

*This section provides guidelines on intersection planning and designs for people, bicyclists and motor vehicles. Chapter Three, Part Four, provides recommendations for pedestrian-friendly intersections. This section provides guidelines detailing when and how to apply these recommendations.*

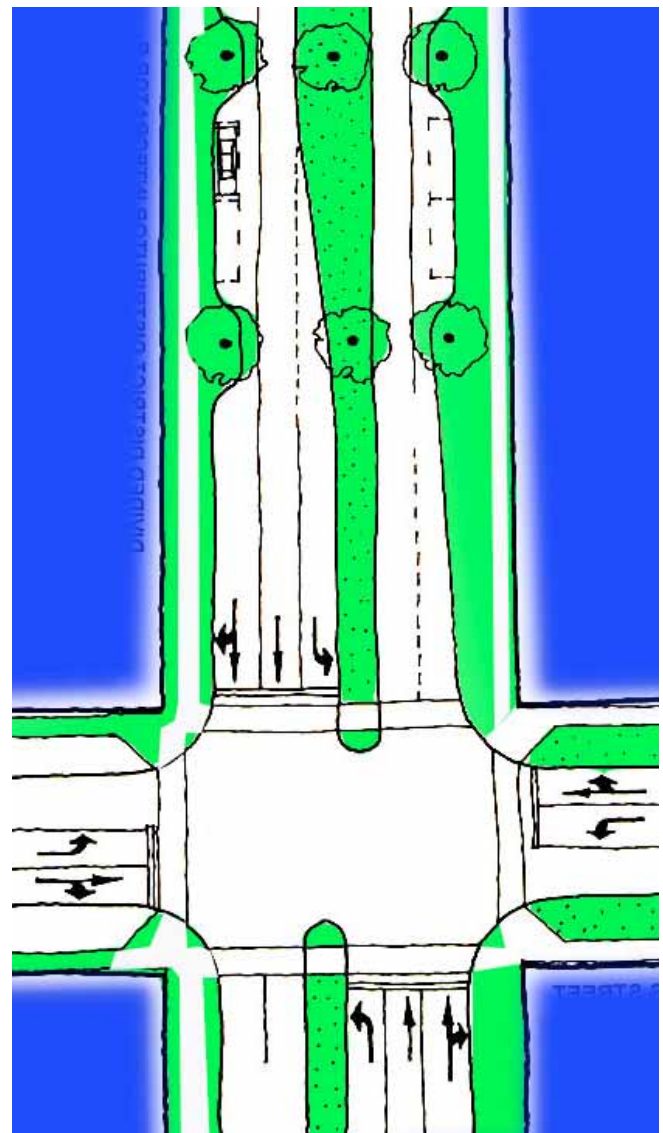
# Section D

## Guidelines for Intersections and Street Crossings

### Intersection Purposes and Elements

Well designed intersections are cornerstones of healthy, top performing, walkable communities. Not only do well conceptualized and built intersections move traffic efficiently, they set the stage for active town center or village life. Just one poorly constructed intersection significantly dampens the ability of people to move by wheel and foot.

City of Marina intersections should be planned, designed, constructed, operated and maintained to maximize safety, capacity and choice in transportation. In addition to providing effective movement of people and vehicles, all intersections should be designed to maximize safety, reaction and response times through low speed designs. To the greatest extent practicable designs shall minimize the numbers of conflict points, the speed at which



Chicago's Michigan Avenue is one of the nation's top money earning streets, all while moving more than 60,000 cars and 30,000 pedestrians daily. Minimal delays for pedestrians at key intersections is key to the success of this and other world class streets.

## Intersection Details

### Reducing Intersection Conflicts

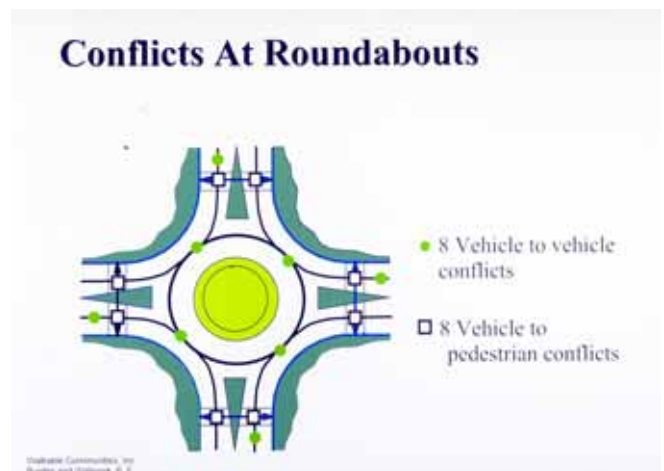
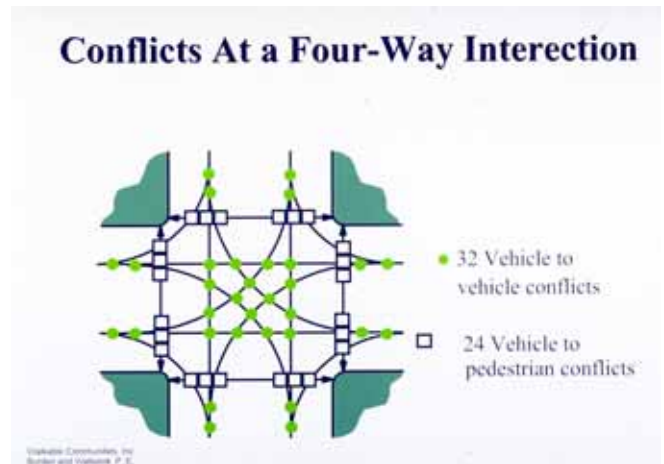
Standard signal or stop sign controlled four-cross intersections (shown to the right) produce 32 vehicle to vehicle conflicts and 24 vehicle to pedestrian conflicts. Thus, pedestrians face six potential conflicts on each street leg they cross.

### Conflict Points

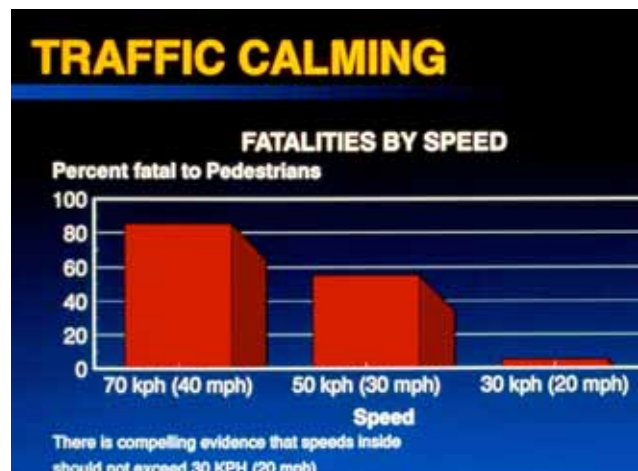
Well constructed intersections use raised islands (such as channels or medians) or roundabouts to reduce the number of conflicts pedestrians and motorists encounter at any given time. With roundabouts motorists only have 8 vehicle-to-vehicle conflicts and pedestrians only have one low-speed (15-20 mph) motorist conflict (not six) at a given point in time. For these reasons well designed roundabouts have proven to be the safest intersection design for motorists and pedestrians. Research also indicates that roundabouts reduce crashes to bicyclists 30%, and injury severity at least 50%.

### Conflict Speed

Well constructed intersections use curb extensions and median noses to reduce the speed of turning motorists. Short signal cycles encourage red signal compliance. Long signal cycles have the undesired effect of inducing red signal running and speeding into intersections. Raised intersections and roundabouts reduce conflict speeds at intersections.



Well designed intersections provide compact and efficient movement of vehicles and people. Connecticut and "K" Street in Washington D.C. (below) moves six lanes of traffic in each quadrant, while managing efficient crossings of more than 40,000 pedestrians daily. Right, speed of conflict is critical. Pedestrians hit at 40 mph have only a slight chance of survival, while 95% of pedestrians hit at 20 mph survive.





