CHAPTER 6: INTERSECTIONS

INTRODUCTION

Most conflicts between roadway users occur at intersections, where travelers cross each other's path. Good intersection design indicates to those approaching the intersection what they must do and who yields to whom. Pedestrians' and bicyclists' movements are complicated by their lesser size and visibility.

This chapter is divided into intersection designs for bicyclists, intersection designs for pedestrians, and intersection and interchange designs for both pedestrians and bicyclists. These basic principles apply to all users:

- Unusual and unexpected conflicts should be avoided.
- Good intersection designs are compact.
- Simple right angle intersections are best for bicycle and pedestrian movement. The problems are more complex at skewed and multi-legged intersections.
- Free-flowing movements should be avoided.
- Access management practices should be used to remove additional conflict points near the intersection.
- Signal timing should not hinder bicycle or foot traffic with overly long waits or insufficient crossing times.

BICYCLISTS

These basic principles apply to bicyclists:

- Good design creates a path for bicyclists that is direct, logical and close to the path of motor vehicle traffic; only in rare cases should they proceed through intersections as pedestrians.
- Bicyclists should be visible and their movements should be predictable.
- Bike lanes should be striped to a marked crosswalk or a point where turning vehicles would normally cross them. The lanes should resume at the other side of the intersection. The bike lane stripe may be dashed prior to the crosswalk to indicate a potential conflict point to both bicyclists and drivers

RIGHT-TURN LANES

Right-turn lanes should be used only where warranted by a traffic study, as they present these problems for cyclists:

- Right-turning cars and through bicyclists cross paths;
- Right-turns are made easier, which may cause inattentive drivers to not notice bicyclists on their right.

The design shown above makes through bicyclists and right-turning motor vehicles cross prior to the intersection, with these advantages:

- This conflict occurs away from other conflicts at the intersection;
- The difference in speeds enables a motor vehicle driver to pass a bicyclist rather than ride side-by-side; and
- Bicyclists follow the rules of the road: through bicyclists proceed to the left of right-turning vehicles.

This design should also be used where there are currently no bike lanes approaching or beyond the intersection, for these reasons:

- This design enables bicyclists and drivers to position themselves correctly;
- When the roadway is striped with bike lanes in the future, the intersections are already designed correctly.

OTHER RIGHT-TURN LANE DESIGNS

Not all intersections can be widened to provide a right-turn lane. A bike lane to the left of right turning cars should still be provided.
Note: This is a difficult movement for bicyclists as they must merge left and find a gap in the traffic stream.

On bike lane retrofit projects, where there is insufficient room to mark a minimum (4-foot) bike lane to the left of the right-turn lane, a right-turn lane may be marked and signed as a shared-use lane, to encourage through cyclists to occupy the left portion of the turn lane. This is most successful on slow-speed streets.

EXCEPTIONS

Heavy Right Turns

If the major traffic movement at an intersection is to the right, and the straight through move leads to a minor side street, the bike lane may be placed on the right if most cyclists are turning right. This often occurs where a highway winds through town and is routed over local streets.

Tee Intersections

At a T-intersection, if the traffic split is approximately 50% turning right and 50% turning left, the bike lane should be dropped prior to the lane split so cyclists can position themselves in the correct lane; where traffic volumes are very high, a left- and right-turn bike lane should be considered.

SIGNALS

Traffic signals are timed to accommodate smooth motor vehicle flows at a desired operational speed. In urban areas, this ranges from 15 to 45 MPH. These speeds are higher than typical bicycling speeds: 10 to 20 MPH.

Signal timing can create difficulties for bicyclists trying to maintain a constant speed. They may be able to get through two or three lights, then have to stop and wait, to start over again. This can tempt bicyclists to get a jump on a light or to run red lights out of frustration or to take advantage of their momentum.

Where bicycle use is high, signal timing should take into account the convenience of bicyclists. For example, the traffic signals in downtown Portland are timed for 14 MPH, allowing bicyclists to ride with motor vehicle traffic.

