**RECOMMENDED**

1. **Install a midblock crosswalk** where there is a significant pedestrian desire line. Frequent applications include midblock **bus stops**, metro stations, parks, plazas, building entrances, and midblock passageways.

2. **Stop lines at midblock crossings** should be set back 20–50 feet. This ensures that a person crossing the street is visible to the second driver when the first driver is stopped at the stop line.

3. **Stripe the crosswalk**, regardless of the paving pattern or material. Otherwise, drivers are not likely to see it, especially at night.

4. **Medians or safety islands** create a 2-stage crossing for pedestrians, which is easier and safer.

**Vertical elements** such as trees, landscaping, and overhead signage help to identify crosswalks and islands to drivers.

**Daylighting in advance** of a crosswalk makes pedestrians more visible to motorists and cars more visible to pedestrians. This may be accomplished by restricting parking and/or installing a curb extension.

**At key access points to parks, schools, and waterfronts, and at intersections with local streets, raised crossings increase visibility, yielding behavior, and create a safer pedestrian crossing environment.**

**Where an unsignalized crossing exists at a transit stop**, enhanced crossing treatments or actuated signals should be added. Transit stops should ideally be located so that pedestrians cross behind the bus or transit vehicle. Far side stop placement is preferable to near side or midblock placement and increases the visibility of pedestrians crossing behind the bus.

**OPTIONAL**

A pedestrian tracking survey may be used to document where and how people cross a street, complex intersection, or plaza. This information is useful in locating crosswalks and safety islands, redesigning intersections, and understanding the interface between streets and the surrounding buildings and public spaces.

**Actuated pedestrian signals** (half-signals), hybrid beacons, or rapid flash beacons may be considered at greenway crossings, midblock locations, or unsignalized crossings where infrequent crossings make a traffic signal or stop sign unnecessary. **Fixed-time signals** or passive detection are preferable to pushbutton detection.

**Unsignalized crossings** should be highlighted using additional warning signage, high visibility lighting and markings, actuated beacons (where applicable), and traffic calming features, such as raised crossings and mid-block curb extensions.

**Unsignalized midblock crosswalks** may be applied at locations with inconsistent pedestrian demand or where a pedestrian connector intersects midblock with a small or mediumsized roadway.

**Where midblock pedestrian crossings in a low-volume downtown commercial or neighborhood residential area are frequent**, a designer may consider the application of a **shared street** treatment. **Shared streets** should have limited or no markings to reinforce the regulation of the street as a shared space.

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Adapted from the Urban Street Design Guide, published by Island Press.
Pedestrian Hybrid Beacons

U.S. Department of Transportation
Federal Highway Administration

The pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross busy or higher-speed roadways at midblock crossings and uncontrolled intersections. The beacon head consists of two red lenses above a single yellow lens. The lenses remain “dark” until a pedestrian desiring to cross the street pushes the call button to activate the beacon. The signal then initiates a yellow to red lighting sequence consisting of steady and flashing lamps that direct motorists to slow and come to a stop. The pedestrian signal then flashes a WALK display to the pedestrian. Once the pedestrian has safely crossed, the hybrid beacon again goes dark.

More than 75 percent of pedestrian fatalities occur at non-intersection locations, and vehicle speeds are often a major contributing factor. As a safety strategy to address this pedestrian crash risk, the PHB is an intermediate option between a flashing beacon and a full pedestrian signal because it assigns right of way and provides positive stop control. It also allows motorists to proceed once the pedestrian has cleared their side of the travel lane, reducing vehicle delay.

Average risk of death at impact for a pedestrian rises as speed increases.

- 10% at 23 mph
- 50% at 42 mph
- 90% at 58 mph

Data from the AAA Foundation for Traffic Safety, Impact Speed and a Pedestrian’s Risk of Severe Injury or Death, September 2019.

Transportation agencies should refer to the Manual on Uniform Traffic Control Devices for information on the application of PHBs. In general, PHBs are typically used when gaps in traffic are not large enough or vehicle speeds are too high for pedestrians to cross safely. PHBs are not widely implemented, so agencies should consider an education and outreach effort when implementing a PHB within a community.