## Basic Intersection Conflict Speed Reduction Measures

### Geometric Speed Controls at Intersections

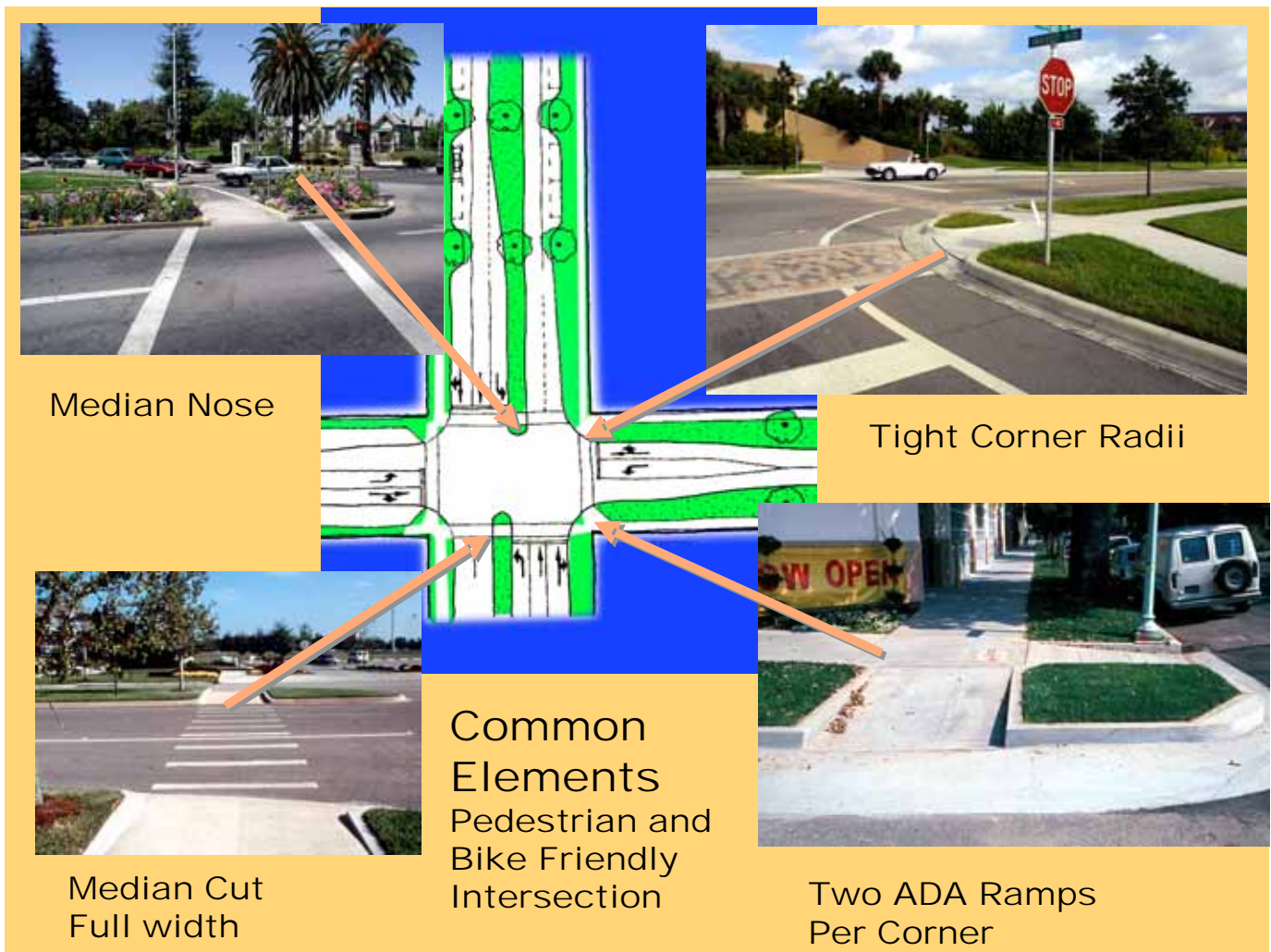
Intersection speed is controlled through a combination of (1) geometric design options (e.g. medians, curb extensions, corner radii) and (2) operational controls (e.g. signals, lane widths, number of lanes).

### Geometric Tools

Effective intersection designs promote legal behaviors, such as pedestrians crossing in crosswalks, and discourage illegal practices, such as inappropriate parking. Shown below are four geometric tools most often used to enhance appropriate pedestrian behaviors while discouraging inappropriate motorist behaviors.

Whenever practicable pedestrians should be allowed to cross at locations within several feet of the intersecting streets. The farther removed pedestrians are from actual intersections the less opportunity motorists have to detect and respond to them.

Tight corner turning radii keep motorist conflict speeds to the safest possible levels. Actual turning radii of 25-35 feet on commercial streets and 10 to 20 feet in neighborhoods are easier to achieve when bike lanes and on-street parking creates wider effective turning radii. Curb extensions can also significantly assist with effective turning radii.



## Maximizing Geometric Speed Controls

### Slowing Motorists Before Entry

The two Mountain View, California intersections shown on this page are exemplary designs. They combine good geometrics with good operation controls. These modified intersections place final twists in each roadway just before entering conflict areas.

Most signal controlled intersections allow straight alignment entries which have the undesired effect of inducing high entry speeds. Motorists tend to speed up just as signals are about to change to red.

Through use of curb extensions, medians, a change in the roadway alignment and other geometric controls motorists are slowed before entry. In the second photo the use of a narrow median controls the speed of the motorist around the curving intersection. Use of this median has two side benefits, (1) creating a short pause point for pedestrians to shift their gaze to the new danger when they are crossing, and allowing the effective placement of added signal heads where motorists are most likely to see them.

The bottom two photos repeat these themes and illustrate the reduced crossing widths of pedestrians crossing what had been wide streets and intersections.

Instead of using more costly overhead signals, well placed post mounted poles have been used. Post mounted signals used in this intersection are visually superior to most other placements. Humans' clear cone of vision is only 3 degrees. Thus, motorists need to see signal heads, pedestrians and gaps in traffic all within a tight 3 degree cone.





## Modifying Non-Signalized Intersections

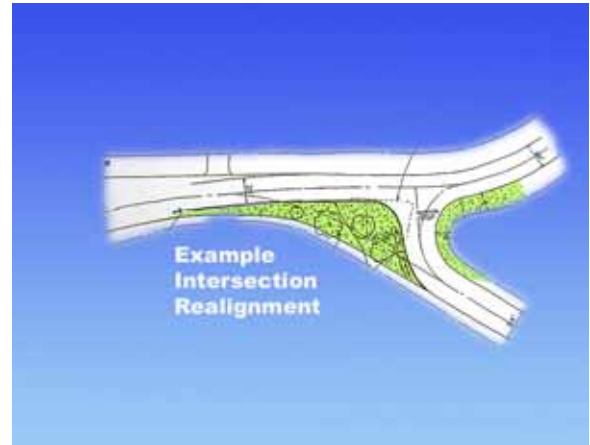
### Slowing Motorists Before Entry

The same principles of speed reduction that apply to signal controlled intersections apply at non-signalized locations. Historically, many dirt intersections allowed generous turns. Little attempt was needed to control speeds of older vehicles when these original curb lines were set. Today many motorists are capable of higher turning speeds. Often motorists take advantage of overly wide intersections. Going back to retrofit these intersections can be costly. But this must be done if pedestrians are to be a part of transportation choice.

This section shows why many intersections must be adjusted in order to achieve pedestrian friendly areas. Costs can often be kept reasonable by making changes a part of a normal rebuild, inserting costs into other constructed change such as sewer reconstruction projects, or by providing open drain lines when they are acceptable to maintenance people.

The top two illustrations provide a variety of tools to square up intersections for lower speed entries and exits. A refuge island is sometimes used to further control entry speeds. Truck turning templates are used to assure that all appropriate size vehicles are included in turns. Designs accommodate over-sized vehicles by permitting them to cross over center lines when traffic volumes are moderate (2,000 or fewer vehicles per day.) Another variable is the volume of trucks daily. Most neighborhood streets, for example, receive fewer than 10 trucks with a wheel base of 30 feet or higher on any given day.

Note in photo three (Cambridge, Massachusetts) that the curb line was fully rebuilt. This requires new drainage and can significantly add to the cost of modifying intersections. Meanwhile in the bottom photo the curb extension is not attached to the old curb, allowing water to flow downhill to an existing drain. Although this is a lower-cost option, maintenance issues must be worked out with appropriate departments and agencies.



## Signalized Intersections

Signalized intersections in the City of Marina should be as compact and efficient as practicable. Key intersections are poorly designed, with excessive width on approach (including storage lanes), that create excessively wide crossings for pedestrians. Wide intersections reduce the efficiency of moving both pedestrians and motorists.

The top two photos are examples of intersections handling high volumes of vehicles, while keeping pedestrian movements compact. Most lanes in Washington, D.C. (top photo is Pennsylvania Avenue) are nine or ten feet wide. In the second photo, San Luis Obispo, California has reduced most lanes in the downtown to 10 feet in order to reduce speeding. By keeping lane widths and curb radii and adding curb extensions when practicable, crossing distances are kept short. Short crossing times add to safety and make it possible to have more efficient signal cycles.

The City of Marina's Reservation Road crossing of 112 feet is excessive. This requires a pedestrian clearance interval (time it takes the pedestrian to cross the street) of 32 seconds. A redesign of this intersection using signals could get crossings down to 50-60 feet. This would allow the signal cycle to be cut in half, allowing for shorter signal cycles and less delay to all roadway users.

In all cases pedestrians are currently required to push buttons in order to cross all signalized intersections. Several key intersections (e.g. South leg of Del Monte Boulevard) deny crossings to pedestrians. This has the unintended effect of forcing many pedestrians to cross the boulevard randomly at midblock locations.

All signalized intersections should be evaluated for methods to make them more pedestrian friendly.

In some cases roundabouts should replace current signal controls. The proposed single and two-lane roundabout for the Del Monte Boulevard and Reservation Road (shown here and later in this chapter) has many benefits. Motorists and pedestrians have less delay. Potential injury producing crashes are reduced 80-90%. There is less pollution and noise. The intersection serves as a key gateway to Marina's emerging downtown.



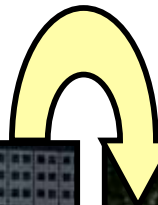




Seattle streets are being systematically narrowed to reduce speed, provide shorter crossing distances for pedestrians, and maximize on-street parking. The top photo illustrates reclaimed roadway space at a key intersection off of Second and Third Avenues, downtown near the waterfront.

In sharp contrast, the bottom left photo shows the next block waiting to be reclaimed. Seattle is one of the most livable cities in America. Each year they complete 200 separate projects aimed at making the city more pedestrian friendly.

Un-reclaimed



Reclaimed



## Signals and Other Operations Controls

Mast arm-mounted signals, accentuated with post-mounted signal heads on key corners and medians, give maximum signal coverage and allow motorists to draw in critical information (gaps in traffic, presence of pedestrians and signal) all at one time.

### Common Problems/Solutions

Even with these quality placements, problems with motorists persist. For example, the motorist in the top photo is denying pedestrians their opportunity to enter the street. In many locations pedestrians can be aided by a 2-4 second "lead pedestrian interval". Once the opposing traffic has been stopped and before motorists are given a green light, the pedestrian signal head is activated, allowing pedestrians to claim their space before motorists proceed.