On signals that function "on-call" (with loop detectors), these improvements can be made to benefit cyclists:

- Placing loop detectors in bike lanes on side street to trip the signal;
- Placing loop detectors in bike lanes to prolong green phase when a bicyclist is passing through (the yellow phase may not allow enough time for a cyclist to cross a wide intersection);
- Increasing the sensitivity of existing loop detectors in bike lanes;
- Painting stencils to indicate to cyclists the most sensitive area of the loop; and
- Placing push-buttons close to the roadway where a bicyclist can reach them without dismounting.

PEDESTRIANS

Basic principles of intersection design for pedestrians:

- All legs of an intersection should be open to pedestrians.

- If a crosswalk is closed for safety or capacity reasons, and there are pedestrian destinations at the closed crosswalk, every effort should be made to mitigate the closure justification and reopen the crosswalk. Refer to the ODOT Traffic Manual for ODOT's policy on crosswalk closure.

- The pedestrian's path of travel should be direct, with minimal out-of-direction travel, and obvious to drivers.
- Pedestrians should not have to cross too many travel lanes without a refuge island available.
- Pedestrian refuge islands should be used to decrease crossing distances and separate conflicts.

Minimizing crosswalk length

Crosswalks should be kept as short as possible. This can be achieved by:

- Making the radius of a corner as small as needed to accommodate design vehicles. The effective radius takes into account parking and bike lanes. The radius can be very tight on one-way streets where no turn movements are allowed at a corner
- Using curb extensions on streets with on-street parking, as they make pedestrians more visible to motorists. At signalized intersections, they improve signal timing by reducing the time needed for the pedestrian phase.
- Using islands to interrupt long crosswalks; and
- Lining up curb cuts with the crosswalk.

Crosswalk Placement

There are many situations where it is difficult to determine the best location for a crosswalk, often because of skews, large radii or other complicating factors. There are three ways to approach the problem:

1. Place the crosswalk in a direct line with the pedestrians' line of travel as they approach the intersection;
2. Place the crosswalk where the distance across the roadway is shortest; or
3. Place the crosswalk midway between the above two locations.

The first two approaches can yield undesirable results: the shortest distance is often in a location too far from the intersection to be obvious to drivers and pedestrians; the most direct route often creates a long crosswalk. Sometimes the best crosswalk placement is to split the difference between these two extremes, locating the crosswalk where it is visible to drivers and used by pedestrians.

Crosswalk markings/materials

See Chapter 5 for information on crosswalk striping, colors and texture.

Pedestrian Signal Head Placement

All signalized intersections should have pedestrian signal heads; they should be clearly visible, placed within, or at least close to the crosswalk they control, at a height of 7 to 10 feet, so pedestrians can see them.

Push Button Placement

At signalized intersections, where pedestrian pushbuttons are necessary, they should be clearly visible and be placed close to the level landing at the top of curb ramps. The pushbuttons should be within 10 feet of the curb, 5 feet of the prolongation of the crosswalk, and mounted on a pole or pedestal adjacent to the crosswalk they control at a height of 42". In most cases a separate pedestal is needed to fulfill these requirements; mounting two pushbuttons on one pole rarely satisfies these requirements.

Pushbuttons should be equipped with the most up-to-date accessibility features (vibro-tactile, audible).

Push buttons should not be used in high pedestrian use environments, such as a central business district, where the pedestrian phase should be recalled at every cycle.

ISLANDS & REFUGES

A median island at an intersection helps pedestrians who cannot cross all the way at one time. Islands must be at least 6 feet wide, preferably 8 feet or more, and large enough to provide refuge for several pedestrians waiting at once. For wheelchair accessibility, it is preferable to provide at-grade cuts rather than ramps.

Right-turn lanes should be used only where warranted by a traffic study, as they present problems for pedestrians:

- The additional lane width adds to the pedestrian crossing distance;
- They can add confusion to pedestrians with vision impairments, as right-turning vehicles mask the sound of stop-and-go through traffic; and
- Right-turn moves are made easier for motorists, which may cause inattentive drivers to not notice pedestrians on the right.