For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures.
Conventional Crosswalks

CRITICAL

1. Stripe all signalized crossings to reinforce yielding by vehicles turning during a green signal phase. The majority of vehicle-pedestrian incidents involve a driver who is turning.

2. Stripe the crosswalk as wide as or wider than the walkway it connects to. This will ensure that when two groups of people meet in the crosswalk, they can comfortably pass one another. Crosswalks should be aligned as closely as possible with the pedestrian through zone. Inconvenient deviations create an unfriendly pedestrian environment.

3. High-visibility ladder, zebra, and continental crosswalk markings are preferable to standard parallel or dashed pavement markings. These are more visible to approaching vehicles and have been shown to improve yielding behavior.

RECOMMENDED

4. Keep crossing distances as short as possible using tight corner radii, curb extensions, and medians. Interim curb extensions may be incorporated using flexible posts and epoxied gravel. See Interim Design Strategies

5. An advanced stop bar should be located at least 8 feet in advance of the crosswalk to reinforce yielding to pedestrians. In cases where bicycles frequently queue in the crosswalk or may benefit from an advanced queue, a bike box should be utilized in place of or in addition to an advanced stop bar.

OPTIONAL

6. Right-turn-on-red restrictions may be applied citywide or in special city districts and zones where vehicle-pedestrian conflicts are frequent. Right-turn-on-red restrictions reduce conflicts between vehicles and pedestrians.

Location: San Francisco, CA

Stop bars should be perpendicular to the travel lane, not parallel to the adjacent street or crosswalk.

Adapted from the Urban Street Design Guide, published by Island Press.
Bike Boxes

Bike Box Benefits

- Increases visibility of bicyclists.
- Reduces signal delay for bicyclists.
- Facilitates bicyclist left turn positioning at intersections during red signal indication. This only applies to bike boxes that extend across the entire intersection.
- Facilitates the transition from a right-side bike lane to a left-side bike lane during red signal indication. This only applies to bike boxes that extend across the entire intersection.
- Helps prevent ‘right-hook’ conflicts with turning vehicles at the start of the green indication.
- Provides priority for bicyclists at signalized bicycle boulevard crossings of major streets.
- Groups bicyclists together to clear an intersection quickly, minimizing impediment to transit or other traffic.
- Pedestrians benefit from reduced vehicle encroachment into the crosswalk.

Typical Applications

- At signalized intersections with high volumes of bicycles and/or motor vehicles, especially those with frequent bicyclist left-turns and/or motorist right-turns.
- Where there may be right or left-turning conflicts between bicyclists and motorists.
- Where there is a desire to better accommodate left turning bicycle traffic.
- Where a left turn is required to follow a designated bike route, access a shared-use path, or when the bicycle lane moves to the left side of the street.
- When the dominant motor vehicle traffic flows right and bicycle traffic continues through (such as a Y intersection or access ramp).

https://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/bike-boxes/
What is a Roundabout?

A roundabout is a type of circular intersection, but is quite unlike a neighborhood traffic circle or large rotary. Roundabouts have been proven safer and more efficient than other types of circular intersections.

Roundabouts have certain essential distinguishing features:

- **Counterclockwise Flow.** Traffic travels counterclockwise around a center island.
- **Entry Yield Control.** Vehicles entering the roundabout yield to traffic already circulating.
- **Low Speed.** Curvature that results in lower vehicle speeds (15-25 mph) throughout the roundabout.

FHWA identified roundabouts as a Proven Safety Countermeasure because of their ability to substantially reduce the types of crashes that result in injury or loss of life. Roundabouts are designed to improve safety for all users, including pedestrians and bicycles. They also provide significant operational benefits compared to conventional intersections.