### Right-Turns-On Red (RTOR)

The common practice of permitting motorists to make Right-Turns-On-Red has an unintended result. Many motorists make illegal turns when pedestrians are attempting to make legal crossings. This leads to serious injuries, and discourtesies that discourage walking. To prevent this unsafe behavior many cities now deny Right-Turns-On-Red at schools, college campuses and many downtowns.

### Push Button Controls

Shown below is a convenient placement of a signal activator for pedestrians (far pole) and bicyclists (near pole). In many suburban locations it is essential for pedestrians to trigger signals. In downtowns and on all side streets, signals should always be on call. Push buttons are not warranted in these locations.





## Stop Line (Stop Bar) Placement

Stop lines (stop bars) are often placed within 4-6 feet of crosswalks in most locations. Some cities eliminate their placement at many or most intersections as a cost cutting measure. This practice leads to many motorists intruding into pedestrian crosswalks. This behavior blocks or prohibits pedestrians from crossing streets, or discourages them from using intersections altogether. Many children, most seniors and people with disabilities must wait for the next signal and hope that the practice is not repeated in the next cycle.

Several ways to avoid this problem include using wider stop lines (24" is helpful), using emphasis crosswalk markings so that the stop line does not appear to just be another line, or moving the stop line back 10 or more feet.

Research in St Petersburg, Florida demonstrated that by placing the stop line back 10 or more feet two benefits occur. First, most motorists no longer block crosswalks, and the placement opens up added sight lines so that both motorists and pedestrians can see one another.

The original stop line in the bottom photo (Honolulu, Hawaii) has been marked out. The new stop line resolved the problem at this and other key locations.



### **From the Manual on Uniform Traffic Control Devices (MUTCD) (Consult document for more details.)**

#### **Section 7C.04 Stop Line Markings**

**Standard: Stop lines shall consist of solid white lines extending across approach lanes to indicate the point at which the stop is intended or required to be made.**

Guidance:

Stop lines should be 300 to 600 mm (12 to 24 in) wide. Stop lines should be used to indicate the point behind which vehicles are required to stop, in compliance with a STOP sign or traffic signal. Stop lines, if used, should be placed 1.2 m (4 ft) in advance of the nearest crosswalk line, except at roundabouts as provided for in Section 3B.24.

In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point, but should be placed no more than 9 m (30 ft) nor less than 1.2 m (4 ft) from the nearest edge of the intersecting traveled way. Stop lines should be placed to ensure sufficient sight distance for all approaches to an intersection. Stop lines at mid-block signalized locations should be placed at least 12 m (40 ft) in advance of the nearest signal indication (see Section 4D.15).

## Manual on Uniform Traffic Control Devices

The following direct language from the most recent MUTCD is provided as a summary introduction. Traffic engineers turn to the MUTCD for guidance when assembling crossings for pedestrians. The manual should be seen as a beginning point and a home base for assuring minimum needed compliance for site treatments. Following this guide often results in reasonable motorist compliance. However, many communities find motorist compliance is insufficient with these levels of treatment in some locations. The MUTCD does not give specifics on many important items. Professional judgment, testing and evaluation of treatments are needed in many areas to come up with solutions that provide for acceptable motorist and pedestrian comfort and safety.

### Standard:

**When crosswalk lines are used, they shall consist of solid white lines that mark the crosswalk. They shall be not less than 150 mm (6 in) nor greater than 600 mm (24 in) in width.**

### Guidance:

Marked crosswalks should not be less than 1.8 m (6 ft) wide. Crosswalk lines, if used on both sides of the crosswalk, should extend across the full width of pavement to discourage diagonal walking between crosswalks (see Figure 3B-15).

Crosswalks should be marked at all intersections where there is substantial conflict between vehicular and pedestrian movements.

Marked crosswalks also should be provided at other appropriate points of pedestrian concentration, such as at loading islands, midblock pedestrian crossings, or where pedestrians could not otherwise recognize the proper place to cross.

Crosswalk lines should not be used indiscriminately. An engineering study should be performed before they are installed at locations away from traffic signals or STOP signs.

Because nonintersection pedestrian crossings are generally unexpected by the road user, warning signs (see Section 2C.37) should be installed and adequate visibility should be provided by parking prohibitions.

### Support:

Section 3B.16 contains information regarding placement of stop line markings near crosswalk markings.

### Option:

For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow as shown in Figure 3B-15. When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking may be used at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or at places where a pedestrian crosswalk might not be expected.

### Guidance:

If used, the diagonal or longitudinal lines should be 300 to 600 mm (12 to 24 in) wide and spaced 300 to 600 mm (12 to 24 in) apart. The spacing design should avoid the wheel paths.

### Option:

When an exclusive pedestrian phase that permits diagonal crossing is provided at a traffic control signal, a marking as shown in Figure 3B-16 may be used for the crosswalk.

Figure 3B-15. Typical Types of Crosswalk Markings

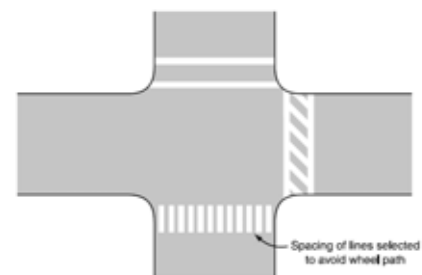
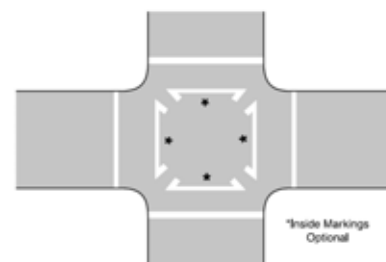


Figure 3B-16. Typical Crosswalk Markings for Exclusive Pedestrian Phase That Permits Diagonal Crossing





## Crosswalks and Crosswalk Markings

We consider minimum MUTCD markings (6" wide lines, 6' crosswalks) insufficient in all but the very lowest speeds. As a general rule crosswalk line widths should be 12 inches up to 30 inches wide, and crosswalks should be 10 feet wide up to over 50 feet wide. Line width is based on motorist speed; higher speeds demand greater line widths or enhanced crosswalk markings. Crosswalk widths are based on volumes of pedestrians and site factors. For example, the scene to the right is a 50 foot wide crosswalk in downtown Victoria, British Columbia at a popular shopping mall. The second photo is in Salt Lake City in front of a large commercial building. Additional detail follows.



### Crosswalk Width and Materials

Crosswalks should be clearly visible to motorists at all times. Use of materials, spacing of lines and physical location of crosswalks can add to durability of lines. Use materials and treatments that last. The six foot minimum width for crosswalks allowed for in the Manual of Uniform Traffic Control Devices (MUTCD) should be avoided in general practice. A recommended minimum width of 10 feet should be applied. The goal of markings and widths is to get high motorist recognition and get pedestrians into and out of streets efficiently, allowing peak numbers of people to remain inside markings.



### Special Markings

High emphasis markings (shown on this page) are suggested in commercial zones, school zones, key transit location, near medical centers and similar locations. As a general rule, the higher the speed and volume of traffic the more important high emphasis markings become. To save on maintenance costs parallel line markings are often used on side streets. When this is done it is recommended that these parallel lines be a minimum of 12 inches wide, with 18-24 inches preferred. Retroreflective markers or other high reflectivity materials are suggested for improved night visibility.



### Non Standard Markings

Many of the below markings are considered superior for visibility and maintenance to standard MUTCD choices of markings. Sacramento's 4 x 4 x 4 (second photo from bottom) is preferred in order to minimize materials and to allow people with high heels, baggage, baby strollers and wheelchairs to traverse a smooth surface. Note the added retroreflective markers, used to increase night time visibility in non snowplow regions.



### King County Piano Keys Markings

For maintenance purposes the King County markings (bottom photo) receive minimal wear, since motorists wheels track in non-marked areas of crosswalks. These special markings often only need touchups every 4-7 years.

## High Emphasis Markings Are Critical on Arterials

A picture is worth a thousand words when it comes to crosswalk markings. In the below crosswalk marking pedestrians are invited into a clearly marked space. Meanwhile, under the best of conditions motorists do not see this marking until two or three seconds from the event. Higher emphasis markings can be seen from distances of 250 to 300 feet out, which at 40 mph (average speed on this road) is slightly less (4 to 5 seconds) than the recommended six seconds of detection, reaction and response times.



**Left:** What the Pedestrian sees.

**Below:** What the Motorist Sees

**Top Horizontal Photo:** Two parallel lines were used. Motorists are not able to detect this crosswalk marking until they are within 2 seconds of the collision. Note that with other commercial sign clutter it is difficult to detect standard size pedestrian signs.

**Bottom Photo:** Moderately well marked crossing using high emphasis markings. Motorists sitting at average vehicle heights are able to detect this marking from 200 – 300 feet out (5-6 seconds of reaction and braking time at 35 mph).





## Exotic Colors Do Not Help Pedestrians

As shown in these illustrations, when exotic blue, yellow, red or green paint is used to define crossing areas, motorists on approach see little or none of what invites pedestrians into the street.

The pedestrian perceives, "gee, everybody on the planet must see that this is a crossing," while the motorist is being shown a fairly faint two lines along with many other competing visual street details. Even hours after the bright blue paint is presented, motorists are not likely to detect crossings until almost on top of them. Weeks or months later the strong blue, green, red or yellow paint will fade. Meanwhile the two anemic lines will continue to have low value.

The key lesson to this visual exercise, standard signs and advanced pavement markings, and wide longitudinal lines (24" wide) are superior in catching motorists' attention to the flat marking of painted or surfaced crosswalks. Crosswalk lines or high emphasis white markings are superior to red, blue, green or other exotic treatments.

On primary roads, especially with speeds of 30 mph or higher always use 18 to 24 inch longitudinal lines or other high emphasis crosswalk markings.