Once the decision has been made to provide a right-turn lane, placing a raised island between the through lanes and the right turn lane benefits pedestrians as they:

- Allow pedestrians to cross fewer lanes at a time;
- Allow motorists and pedestrians to judge conflicts separately;
- Provide a refuge so that slower pedestrians can wait for a break in traffic;
- Reduce the total crossing distance (which provides signal timing benefits); and
- Provide an opportunity to place accessible pedestrian push-buttons.

The design of right-turn lane channelization islands is critical to pedestrian and driver safety:

- The angle of approach of right-turning cars must be such that the crossing pedestrian is clearly visible;
- The crosswalk across the right-turn-lane should be placed one car length back, allowing a driver to proceed to the intersection proper after having dealt with the potential pedestrian conflict at the crosswalk.
- This is accomplished by creating an island that is roughly twice as long as it is wide.
- The cut-throughs within the island must line up with the crosswalks.

SIGNALS

Traffic signals are timed to accommodate smooth motor vehicle flows at a desired operational speed. In urban areas, this ranges from 15 to 45 MPH. These speeds are higher than typical walking speeds.

Signal timing can create difficulties for pedestrians trying to maintain a constant walking speed. They may be able to get through one or two signals, then have to stop, wait, and start over again. This tempts pedestrians to walk against the light out of frustration. Where pedestrian use is high, signal timing should take into account the pedestrian convenience. Signal improvements for pedestrian mobility include:

- Incorporating a pedestrian phase in the signal sequence (on recall), rather than on-demand, in locations with high pedestrian use;
- Using short signal cycles to limit the time a pedestrian has to wait.
- Placing pedestrian push-buttons where they’re easy to reach, next to the sidewalk, with a clear indication as to which signal the button activates (this will improve operations, as many pedestrians push all buttons to ensure that they hit the right one);
- Motion detectors (video/infrared/microwave) that calls for a pedestrian phase when a pedestrian awaits.

Signalized intersections also present many potential conflicts; pedestrians are particularly vulnerable when the walk phase is concurrent with the vehicular turn movements, especially left turns. The latter account for the greatest number of pedestrian crashes at signalized intersections. Signal improvements for pedestrian safety include:

- Pedestrian countdown signals let pedestrians know how much time is left to cross; this has proven effective at reducing conflicts between turning vehicles and pedestrians still in the crosswalk at the end of the crossing phase.
- A longer all-red phase: this can prevent conflicts with vehicles entering the intersection on the tail end of a yellow light and not making it to the far crosswalk before it turns to the steady walk phase for the pedestrian.
- The Leading Pedestrian Interval (LPI) gives pedestrians a 2-5 second head start before the concurrent vehicle phase turns green; this helps reduce conflicts with pedestrians and turning vehicles, as pedestrians enter and occupy the crosswalk before turning vehicles get there. Accessible Pedestrian Signal features are essential, so pedestrians with vision impairments know when the walk indicator has come on for them.
- Protected left turns: This virtually eliminates left-turn conflicts, as the walk phase is not concurrent with left-turning vehicular movements.

ISSUES FOR PEDESTRIANS AND BICYCLISTS

SKEWED INTERSECTIONS

Skewed intersections are generally undesirable and introduce complications for bicyclists and pedestrians:

- Bicyclists and pedestrians approaching from an acute angle are not very visible to motorists;
- The crosswalks are longer, which lengthens the pedestrian phase at a signalized intersection; and
- The path a bicyclist must follow may not be evident.

To alleviate these concerns, several options are available:

- Every reasonable effort should be made to design the intersection closer to a right angle;
- Pedestrian refuges should be provided if the crossing distance is excessive; and
- Bike lanes may be striped with dashes, or colored, to guide bicyclists through a long undefined area.

