IV Bicycle Facilities (also known as separated bikeways, protected bikeways, or cycle tracks) are for the exclusive use of bicycles and are physically separated from vehicle traffic, parking lanes, and sidewalks with a vertical and/or horizontal feature. These features include flexible posts, inflexible physical barriers, planters, parked vehicles, and curbs. Separated bikeways may be one-way or two-way, and may be at street level or sidewalk level. The separation width can vary for these facilities according to roadway geometry. Near transit stops, separated facilities can be incorporated with the use of transit boarding islands.

Design Contexts
- Streets with high demand for double parking, and high parking turnover
- Streets with multiple lanes
- Streets with conflicts at intersections
- Streets with high bicycle volumes
- Streets with high motor vehicle volumes
- Streets with high vehicle speeds

CMF / Rating
A CMF has not yet been determined.

Estimated Cost
The cost per mile depends on several factors including facility width, vertical elements used, etc.
Properly designed detection can deter unsafe behaviors, such as disregarding red signal indications, by reducing delay at signalized intersections. Bicycle signal detection also increases the convenience of bicycling. Passive detection (i.e., when the signal system automatically detects the presence of the user), is considered best practice where feasible. Loop detectors, commonly used for motor vehicle detection, can also be used to detect bicyclists. Other passive detection devices include video and microwave detection. Bicycle detection devices can be used to call a phase or to prolong the phase to allow a bicyclist to clear an intersection. This is particularly important at locations where the minimum green has been established to serve motorists and may not be long enough to serve bicyclists, especially older bicyclists, children, or those towing bicycle trailers. Pavement markings and/or signs should be used to notify bicyclists of the proper bicycle detection location. Combining passive bicycle detection with detection confirmation lights or active detection (push buttons) may improve compliance by assuring bicyclists that they have been detected.

**Design Contexts**

- Signalized intersections that require users to be detected to actuate a signal for one or more movement
- Intersections with bicycle signals and/or bicycle-specific phasing
- Bike lanes approaching intersections with bicycle signals
- Left turn lanes with left-turn signals where bicyclists also turn left (NACTO 2012)

**CMF / Rating**

A CMF has not yet been determined; initial use of this treatment indicate that it is promising.

**Estimated Cost**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td>&lt;$2,500</td>
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<tr>
<td>$$</td>
<td>$2,500–$49,999</td>
</tr>
<tr>
<td>$$$</td>
<td>$50,000–$150,000</td>
</tr>
<tr>
<td>$$$$</td>
<td>&gt;$150,000</td>
</tr>
</tbody>
</table>

*Figure 30. Pavement Markings Indicate the Bike Detection Location*
The number of lanes on a roadway determines how far pedestrians or bicyclists must cross at an intersection and how many conflict points might exist between turning traffic and bicyclists or pedestrians. Efforts have been made to reduce the number and width of lanes through ‘road diets’ that not only reduce the number of lanes but provide space to implement additional pedestrian and bicyclist safety treatments such as adding bike lanes, median crossing islands, and reducing travel speed. Road diets are often completed to improve access management, increase bicycle and pedestrian access, and to enhance roadway safety. The most common road diet configuration involves converting a four-lane roadway into three lanes, with one travel lane in each direction, a center two-way left-turn lane, and bike lanes in each direction, often supplemented with painted or raised center islands.

**Design Contexts**

- Priority bicycle and pedestrian routes
- Urban and rural areas
- Multi-lane roads

**CMF/Rating**

0.71 for total crashes (Harkey et al. 2008). Safety benefits may vary depending on the type of treatments implemented, however studies suggest that road diets are associated with increased pedestrian safety and reduced vehicle speeds (Thomas et al. 2016).

**Estimated Cost**

$ = <$2,500  
$$ = $2,500–$49,999  
$$$ = $50,000–$150,000  
$$$$ = >$150,000
A two-stage left turn queue box (also known as a Copenhagen-Left or jug-handle turn) designates an area outside of vehicle conflicts for bicyclists to wait for traffic to clear before proceeding in a different direction of travel. It may be used for left or right turns. They may be useful at locations where bicyclists would have to merge across multiple lanes of traffic, would have to wait in a shared travel lane with motorists to turn, or at locations with separated bike lanes or side paths where it is not possible for bicyclists to merge into motor vehicle lanes in advance of the intersection. This can be advantageous on roadways with higher volumes of traffic or operating speeds to reduce conflicts between motorists and turning bicyclists. Bicycle symbol and turn arrow pavement markings indicating the appropriate direction for bicyclists to turn and wait within the box are recommended, as well as the prohibition of right turns on red if turning vehicles would travel through the area of the two-stage bicycle turn box.

An agency should request permission to experiment from FHWA to use this treatment as it is not currently approved for use.

**Design Contexts**

- Signalized intersections that require users to be detected to actuate a signal for one or more movement
- Multi-lane intersections where bicyclists frequently turn left from a facility on the right side of the roadway
- Cycle tracks or bike lanes with multiple adjacent motor vehicle travel lanes with high traffic speeds and/or traffic volumes (NACTO 2012)

**CMF / Rating**

A CMF has not yet been determined; initial evidence indicates the safety benefits of this treatment are promising (Xiaomin and Shao 2014).

**Estimated Cost**

- $ = < $2,500
- $$ = $2,500–$49,999
- $$$ = $50,000–$150,000
-$$$$ = > $150,000