## Paver Stone, Stamped Crossings

A number of communities choose to use paver stones, stamped concrete or stamped asphalt for crosswalks. Although this can be done for aesthetic purposes, such materials are quite difficult for motorists to see until they are right on top of the crossing area. Indeed, the photos on the previous page illustrate how difficult it is to see even parallel lines. Thus stamped red concrete or asphalt blends fully into the street from approach distances of as little as 100 feet.

Although the paver or stamped features look clean and crisp to pedestrians waiting to cross, motorists can rarely see the crosswalks.

Under no circumstance are pavers or colorized treatments recommended for higher speed roadways with speeds exceeding 35 mph.

When paver or stamped materials are used, parallel painted or thermoplastic lines with a width of 18 to 24 inches each are highly encouraged.

### **Studebaker Strip**

The "Studebaker Strip," named after Chico's Steve Studebaker, is recommended in all cases of uneven surfaces. Stamped materials and some pavers are challenging to people with disabilities, people in high heels and others. When these materials are used a 4 foot smooth surface should be created in the center-most portion (see photo).

Finally, using pavers to accentuate entire intersections, then using lighter paver stones for crosswalk areas has an especially pronounced effect on pedestrian emphasis zones (Climatis Street in West Palm Beach, Florida).





## Standard Midblock Signs

The following direct language from the most recent MUTCD is provided as a summary introduction to signing for midblock locations, and other areas where motorists may not expect pedestrians.

### Section 2C.37 Crossing Signs (W11-1, W11-2, W11-3, W11-4, W16-7P)

#### Option:

Crossing (W11-1 through W11-4) signs may be used to alert road users to locations where unexpected entries into the roadway by pedestrians, bicyclists, animals, and other crossing activities might occur.

#### Support:

These conflicts might be relatively confined, or might occur randomly over a segment of roadway.

#### Option:

Crossing signs may be supplemented with supplemental plaques (see Section 2C.39) with the legend AHEAD, XX METERS (XX FEET), or NEXT XX KILOMETERS (NEXT XX MILES) to provide advance notice to road users of crossing activity.

#### Standard:

Crossing signs shall be used adjacent to the crossing location. If the crossing location is not delineated by crosswalk pavement markings, the Crossing sign shall be supplemented with a diagonal downward pointing arrow plaque (W16-7P) showing the location of the crossing. If the crossing location is delineated by crosswalk pavement markings, the diagonal downward pointing arrow plaque shall not be required.

#### Option:

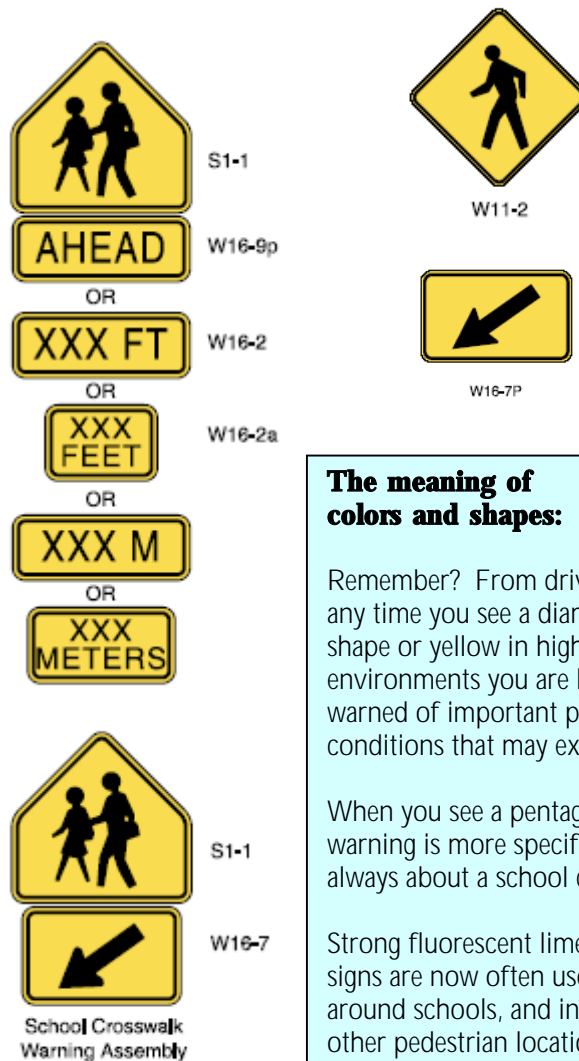
The crossing location may be defined with pavement markings (see Section 3B.17). Pedestrian, Bicycle, School Advance Crossing, and School Crossing signs may have a fluorescent yellow-green background with a black legend and border.

#### Guidance:

When a fluorescent yellow-green background is used, a systematic approach featuring one background color within a zone or area should be used.

The mixing of standard yellow and fluorescent yellow-green backgrounds within a selected site area should be avoided.

Crossing signs should be used only at locations where the crossing activity is unexpected or at locations not readily apparent.



#### The meaning of colors and shapes:

Remember? From drivers-ed, any time you see a diamond shape or yellow in highway environments you are being warned of important potential conditions that may exist.

When you see a pentagon the warning is more specific... always about a school crossing.

Strong fluorescent lime-green signs are now often used around schools, and in some other pedestrian locations. The human eye is attracted to strong lime green more than any other color.

## What Do The Signs Mean?

The variety of signs in use along our highways can be confusing ... even to engineers. The top sign is no longer in general use. The two parallel lines indicated the specific location of a pedestrian crosswalk. This sign was normally preceded with a sign of a pedestrian without the two parallel lines. The advance sign indicated that a pedestrian crosswalk could be anticipated downstream in 6 seconds. Motorists never fully knew the difference between the two signs. It appears that engineers didn't either, since signs were often put up in reverse order.

Current best practice is to use either the pedestrian or school signs without arrows as an advance notice, and then place the sign and emphasis arrow to indicate the specific location of the crosswalk. The word (Ahead, or XXX Feet) can also be used for the advanced placement. It is important to have advance signs, since motorists need about six seconds in order to react safely.

On the next several pages additional signing, pavement markings and technologies are presented. Although many of these treatments are not in conventional engineering bibles, many are proving essential for midblock crossings. There has been a fifty year silence in addressing appropriate technology for geometric and operational crossing guidance.







Pop-Ups, pavement markers and edge signing. The Manual of Traffic Control Devices is silent on the use of these additional signs. However, experience in many New England States (New York, New Hampshire, Connecticut and others) shows higher motorist compliance with yielding where these added signs and markings are used. One note of caution, these signs and markings should not be used in lieu of standard MUTCD signing. The center lane pop up sign is bolted in place, and is often removed during plowing season.



## More on Non-Intersection Crossings

Pedestrians desire to cross streets without going more than 150 feet out of their direction of travel. In highly supportive pedestrian districts, crossings are organized every 300 feet. This is not always possible, nor practical in most other locations.

Meanwhile, the longer the separation between legal crossings the more random pedestrian movements become. For these reasons it is essential to plan appropriate crossings to assist motorists and pedestrians by applying appropriate midblock street crossings. This is most easily achieved when speeds are low, lighting and sight distances are good, and when there is high expectation that pedestrians will be plentiful. It is highly challenging when these conditions do not apply.

City of Marina primary roadways have inadequate non-intersection crossings. Too many signal controls create travel inefficiencies and safety problems for all roadway users. Signal controlled intersections are often spaced 800, 1200, 2400 or more feet apart. As signal controlled intersections are spaced farther and farther apart pedestrians cross streets more randomly.

Today, there are few guides provided to traffic engineers on how, when, and where to place mid-block crossings. Failure to have such a guide is one of the greatest oversights in modern traffic engineering. Meanwhile, progressive communities must develop interim guidelines, evaluating and perfecting methods to provide appropriate crossings. To not do so invites risky and unsafe movements that neither the pedestrian nor motorist can deal with.



Photos: 1. Del Monte Boulevard is an example of a roadway with widely spaced signals. More people cross this street midblock than at nearby signalized intersections. 2. Trail crossings are often placed within 400 feet of signalized intersections. Most pedestrians and trail users will not go out of their route of travel to a place with more conflicts, delays and distance. (3) Numerous tools are now available to improve crossings. These include imbedded lights in pavement that pulse when pedestrians are crossing, as well as lights that activate on signs.



## Crosswalks Work Best With Curb Extensions



These crosswalks are nearly ideal aids accentuating the quality built into each of these two commercial areas. When properly positioned along with curb extensions, bollards, quality lighting and other streetscaping and building materials, crosswalks are easy to maintain, while not detracting from place making. Top photo: Easton Town Center green field development, Columbus, Ohio. Bottom Photo, City Place, infill development in West Palm Beach.

## Side Street Markings

Location: New urbanist development, Issaquah Highlands, Issaquah, Washington

There is no general convention on when and how to mark side streets (secondary street crossings) along primary roads. Some state agencies have a uniform policy to leave these unmarked. This saves on costs of marking and painting, but increases problems with motorists failing to yield to pedestrians.

By law, all people within highway rights-of-way (generally at the back of sidewalk), whether in vehicles or not, moving up and down primary routes of travel have right of way over any vehicle entering or exiting roadways. Marking important side streets needs to be the rule rather than the exception.

As a general rule, the wider the street, the more significant the route of travel (e.g. school routes, commercial areas, transit stations or high emphasis pedestrian areas), the more essential the side street markings are.

States and municipalities should have policies to mark these side streets on a priority basis. In some areas side streets may go unmarked, especially if crossings are narrow and speeds are low.

Where it may be desirable to mark some or many side streets using two parallel lines, it is recommended that paint stripes be a minimum width of 12 inches, with 18 inches preferred.



**Bottom Photo:** The bottom photo is a near perfect side street crossing and junction. The combination of curb extension, bike lanes, crosswalk location, crosswalk width, tactile entry, spacing of lines (motorist wheels track around markings) and stop bar width and placement all lead to very little confusion, and high levels of yielding behavior. Note that although this crosswalk is set back from the intersect lines of the intersection, speeds are kept low and the sidewalk is visually clear to approaching or turning motorists. In contrast, note the problem with the crossing placement on the next page.