MULTI-LEG INTERSECTIONS

Multi-leg intersections are generally undesirable and introduce complications for bicyclists and pedestrians:

- Multiple conflict points are created as motor vehicles arrive from several directions;
- The visibility of cyclists and pedestrians is poor as they are not seen by many approaching vehicles;
- The unpredictability of motorists, cyclists and pedestrians is increased;
- Pedestrians and bicyclists must cross more lanes of traffic and the total crossing distance is great; and
- At least one leg will be skewed.

To alleviate these concerns, several options are available:

- Every reasonable effort should be made to design the intersection so that only two roads cross at a given point. This is accomplished by removing one or more legs from the major intersection and creating a minor intersection further downstream;
- One or more of the approach roads can be closed to motor vehicle traffic;
- Innovative designs such as roundabouts should be considered at complex intersections.

- Pedestrian refuges should be created if the crossing distance is excessive;
- Bike lanes may be striped with dashes, or colored, to guide bicyclists through a long undefined area.

DUAL RIGHT-TURN LANES

This situation is particularly difficult for bicyclists and pedestrians. Warrants for dual turn lanes should be used to ensure that they are provided only if absolutely necessary. The design for simple right-turn lanes allows bicyclists and motorists to cross paths in a predictable manner, but the addition of a lane from which cars may also turn adds complexity: some drivers make a last minute decision to turn right from the 2nd turn lane without signaling, catching bicyclists and pedestrians unaware.

Users should be guided to areas where movements are more predictable, so bicyclists, pedestrians and motorists can tackle one conflict at a time, in a predictable manner.

Four possible ways to mitigate for the effect of dual right-turn lanes are:

A. This design allows cyclists to choose a path themselves by dropping the bike lane prior to the intersection (this is the AASHTO recommendation).
B. This design encourages cyclists to share the optional through/right-turn lane with motorists.
C. This design guides cyclists up to the intersection in a dedicated bike lane.
D. This design places an island between the right-turn lane and the optional through/right turn lane. This creates a more conventional intersection, separating the conflicts. This design is also better for pedestrians, as the island provides a refuge.

Engineering judgment should be used to determine which design is most appropriate for the situation.

MODERN ROUNDABOUTS

A roundabout is a type of intersection commonly used around the world; roundabouts are now gaining acceptance in this country. Modern roundabouts should not be confused with small traffic-calming circles or large rotaries, which are often signalized. Early roundabout designs were often unsuccessful for several reasons, mainly:

- They were too small (creating difficulties for trucks);
- They were too large (encouraging high speeds);
- The right of way was not clearly defined (causing confusion and collisions); or
- Pedestrians were allowed access to the middle of the roundabout.

Modern roundabouts have several distinctive features:

- Deflection to encourage slow traffic speeds, but that allows movement by trucks.
- A landscaped visual obstruction that obscures the driver's view of the road ahead, to discourage users from entering the roundabout at high speeds;
- Clearly established right of way: drivers entering the roundabout yield to drivers already in the roundabout;
- Splitter islands, to force drivers to turn right, and to provide a refuge for pedestrians; and
- No pedestrian access to the center island, which should not contain attractions.

One major advantage of roundabouts is the reduced need for travel lanes (signals create stop-and-go conditions, resulting in a need for extra travel lanes to handle capacity at intersections). Other advantages include:

- Reduced crash rates;
- Reduced severity of injuries (due to slower speeds);
- Reduced long-term costs (compared to traffic signals, which require electrical power); and

- Reduced liability by transportation agencies (there are no signals to fail).

Advantages of roundabouts for bicyclists and pedestrians:

- The reduced need for travel lanes enables the right-of-way to be used for bicycle and pedestrian facilities;
- Traffic flows at a more even pace, making it easier for pedestrians to judge crossing movements;
- Pedestrians have to cross only one or two lanes of traffic at a time, in clearly marked crosswalks;
- Motor vehicle operators negotiate the intersection at speeds closer to that of bicyclists; and
- Improved midblock crossing opportunities if the number of travel lanes can be reduced.