Educational Resources

- Michigan “How to Use a Roundabout – Sharing the Road” Informational Brochure
- New York Guidance for Roundabout Users
- Washington State videos for Roundabouts and Pedestrians and Bicycles
  - [www.wsdot.wa.gov/Safety/roundabouts/PedestriansCyclists.htm](http://www.wsdot.wa.gov/Safety/roundabouts/PedestriansCyclists.htm)

Leveraging Partnerships

- PEDSAFE Pedestrian Safety Guide & Countermeasure Selection System – Roundabouts
- BIKESAFE Bicycle Safety Guide & Countermeasure Selection System – Roundabouts
- Choosing Roundabouts for Safe Routes to School
  - [www.saferoutesinfo.org/program-tools/case-study-bellingham-wa](http://www.saferoutesinfo.org/program-tools/case-study-bellingham-wa)
- AARP Livable Communities Fact Sheet Series

For More Information

- Jeffrey Shaw, P.E., PTOE, PTP
  - FHWA Office of Safety
  - 708.283.3524 or jeffrey.shaw@dot.gov
- Hillary Isebrands, P.E., PhD
  - FHWA Resource Center
  - 720.963.3222 or hillary.isbrands@dot.gov

To learn more about roundabouts, please visit: [safety.fhwa.dot.gov](http://safety.fhwa.dot.gov)

Publication number FHWA-SA-15-016

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Currency of the future = Capitalism? 

On average, roundabouts reduce severe crashes – those resulting in injury or loss of life – by 78-82%.

**Lower speed.**
Traffic speed at any road or intersection is vitally important to the safety of everyone, especially non-motorized users. Lower speed is associated with better yielding rates, reduced vehicle stopping distance, and lower risk of collision injury or fatality. Also, the speed of traffic through a roundabout is more consistent with comfortable bicycle riding speed.

**Less conflict.** Roundabouts have fewer conflict points. A single lane roundabout has 50% fewer pedestrian-vehicle conflict points than a comparable stop or signal controlled intersection. Conflicts between bicycles and vehicles are reduced as well.

**Shorter, setback crossings.**
Pedestrians cross a shorter distance of only one direction of traffic at a time since the entering and exiting flows are separated. Drivers focus on pedestrians apart from entering, circulating and exiting maneuvers.

**Features for All Users.** Adding certain treatments at roundabouts can enhance the experience for both pedestrians and bicycles.
- At more complex roundabouts, such as those with multiple lanes, certain design elements and enhanced crossing treatments can improve accessibility for visually impaired pedestrians.
- Where bicycle facilities lead to a roundabout, providing an option to bicyclists to either ride in the travel lane or use a ramp to and from a separated shared use path.
Traffic Signals

The introduction to this issue brief provides an overview of traffic signals (purpose, warrants for signal installation, advantages, disadvantages, and factors to consider) followed by an introduction to the contents of this issue brief (crash reduction factors, presentation of the crash reduction factors, and using the tables).

Purpose of Traffic Signals

Traffic signals are used to assign vehicular and pedestrian right-of-way. They are used to promote the orderly movement of vehicular and pedestrian traffic and to prevent excessive delay to traffic.

Traffic signals should not be installed unless one of the warrants specified by the Manual on Uniform Traffic Control Devices (MUTCD) has been satisfied. The satisfaction of a warrant is not in itself justification for a signal. A traffic engineering study must be conducted to determine whether the traffic signal should be installed. The installation of a traffic signal requires sound engineering judgment, and must balance the following, sometimes conflicting, goals:

- Moving traffic in an orderly fashion.
- Minimizing delay to vehicles and pedestrians.
- Reducing crash-producing conflicts.
- Maximizing capacity for each intersection approach.

Where Should a Signal Be Installed?

The MUTCD lists eight warrants for the placement of traffic signals. Readers are encouraged to review Part 4 of the MUTCD for more specific information regarding signal warrants. Access management considerations and the spacing of signals on arterial roadways are critical elements of system efficiency and operational safety. The basic question that must be answered is, “Will this intersection operate better with or without a traffic signal?”

Advantages of Signals

Traffic signals that are properly located and operated are likely to:

- Provide for orderly movement of traffic.
- Increase traffic capacity of the intersection.
- Reduce the frequency of certain types of crashes (e.g. right-angle crashes).
- Provide for continuous or nearly continuous movement of traffic along a given route.
- Interrupt heavy traffic to permit other traffic, vehicular or pedestrian, to cross.

Disadvantages of Signals

Traffic control signals are often considered a panacea for all traffic problems at intersections. This belief has led to the installation of traffic control signals at many locations where they are not needed and where they may adversely affect the safety and efficiency of vehicular, bicycle, and pedestrian traffic.