## Crosswalk Placement

Crosswalks must be placed in close proximity to the streets they connect. This crosswalk is nearly 20 feet from the imaginary intersect lines of these two streets. For each 5 feet the pedestrian is separated from turn movements there is a 50% reduction in motorists yielding to pedestrians. Thus, there is only a 25% chance these motorists will yield.

Only the third car in the stream yielded ... and then largely because the pedestrians finally ran into the street

In contrast, the bottom left scene depicts a properly placed crosswalk, close to the intersecting streets.

### **Ultimate Crosswalk Marking Is No Marking**

This Cambridge, Massachusetts marking is easy for motorists to see and respond to when someone is crossing. Also note the use of different street materials, eliminating the need to paint crossings. The treatment is a natural extension in materials, pattern and emphasis. The message the motorist receives is "Hey, you are about to intrude on a pedestrian pathway, slow down and look."

While some folks may say we want to make the pedestrian feel they are intruding on vehicle space, it is the motorist that has the potential to do the most harm, and we need many direct visual messages to help them understand their duties.



## Common Mistakes At Intersections

My evaluation of intersections throughout the nation reveals that there are no fully perfect designs. Meanwhile to get a score of 7 (out of a possible 10) is not a difficult task. Several Marina intersections score 2 out of a potential 10 (Reservation Road and Del Monte Boulevard). Marina intersections fail in a number of significant ways. Proper signal clearance intervals (time it takes to cross the street at 4 feet per second) has not been achieved at any of the nearly 20 legs of crossing on the 5 intersections we measured. One clearance interval required the pedestrian to run almost full speed to get into and out of the street before facing opposing traffic. All clearance intervals must be set for 4.0 feet per second, or less (3.5 or 3.0 feet if numerous older people or children are present).

### Other common mistakes:

1. Top Photo: No stop bar. Signal activator loops are pulled forward into the crosswalk, rewarding motorists who block the crosswalk.
2. Exceptionally wide crossing, with crosswalk bent in the middle (a blind person would not be able to navigate to a safe location).
3. Missing crosswalk at intersection. Only in extreme cases should crosswalks be omitted at signal controlled intersections. When a crossing is omitted pedestrians must cross three separate legs, taking nearly five minutes and exposing them to 18 potential conflicts.

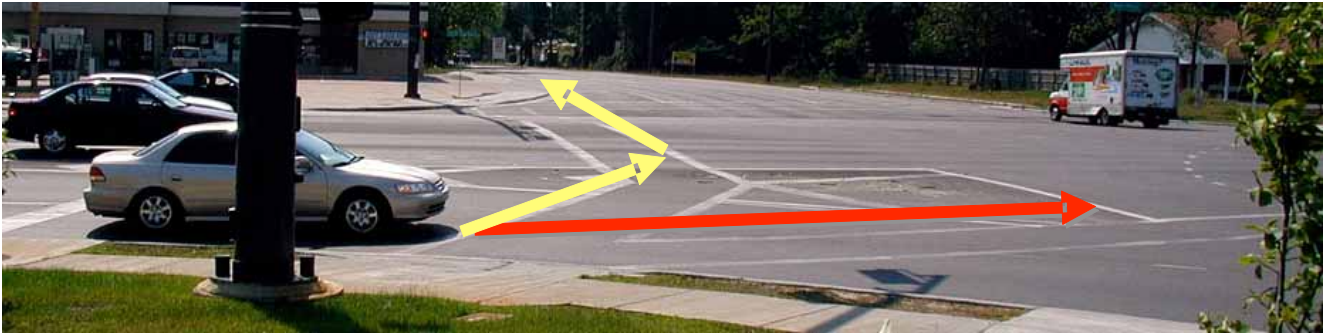
As a general rule the only time crosswalks are omitted from a particular leg of an intersection is with a tee-intersection, where sometimes one leg is omitted to eliminate conflicts with high volumes of left (or right) turning traffic.

In the above Reservation Road and Del Monte intersections the prohibition of pedestrian movement exists to permit a dual right turn lane on the far side of the street. The dual right turn lane needs to be eliminated. For problems associated with this design, see next page.

If a roundabout is not chosen for this intersection, a single lane urban channelized turn lane can handle all needed traffic. On-street parking and bike lanes could be added in the vast recovered space (20 feet).







### Avoid Dual Right Turn Lanes

Under no circumstance should dual right turn lanes be considered good intersection design. Although in rare cases engineers may feel forced to compromise intersections by adding dual-right-turn-lanes (DRTL's), all efforts should be made to avoid such measures. For the pedestrian there is no safe time to cross. Adding extra lanes adds significantly to signal cycles. The crossing in this scene is 138 feet, calling for a 35 second clearance level (4 feet per second).

In the extreme case above, pedestrians are invited to walk with their backs to traffic in one direction, with dual lanes approaching from their rear. In the second case, one motorist may yield, setting up a condition where the second motorist hits the pedestrian.

The photo simulations (bottom photos) show two possible partial solutions if dual right turn lanes were kept. Signals are used to stop all traffic, or raised speed tables are added to slow traffic to about 15 mph.

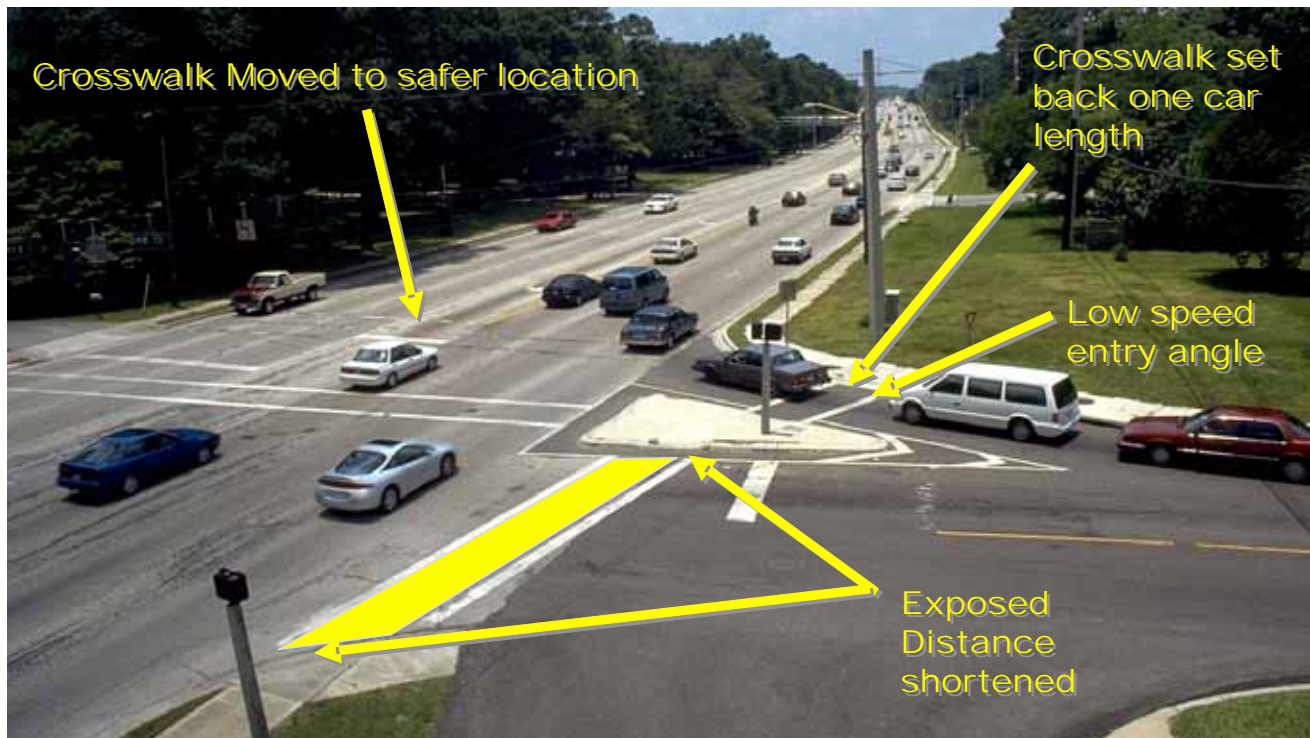
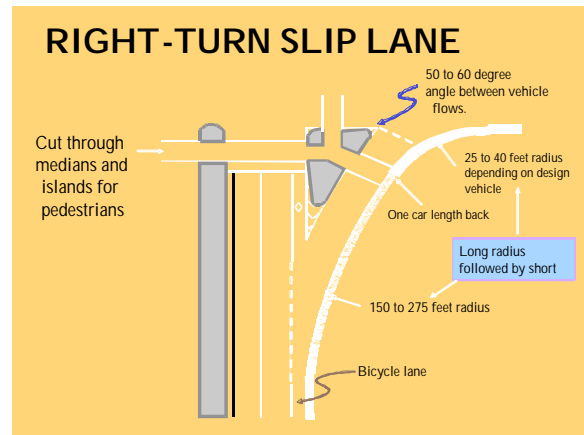
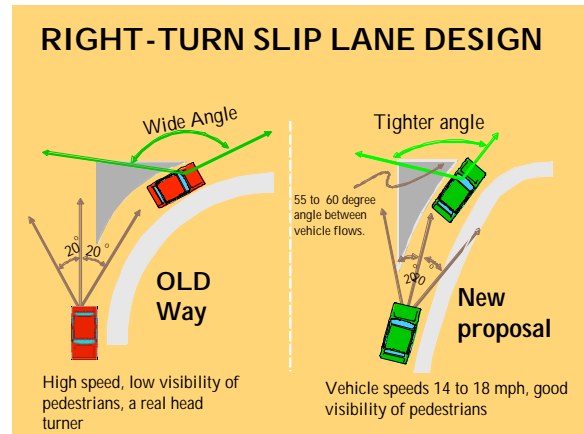
Options to dual right turn lanes include: Improved distribution of traffic on multiple sets of roadways, roundabouts, or appropriately designed single right turn lanes with urban designs to slow traffic. Chances are excellent that even high volumes can be handled with well designed urban right turn lanes and reasonably long queue lanes on the departure road.