Disadvantages for pedestrians and bicyclists

Even though drivers must yield to pedestrians in crosswalks, this doesn't always happen; the absence of signals may have the following consequences:

- Traffic flowing more evenly may reduce pedestrian crossing opportunities as fewer gaps are created;
- Pedestrians with impaired vision may have difficulty finding traffic gaps, especially the blind who depend on traffic sounds to ensure traffic has stopped;
  - As mitigation, pedestrian signals can be added at special sites;
- Bicyclists must share the road and occupy a travel lane; by riding too far to the right, they risk being cut off by vehicles leaving the roundabout in front of them.
- Multi-lane roundabouts are more challenging, because it's harder to control speed through deflection; at low traffic volumes, a driver can enter from the outside lane, cut across the inside lane in the circulating roadway and exit at high speed from the outside lane.

Roundabout designs for pedestrians and bicyclists

The following design principles help ensure roundabouts work well for pedestrians and bicyclists:

- Slow speeds provided by deflection, with constrained entries, narrow circulating roadway and truck apron.
- Simple, single lane, throughout
- Well-defined pedestrian crossings, one car-length back from yield line
- Splitter islands to allow pedestrians to cross one lane at a time
- Bike lane dropped on approaches to encourage cyclists to enter the roundabout with traffic and ride in the circulating roadway. The bike lane should be dropped about 30-50 feet prior to the entry lane crosswalk, and dashed for approximately 30 feet. A ramp should be provided where the dashes begin to allow cyclists to use the sidewalks and crosswalks to negotiate the roundabout, if they so prefer.

INTERCHANGES

INTRODUCTION

Freeways in urban areas can present barriers to pedestrian and bicycle circulation. Interchanges can be obstacles to walking and bicycling if they are poorly designed. Pedestrians and bicyclists should be accommodated on the intersecting and parallel local roads and streets.

In rural areas, traffic volumes are usually low, little pedestrian use is expected, and recreational and touring bicyclists are usually experienced enough to make their way through an interchange. Shoulder widths through interchanges should be wide enough for bicycle and occasional pedestrian use. At interchanges with services such as restaurants, motels and stores, sidewalks, crosswalks and other pedestrian features should be provided.

In urban and suburban areas, pedestrians and bicyclists of all skill levels travel on the intersecting cross-streets. Well designed interchanges provide safe and convenient passage for non-motorized traffic.

To alleviate conflicts, more non-interchange crossings of freeways should be provided, with these advantages for bicyclists and pedestrians:

- Bicyclists and pedestrians can cross the freeway at locations where there are no conflicts with vehicles entering and exiting freeway ramps; and
- The additional crossings will relieve some motor vehicle traffic from the interchanges, making it easier for bicyclists and pedestrians who must cross at these locations.

BASIC PRINCIPLES

The critical areas for pedestrian and bicyclist safety, access and convenience are at the freeway ramps, where freeway traffic interacts with local traffic. The interface between the ramps and the local cross-streets must be designed so drivers understand there will be conflicts, and they should reduce their speeds to appropriate urban speeds, for example from 65 to 25 MPH.

Designs that encourage high speed and/or free-flowing motor vehicle traffic movements are the most difficult for pedestrians and bicyclists to negotiate safely and comfortably. Conversely, designs that provide safe and convenient pedestrian and bicycle passage may require some slowing or stopping of motor vehicle traffic.

It is important to consider both convenience and safety when accommodating pedestrian and bicycle travel near interchanges. The issue of safety becomes moot if facilities are not used because of perceived inconvenience. The expected path of pedestrians and bicyclists must be obvious and logical, with minimal out-of-direction travel and grade changes.