Even when justified by traffic and roadway conditions, traffic control signals can be ill designed, ineffectively placed, improperly operated, or poorly maintained. Unjustified or improper traffic control signals can result in one or more of the following disadvantages:
Traffic Signals

- Excessive delay.
- Excessive disobedience of the signal indications.
- Increased use of less adequate routes as road users attempt to avoid the traffic control signals.
- Significant increases in the frequency of crashes (especially rear-end crashes).

As angle crashes tend to be more severe than rear-end crashes, traffic engineers are usually willing to trade off an increase in the number of rear-end crashes for a decrease in the number of angle crashes, but if an intersection does not have an angle-crash problem, the tradeoff does not apply, and the installation of traffic signals can actually cause a deterioration in the overall safety at the intersection.

Factors to Consider when Installing a Signal

A number of factors should be considered when planning to signalize an intersection. These factors include:

- The negative effects of traffic delay. Excessive delay results in significant fuel waste, higher motorist costs, and air pollution.
- Potential diversion of arterial traffic into neighborhood streets.
- Red-light running violations and associated crashes.
- Cost. The cost for a signal ranges from $50,000 to more than $200,000 depending on the complexity of the intersection and the characteristics of the traffic using the intersection. In addition, the annual operating cost of each signal ranges from $1,000 to $5,000.

Signal Improvements That May Decrease Crashes

The following changes may decrease crashes:

- Signal retiming, phasing, and cycle improvements;
- Review and assurance of adequacy of yellow change interval/all-red clearance interval for safer travel through the intersection;
- Use of longer visors, louvers, backplates, and reflective borders;
- Installation of 12-inch signal lenses;
- Installation of additional signal heads for increased visibility;
- Provision of advance detection on the approaches so that vehicles are not in the dilemma zone when the signal turns yellow;
- Repositioning of signals to overhead (mast arm) instead of pedestal-mounted;
- Use of double red signal displays; and
- Removal of signals from late-night/early-morning programmed flash.

Introduction to the Contents of this Issue Brief

This issue brief documents estimates of the crash reduction that might be expected if a specific countermeasure or group of countermeasures is implemented with respect to traffic signals. The crash reduction estimates are presented as crash reduction factors (CRFs).

Traffic engineers and other transportation professionals can use the information contained in this issue brief when asking the following types of question: Which countermeasures might be considered at the signalized intersection of Maple and Elm streets, an intersection that is experiencing a high number of crashes? What changes in the number of crashes are possible with the various countermeasures?

Crash Reduction Factors

A CRF is the percentage crash reduction that might be expected after implementing a given countermeasure. In some cases, the CRF is negative (i.e., the implementation of a countermeasure is expected to lead to a percentage increase in crashes).

One CRF estimate is provided for each countermeasure. Where multiple CRF estimates were available from the literature, selection criteria were used to choose which CRFs to include in the issue brief:

- Firstly, CRFs from studies that took into account regression to the mean and changes in traffic volume were preferred over studies that did not.
- Secondly, CRFs from studies that provided additional information about the conditions under which the countermeasure was applied (e.g., road type, area type) were preferred over studies that did not.

Where these criteria could not be met, a CRF may still be provided. In these cases, it is recognized that the reliability of the estimate of the CRF is low, but the estimate is the best available at this time. The CRFs in this issue brief may be periodically updated as new information becomes available.

The Desktop Reference for Countermeasures lists all of the CRFs included in this issue brief and adds many other CRFs available in the literature. A few CRFs found in the literature were not included in the Desktop Reference. These CRFs were considered to have too large a range or too large a standard error to be meaningful, or the original research did not provide sufficient detail for the CRF to be useful.

A CRF should be regarded as a generic estimate of the effectiveness of a countermeasure. The estimate is a useful guide, but it remains necessary to apply engineering judgment and to consider site-specific environmental, traffic volume, traffic mix, geometric, and operational conditions that will affect the safety impact of a countermeasure. The user must ensure that a countermeasure applies to the particular conditions being considered. The reader is also encouraged to obtain and review the original source documents for more detailed information and to search databases such as the National Transportation Library (http://ntlsearch.bts.gov) for information that becomes available after the publication of this issue brief.