## Channelized Islands — Geometrics

In order to reduce exposed crossing widths of especially wide intersections, channelized intersections should be used when they are evaluated to be the best tool for pedestrian needs. Channelized intersections shall use urban designs to minimize speed of motorists using channelized islands. As shown in the illustration to the right, the current American Association of State Highway Transportation Officials (AASHTO) guide only lists the old rural design to develop channelized islands. Now referred to as the "rural model," this design leads to high speed right turns. Pedestrians feel uncomfortable with the rural design. The rural design, used in urban locations, has many problems. As motorists enter they lose the ability to see if they have a safe gap. Once they lose confidence, many apply their brakes. Meanwhile, motorists tailing them see the acceptable gap and often drive into motorists stopping suddenly.

The urban design is superior for all urban applications. Improved sight distances allow higher capacity. Tighter entering geometry reduces speed, greatly increasing motorists' desire to yield to pedestrians. The new design calls for a triple centered, compound curve. This minimizes the amount of land needed for the project while allowing oversized trucks to complete the turn in appropriate lanes. Acceleration lanes are highly discouraged in urban settings.



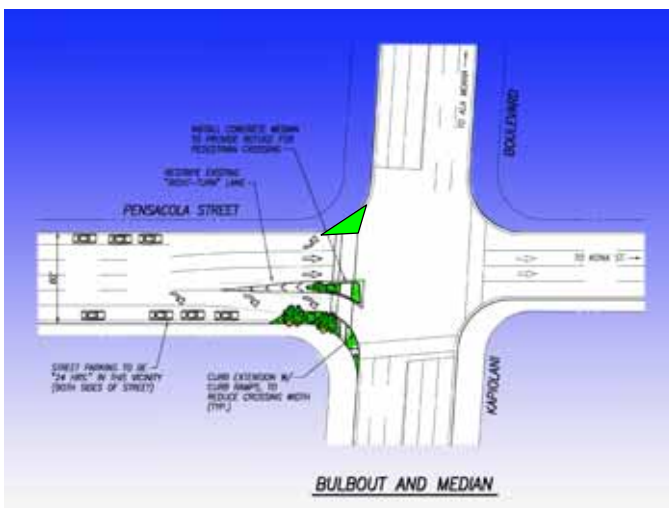
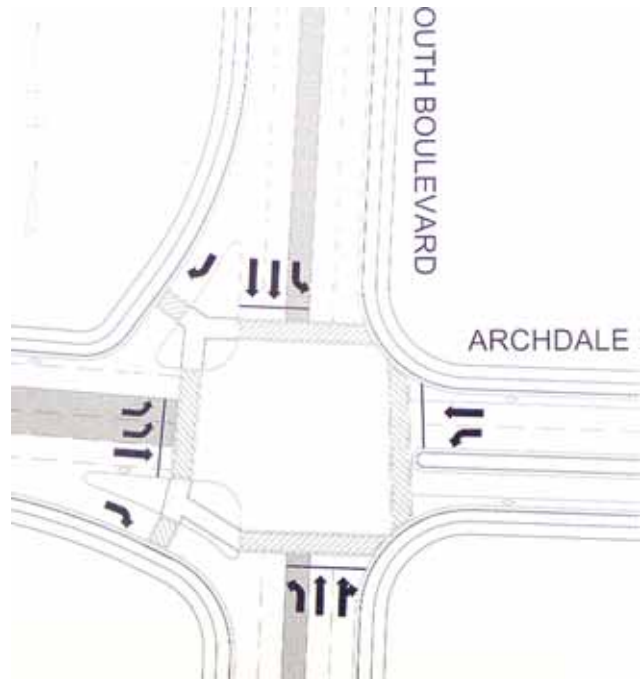


## Channelized Islands — Operations

Proper marking of pedestrian crossings is 22 feet back (one car length) from the yield line. The second photo shows some pedestrians continuing to cross on a direct line, not in the crosswalk. This creates two problems: First, pedestrians have their back to traffic, placing them at risk. Second, when a motorist is properly queued they are blocking the crosswalk. As a general rule high emphasis crosswalk markings should be used. When exceptionally low pedestrian activity is anticipated crosswalk markings through the right turn slip lane are omitted.

Signal heads and push button activators (when needed) are placed on the channelized island. On rare occasion, when pedestrian volumes are exceptionally high (3,000 or more per day) a signal for crossing pedestrians to the island may be considered. However, as a general practice, well constructed islands with low speed entries create many simple gaps for pedestrians, and having to wait for a signal is undesirable.

The design in the bottom photos are illustrations and simulations. They show how much of the pedestrian signalized crossing distance is eliminated. This keeps signal cycles short, rewarding both pedestrians and motorists. In this illustration the pedestrian crossing is placed at the signal, since motorists are not permitted to make Right-Turns-On-Red. This solution drops the exposed crossing distance from 72 feet to 30 feet, and the signal clearance interval drops from 18 seconds to 8 seconds.



## Channelized Islands — Stepping Stones

Snow days and helicopters or skyscrapers are powerful tools helping designers determine unused intersection areas.

Michael Ronkin, Oregon's Pedestrian and Bicycle Coordinator, provides these visual tools showing which portions of this intersection are used.

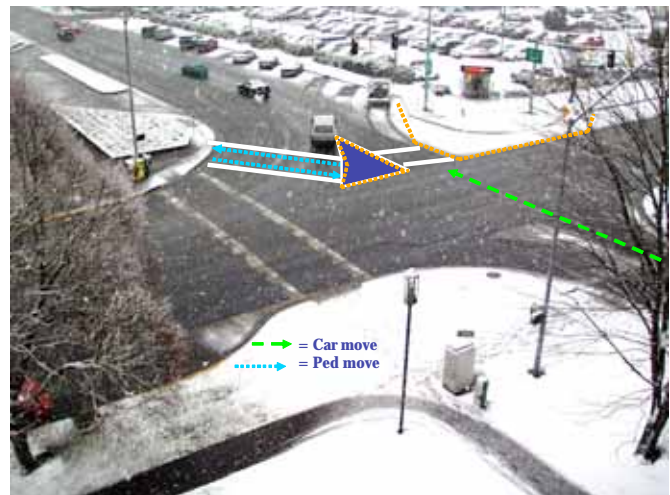
Once patterns are observed and evaluated it is possible to draw in appropriate new channels for both curb extensions and channels.



## Channelized Island Issues

Pedestrian advocates in some regions of the nation are divided on when or if channelized islands are in their best interest. Many of these folks have only experienced higher speed, rural designs. The issue should not be whether such tools help or hinder pedestrians, but "what are pedestrian friendly designs, and what are not."

These pages explain correct geometric and operations solutions. In no case can rural channels be considered pedestrian-friendly. Newer, more modern urban channel designs resolve this issue significantly by bringing down the speed of traffic, greatly increasing yield rates and making the journey from one side of an intersection to the other as short and convenient as possible.



## Upgrading Channel Islands

The channelized island in the bottom photo is poorly conceived and executed. It is too small, hard to detect and uses old rural design geometry. Motorists can enter the crossing at higher speeds; pedestrians leaving the curb have their back to motorists.

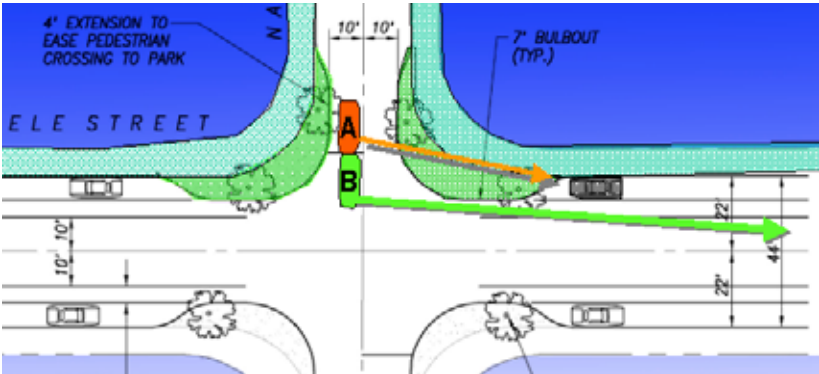
This may be a good location for a well designed channel. A proper channel would have its tail pointing toward the approach driver, while the geometry of the top right corner would be a 55-60 degree angle. The crosswalk would be pulled back.

As a general rule, any intersection requiring signs to notify motorists that they must turn right and to yield to pedestrians is a poorly designed intersection. Good intersections require little or no signing at the intersection.





Curb Extensions  
*(also known as  
 Bulbouts, Bulbs, Bulges, Blimps,  
 Elephant Ears, Nibs)*



Curb Extensions Greatly Improve Sight Distances



Curb Extensions Greatly Improve Motorist Awareness of People Wanting To Cross



## Curb Extensions (Continued)

**Curb Extensions** reduce excessive crossing width at intersections and midblock crossings. Reductions in crossing width add to both the efficiency of signalized and non-signalized intersections while reducing exposure of pedestrians in active roadway environments.

Through attention to design, engineers can both slow the speed of motor vehicles and assure proper access. When curb extensions are not used motorists often park too close to corners and screen the view of motorists and pedestrians.

In most applications engineers can design curb extensions that benefit turning movements of small to large vehicles.

Dollar for dollar there is no greater investment to quality urban walking experiences than well designed curb extensions.