All potential pedestrian and bicycle movements should be accommodated. Closing a crosswalk should only be considered as a last resort. However, the two crosswalks across the cross-street on the inside of the interchange may be closed, as there should be no pedestrian-accessible destinations within the interchange area; the two outer crosswalks must be open to facilitate crossings. Continuity of sidewalks and bike lanes must be provided to ensure linkage with existing facilities beyond the intersection.
In most urban and suburban settings, the appropriate pedestrian facilities are sidewalks, and the appropriate bicycle facilities are bike lanes. Sidewalks should be located on both sides of the intersecting local streets, and should be wide enough to facilitate two-way pedestrian travel. Pedestrians should have access to all 4 quadrants of the interchange, especially when destinations such as restaurants or mini-marts are present. Bike lanes must be placed on both sides of the roadway to allow bicyclists to ride with traffic. Higher design standards should be considered under these special circumstances:

- Sidewalks should be at least 8 feet wide when placed on only one side of the road, if sidewalks are not provided on the other side due to conflicts; this situation should be avoided if possible.
- Sidewalks should be at least 10 feet wide if they are intended for joint use by pedestrians and bicyclists; this situation should be avoided if possible.

GUIDELINES

At-Grade Crossings

Connecting access ramps to local streets at a right angle makes it easier for pedestrians, bicyclists and motorists; the intersection of the ramp and the street should follow the principles of good urban intersection design outlined earlier in this chapter. This interface should be designed as half a regular urban intersection, preferably signalized. The main advantages are:

- The distance that pedestrians and bicyclists must cross at the ramps is minimized;
- Signalized intersections stop traffic; and

- Visibility is enhanced.

Where large truck turning movements must be accommodated, compound curves reduce the distance for pedestrians at crosswalks.
The use of traffic islands can help create pedestrian refuges. Pedestrians won't have to cross too many lanes of traffic at once, which helps improve signal timing. Illumination ensures good nighttime visibility.

Interchanges that use a rural design create more difficult crossing movements for pedestrians and bicyclists, as motor vehicle speeds are higher and movements are less restricted. Configurations with free-flowing right turns and dual left- or right-turns are difficult for pedestrians and bicyclists to negotiate safely. They are particularly vulnerable where a high-speed ramp merges with a roadway.

If these configurations are unavoidable, mitigation measures should be sought. Special designs should be considered that allow pedestrians and bicyclists to cross ramps in locations with good visibility and where speeds are low.

Grade-Separated Crossings

Grade separation should be considered where it is not possible to accommodate pedestrians and bicyclists at grade. Grade-separated facilities are expensive; they add out-of-direction travel and will not be used if the added distance is too great. This can create a potentially hazardous situation if pedestrians and bicyclists ignore the facility and try to negotiate the interchange at grade with no sidewalks, bike lanes or crosswalks.

A separated path provided on only one side of the interchange can lead to awkward crossing movements:

- Pedestrians must cross prior to the interchange (signs should be used to direct them at the nearest signalized crossing); and
- Some bicyclists will be riding on a path facing traffic, creating difficulties when they must cross back to a bike lane or shoulder (clear directions must be given to guide bicyclists' movements that are inconsistent with standard bicycle operation).

To ensure proper use by pedestrians and bicyclists, structures must be open, with good visibility - especially undercrossings. Opportunities to provide direct links to destination points should be sought if they offer less travel distance than following the roadway alignment.

SINGLE-POINT URBAN INTERCHANGE (SPUI)

The Single Point Urban Interchange is gaining favor for urban locations because of the reduced need for right-of-way. It can be made accessible to pedestrians and bicyclists by following these principles:

- Each vehicular movement should be clearly defined and controlled;
- Exit and entry ramps should be designed at close to right angles;
- Pedestrian crossings should be visible and easily identifiable;
- Pedestrians should not be required to cross more than one or two lanes at a time;
- Bicyclists should be able to proceed through the intersection in a straight line;
- Motor vehicles merging to and from freeway on/off ramps should be required to yield to through cyclists.

The SPUI works reasonably well for pedestrians and bicyclists if the intersection is that of a local thoroughfare and a freeway; pedestrian and bicyclists need to be accommodated only on the cross-street, not the freeway. If a SPUI is used for the grade-separated intersection of two surface streets, which accommodate pedestrians and cyclists, then the SPUI design is not effective, as pedestrians and cyclists on one of the streets will be in a freeway-like environment, with free-flowing exiting and merging ramps.