Curb extensions add great value to corners, allowing for many expanded uses of areas near the corner.

In the top two photos, Venice, Florida added curb extensions (at their cost) to a Florida DOT resurfacing project. Speeds were reduced from the mid-30's to around 20 mph. Businesses came back, as did many pedestrians who had stayed away from the numerous vacant stores where speeding traffic once prevailed.

The bottom two photos are an urban infill project on Second Avenue in Davis, California (site of the weekly farmer's market across the street). Note the significant garden space created from some former plain concrete space.





## Curb Extensions (Continued)

### **Curb extensions have universal appeal.**

Once snow plow operators get over their squeamishness of how to handle new street designs, curb extensions are fair game in all climates and zones. Note in the top photo in Toronto how posts guide snow plow operators on where extensions start and end. The gentle sweeping curve aids street sweepers as well as snow plow operators in their maintenance of streets.



### **Curb Extensions create attractive, people scaled streets.**

The second photo reveals a near perfect intersection where every size vehicle can turn. This intersection makes use of paver stones, bollards, lighting and many other features to achieve a 10-15 mph design. Note that curb extension placements inset parking for clean, tidy visual street details. Motorists can better focus on things that matter (people) while seeking a place to park.



### **Curb Extensions Fit Historic Areas**

Below: Winter Park, Florida is one of the state's oldest and best communities. A circa 1998 rebuild of this street achieved quality paver stone construction with clean, crisp white sidewalks and curb extension.

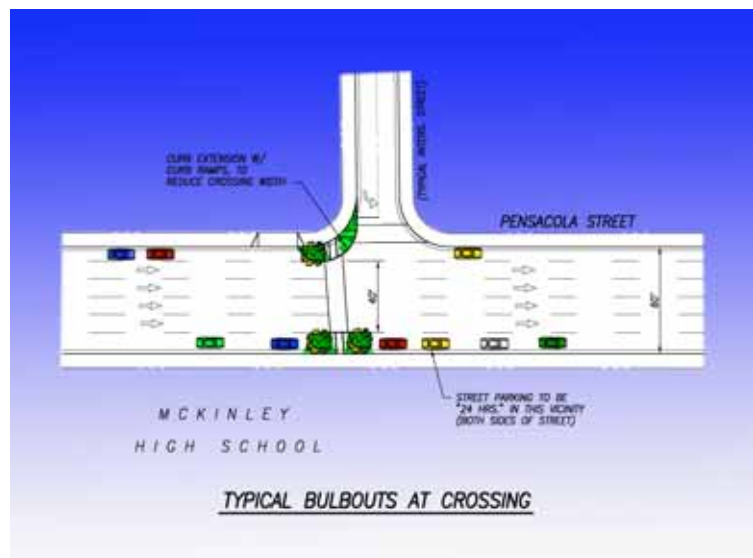
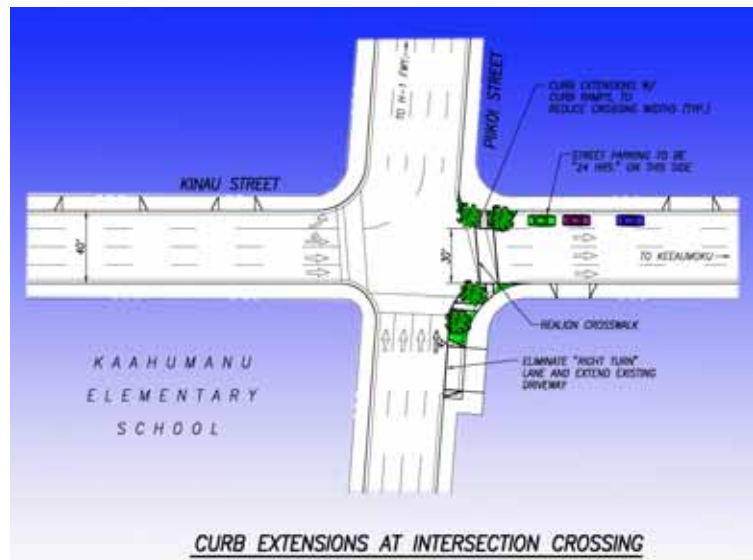
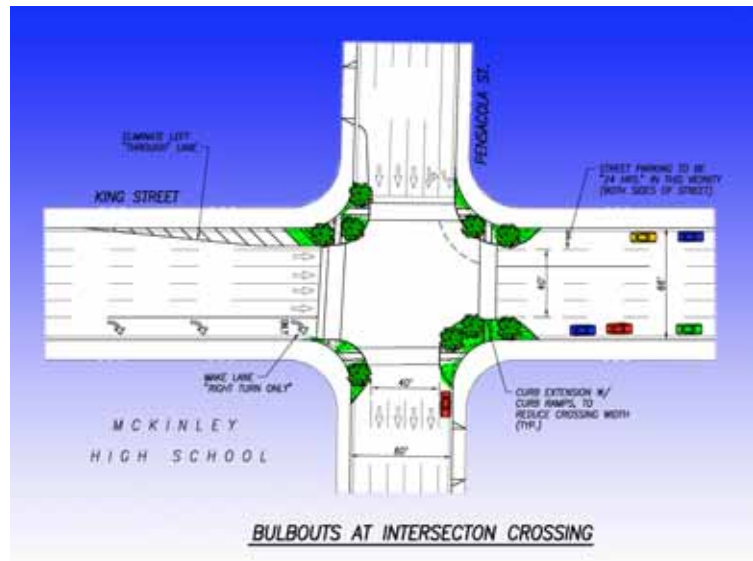


## Curb Extension Opportunities

Curb extensions fit most easily on virtually all streets sporting on-street parking. An interesting exercise for beginning or advanced engineering students is to determine all appropriate locations for curb extensions on downtown streets. As a general rule, curb extensions should be fully considered in the following applications:

1. All streets with right or left turn drop out lanes.
2. All streets having more queuing space than required by intersection signals most hours of the day.
3. Many one-way streets, especially those having parking, or low enough volumes to allow parking.
4. Any location where existing traffic volumes do not justify the current number of assigned lanes.
5. Intersections of streets with diagonal parking can be significantly improved by adding curb extensions. Streets should be evaluated to assess the benefit of diagonal parking. Often many downtown side streets can be amended to offer diagonal parking.

The facing illustrations show streets in conversion for curb extensions in Honolulu, Hawaii. In all cases the addition of curb extensions on these streets adds to signal efficiency by reducing clearance intervals of pedestrians.





## Raised Intersections

Raised intersections reduce speeds at intersections 24-hours a day. Raised intersections are often used in school zones, but can be applied in other locations such as close to parks, town centers, transit hubs and other locations where low speeds are desired.

### Grade

As a general rule a 7% grade achieves the most desirable speed reductions. With this grade motorists feel comfortable at speeds of 15-20 mph. They feel moderate levels of discomfort at higher speeds.

### Crossing Areas

Grade changes are placed before crossing areas, and distinctive colors, textures or markings are used to alert motorists of the changed condition.

### Used in Combination

Raised intersections are best used with added visual effects of curb extensions.

### Advance Warning

When using raised intersections it is essential to provide motorists advance warning of the correct speed and notice of the change in conditions.

### Emergency Response

Emergency responders generally prefer raised intersections to most other traffic calming treatments, since they minimize problems they have with extreme speed reductions, such as at 4-way stops.



*Top three photos: Raised intersection in West Palm Beach, Florida used at school sites on a former 5-lane roadway. Traffic volumes of 18,000 vehicles are handled efficiently throughout the corridor. Bottom photos: Cambridge, Massachusetts has a half-dozen raised intersections, primarily near schools.*



## Stop Controlled Intersections

### Two-Way Stop Controls

Two-way stop controls are often used when secondary routes of travel intersect with primary routes.

### Four-Way Stop Controls

Four-way stop controls are used when intersecting streets have similar volumes of traffic, when there are severe sight limitations or under other unusual conditions where signals and roundabouts are not justified.

These stop controlled crossings can be easy for pedestrians to traverse if lanes are not overly wide. If intersections are too wide pedestrians can be significantly challenged to make these crossings.

In such cases a series of tools shown on this and the next several pages (see medians, median noses, neckdowns and chokers) can be applied.

The following traffic tools should be provided:

1. Well marked crosswalks
2. Crosswalks placed near corners
3. Well positioned stop controls
4. Tight corner radii
5. Clear sight triangles for motorists
6. Parking restrictions
7. Curb extensions

Under more challenging conditions such as steep downhill grades, when traffic calming is needed, or when special needs populations are significant, these additional tools may apply:

1. Median islands or refuge islands
2. Neckdowns
3. Oversized stop signs
4. Stop pavement marking
5. Choker lanes
6. Speed tables
7. Combinations of the above treatments





## Medians and Median Noses

Medians and median noses separate intersection crossings into two more manageable halves. A 60 foot, 5-lane roadway, for example, takes about 13-14 seconds (4 feet/sec) to cross, while a 24 foot crossing to a raised median island takes just 6 seconds. Most people cannot anticipate and react safely within just 13 seconds.

For these reasons, whenever it is feasible to add medians into intersections it is highly advisable. Painted medians have no value to pedestrians.

Under ideal circumstances, minimum widths for medians should be 8 feet. This creates a buffer forward and back for pedestrians. However, medians as narrow as 4 feet can be of great benefit.

### Median Noses

Median noses are small islands extending further toward or into the intersection to control turning speeds of motorists. These are highly valuable and should be used where they are not overly restrictive on motorist turning movements.