MERGING & EXIT LANES

While bike lanes and sidewalks are not appropriate on limited access freeways, they are common on urban parkways, which often have freeway-style designs such as merging lanes and exit ramps rather than simple intersections. Traffic entering or exiting a roadway at high speeds creates difficulties for bicyclists and pedestrians. The following designs help alleviate these difficulties.

Right-Lane Merge

It is difficult for cyclists and pedestrians to traverse the undefined area created by right-lane merge movements, because:

- The acute angle of approach reduces visibility;
- Motor vehicles are accelerating to merge into traffic;
- The speed differential between cyclists and motorists is high.

The following design guides cyclists and pedestrians in a manner that provides:

- A short distance across the ramp at close to a right angle;
- Improved sight distance in an area where traffic speeds are slower than further downstream; and
- A crossing in an area where drivers' attention is not entirely focused on merging with traffic.

Exit Ramps

Exit ramps present difficulties for bicyclists and pedestrians because:

- Motor vehicles exit at fairly high speeds;
- The acute angle reduces visibility; and
- Exiting drivers who don’t use their turn signal confuse pedestrians and cyclists seeking a gap in traffic.

The following design guides cyclists and pedestrians in a manner that provides:

- A short distance across the ramp, at close to a right angle;
- Improved sight distance in an area where traffic speeds are slower than further upstream; and
- A crossing in an area where the driver's attention is not distracted by other motor vehicles.

OTHER INNOVATIVE DESIGNS

These concepts are presented as information, to help ODOT, cities and counties to come up with new solutions to common intersection problems.

BIKE BOXES

On streets with bike lanes and heavy bicycle use, there is often competition for space and time after a light has turned green at an intersection, as bicyclists, through and right-turning motorists try to proceed at the same time. The bike box reduces conflicts as cyclists can pull forward to the front of the queue when the light is red and motor vehicle traffic is stopped; they can then be the first to proceed when the light turns green. The bike box works best at intersections with no right turn on red and with high bicycle use, so drivers understand why they’re being asked to hold back.

RAISED INTERSECTIONS

Raised intersections take the raised crosswalk concept one step further. Motorists see that the area is not designed for rapid through movement; it is an area where pedestrians are to be expected. The driver must be cautious in approaching the intersection and be ready to yield the right of way to pedestrians.

As with raised crosswalks, the incline of the beveled portion is a function of design speed and design vehicle.

Raised crosswalks and intersections have additional advantages:

- It is easier to meet certain ADA requirements, as the crosswalk is a natural extension of the sidewalk, with no change in grade, but they require detectable warnings to be detected by the visually-impaired;
- Raised intersections can simplify drainage inlet placement, as all surface water will drain away from the intersection.

Note: These treatments are more appropriate on roads other than high-speed thoroughfares, or on routes with transit use.

Captions

Large multi-lane intersections pose particular challenges for pedestrians and bicyclists, but solutions exist
Fig 1: Dashing bike lane prior to intersection warns motorists and bicyclists of potential conflict
Fig 2: Standard right-turn-lane with through bike lane
Fig 3: Right-turn lane developed by dropping parking
Fig 4: Right-turn lane developed by dropping a lane. D1 D2 & D3 determined by engineering study; L = length needed for storage.
Fig 5: Combined right-turn lane and through bike lane
Combined right-turn lane and through bike lane
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Fig 17: Old and new pedestrian refuge island at right turn lane
Pedestrian countdown signal
LPI: pedestrian phase initiated prior to green light
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Blue bike lane through skewed intersection
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Modern roundabout in suburban setting
Pedestrian crossing to splitter island at roundabout
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Bicyclist using exit ramp
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Fig 30: Pedestrian and bicyclist crossing at high-speed exit ramp

Fig 31: Bike box
Bike box at bike boulevard intersection (motor vehicle traffic must turn, cyclists may continue straight)
Fig 32: Raised intersection
Pedestrian cut-through on island