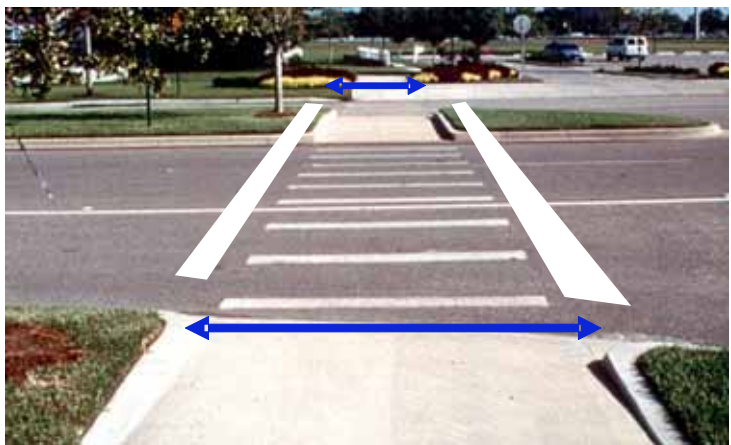
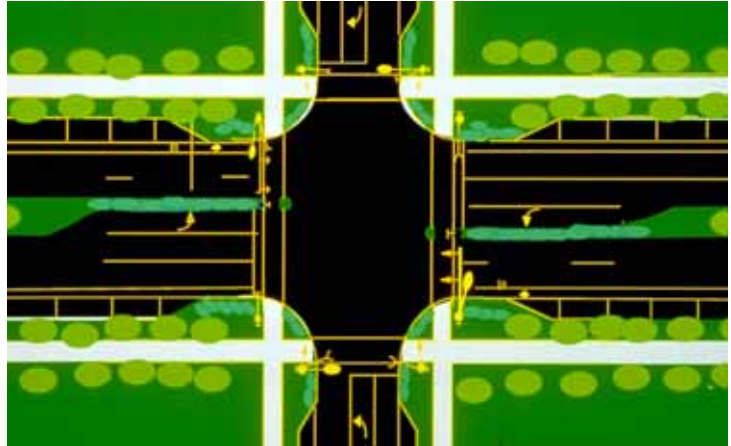
### Median Cuts

Median cuts are areas between the regular median and median nose. These should be amply wide to allow two wheelchairs to pass. As a general rule keep these cuts as wide as the crosswalk.

The median nose and island shown in the adjacent photo is too narrow for two wheelchairs to pass. However, in this application the visually impaired community seeks the narrower opening to aid them in caning and navigating. This conflict within the ADA community is just one of dozens that need to be resolved.

### Refuge Island

Refuge islands are short medians. They have a similar value to full length medians. Since they are less costly to install they can be popular in high pedestrian zones, such as commercial districts, beach frontages and similar locations. Refuge islands should generally be 20 feet long for each leg, or longer. Landscaping and advance lines help detail their presence to motorists, and help slow motorists in advance of encountering these features.

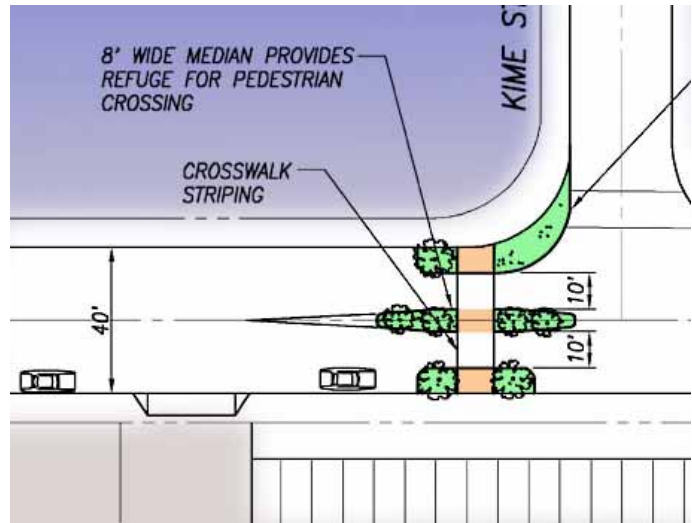


## Medians and Median Noses (Continued)

When vehicular speeds are to be controlled to an even greater extent, medians can be used with curb extensions in order to create a choker effect. When this is desired, travel lanes are best restricted to 10 feet. Vehicles of all sizes can easily manage the 10 foot constricted space. These chokers are very popular around schools, parks and in other settings where special populations or high volumes of pedestrian crossings are anticipated.

### **Flat Median Nose**

Shown in the adjacent photo is a raised median to the left, an open full width pedestrian crossing and a flat median nose. These flat median noses are highly effective in restricting the speed of motorists making turns while still allowing oversize vehicles, such as sanitation trucks and fire equipment to easily navigate turns.





## Two-Lane Street Crossings

Pedestrian crossings are designed, placed and marked based on anticipated speeds. Very low motorist speeds assure higher levels of yielding behavior. At speeds of 15-20 mph most motorists will yield to pedestrians, unless they have other distractions. As motorists' speeds increase in 5 mph increments their desire and ability to yield drops markedly. There is virtually no yielding behavior at speeds of 35 mph and higher.

On very low speed downtown streets (15-20 mph) simple marked crossings with curb extensions may be all that is needed to identify convenient crossings, and to gain high compliance of use and yielding behavior of motorists.

If speeds are higher (25-30 mph or higher) crossings must be better identified. Medians or refuge islands become important in many cases. Bike lanes can be retained, as needed.

As speeds increase beyond 30 mph it is desirable to introduce traffic calming, or consider signals in some applications.

Basic treatments at all mid-block crossings include all appropriate treatments in the Manual On Uniform Traffic Control Devices (MUTCD) and:

1. Well marked pedestrian crossings with high emphasis marking treatments.
2. Crossing areas are well lit
3. Crossing areas generally have curb extensions
4. Crossing areas have signs and appropriate pavement markings ( See MUTCD, Section 2C, W11-1, W11-2).
5. Refuge islands or medians are needed on higher speed roadways.
6. Well developed landscaping helps identify these islands. Ground cover is kept low and easily maintained (below 24 inches in height). If trees are used they are undercut to provide a 7-foot view window.
7. When median/refuge island width permits, a 45 degree angle to the right is inserted helping pedestrians look toward approaching traffic.



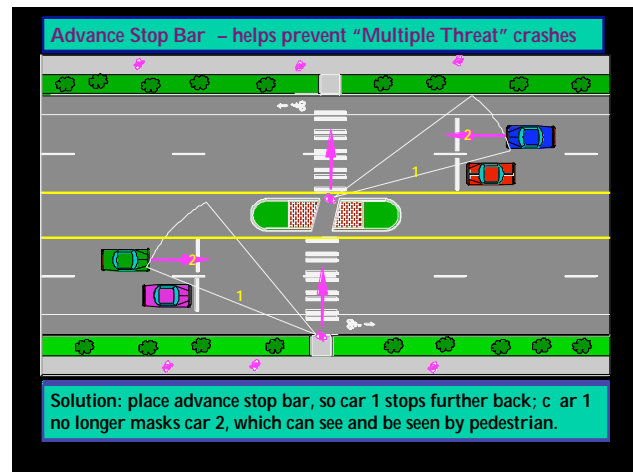
## Multi-Lane Mid-Block Crossing Designs

Mid-block crossings of multi-lane roadways are more complex and require added sophistication. Multi-lane streets not only allow higher speeds and volumes, there is a danger of one motorist stopping to yield and setting up a blind condition where motorists in other lanes hit the pedestrian.

Yet, these are also essential crossing areas, and proper placements must be made. Signing and pavement markings shall be in compliance with the latest version of the Manual On Uniform Traffic Control Devices (MUTCD). All multi-lane crossings require engineering studies, preferably by engineers with experience in these types of designs.

### Advance Stop Lines Are Essential

For multi-lane roadway sections, additional measures should be taken, including median refuge islands, advance stop bars and either speed controls or signals. As a general rule, stop lines should be placed 40 to 60 feet back from the crosswalk. This placement opens up sight lines allowing pedestrians and motorists in other lanes to detect and respond to one another (See illustration above by Michael Ronkin, ODOT).





## Mid-Block Signalized Pelican Crossings

Some mid-block multi-lane crossings require signals. When signals are used, motorist delays of up to 25 seconds can be anticipated on roads of 60-70 feet width. In order to avoid these delays, an advance engineering tool is introduced – the staggered crossing.

A well constructed island is installed in the center lane (normally the fifth lane). This island must be visually significant, well detected day and night hundreds of feet on each approach. Pedestrians are given a priority response when they push the button to call up signals. They cross 22-24 feet at a time. This requires a 4-7 second entry phase and a clearance interval of 6-8 seconds... often resulting in little or no motorist delay. Once on the island pedestrians walk to their right, push the second button and are underway with little or no delay.

Motorists on side streets or others queuing to turn left do not see the signals. However, they benefit every time pedestrians cross. This style of pedestrian treatment can be of significant benefit to transit. In Seattle, up to one-half of all pedestrian fatalities are to people stranded on one side of a multi-lane street; once they see their bus coming they are known to take extraordinary risks to get to the other side.





## Toucan Crossing

The Tucson, Arizona Toucan (two can cross at the same time) crossing uses the conventional British practice of naming all midblock crossing designs after birds. This unique design is used on a popular bicycle boulevard. Bicyclists and pedestrians on approach are detected by a video camera/computer system. Main line traffic is stopped in time for bicyclists to proceed at speed. The result, motorists have little or no delay... and bicyclists get past a troublesome crossing.

Meanwhile, neighbors benefit by a forced right-out only. This practice eliminates potential cut-thru traffic. Again, motorists benefit from bicyclists and pedestrians. Each time they use the signal, gaps are opened, allowing motorists to enter the main street traffic flow.

Tucson, Arizona is this nation's top city for testing and applying midblock crossings. More than 30 midblock crossings have been installed, including on busy streets and on seven, eight and nine lane roadways, such as Speedway, an aptly named street considering the behavior of area suburban drivers.

