5 INTERSECTIONS

Intersections are locations where modes come together and where most conflicts and crashes occur on the roadway. Ranging in scale and complexity, they can be simple or challenging to navigate. In older Alexandria neighborhoods like Old Town and Del Ray, many intersections are compact and crossing is more comfortable for pedestrians and bicyclists; however, in other areas of the city, wide intersections are barriers, dividing communities and separating neighborhoods from daily needs and destinations.

People who travel on Alexandria's roadways should feel safe and comfortable; they should experience a minimal amount of delay during all trips regardless of whether they are made on foot, by bicycle, via transit, or in an automobile. This chapter presents mechanisms to balance the needs of all users while preserving a unique sense of place at Alexandria's intersections.

» ***T&ES is responsible for approving all City intersection designs, along with any other changes made to city-owned right-of-ways. Coordination with VDOT is required on National Highway System (NHS) roadways and on Federal and State funded projects, as well as with stakeholders such as the Alexandria Fire Department and the Commission on Persons with Disabilities.***

Intersection Geometry

Many of Alexandria's intersections have complicated geometric configurations as the street network has been augmented over time. Within the City's historic neighborhoods, the roadway grid pattern provides predictable four-legged approaches, but there are also many instances of larger and more complex intersections.

Designing multimodal intersections requires geometry that increases safety for all users in combination with effective and efficient traffic control measures. Changes in geometry can help to reduce vehicle turning speeds, increase pedestrian comfort and safety, and create space for dedicated bicycle facilities. One of the key considerations of intersection geometry is the location of pedestrian crossing ramps and crossings relative to vehicle paths.

» ***Intersection geometry must be approved by T&ES who utilize guidelines and standards from:***

- **The Manual of Uniform Traffic Control Devices (MUTCD)**
- **The National Association of City Transportation Officials (NACTO) Urban Street and Bikeway Design Guides** ***(both have been endorsed by the City of Alexandria)***
- **American Association of State Highway Transportation Officials (AASHTO) "Green Book"**

CORNERS AND CURB RADII

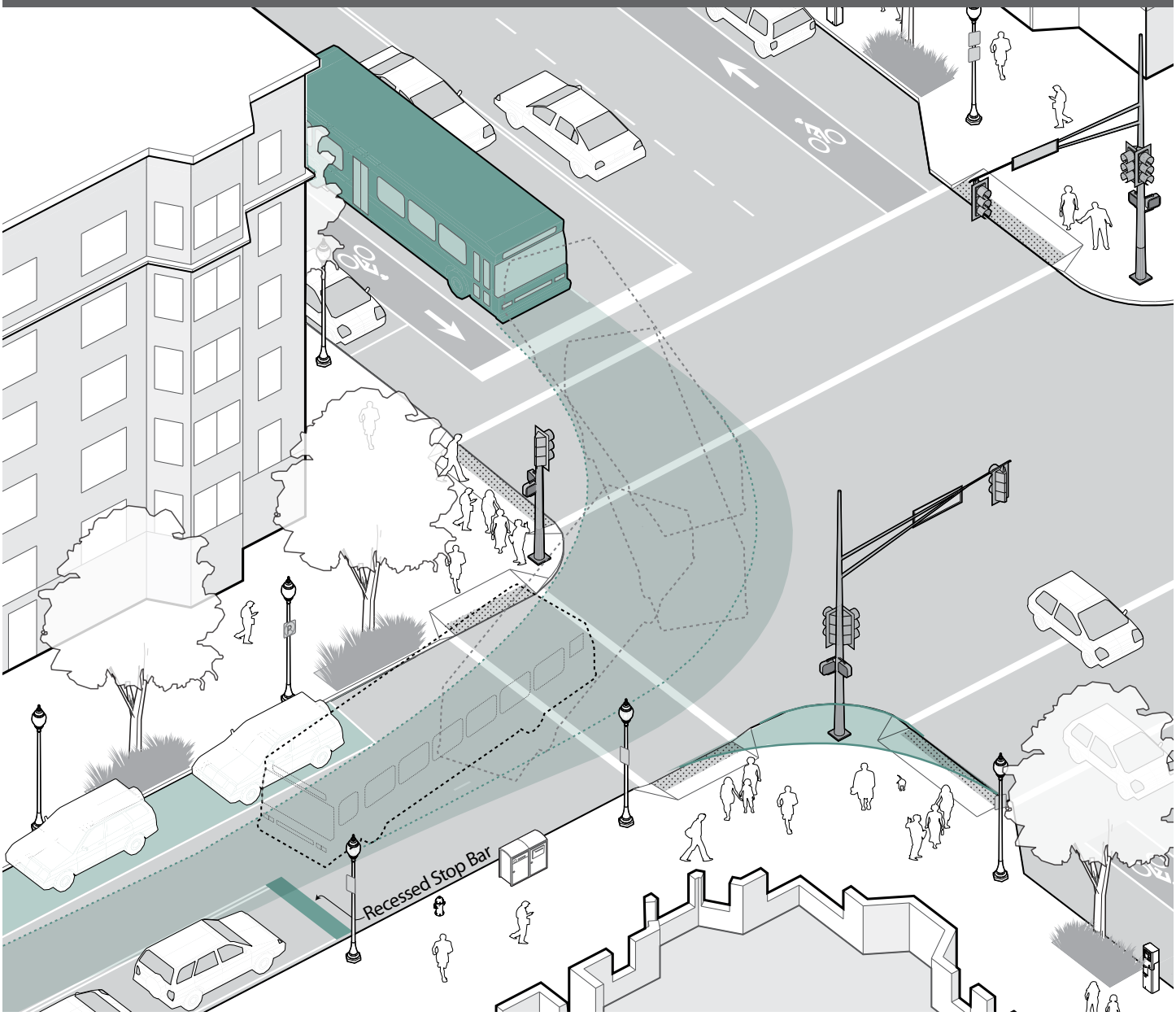
OVERVIEW

Pedestrian safety and comfort is directly impacted by the width and configuration of street corners; however, streets in Alexandria must accommodate large turning vehicles, including school buses and transit vehicles. One of the most challenging aspects of intersection design is to determine methods of accommodating large vehicles while keeping intersections as compact as possible. This requires a great deal of design flexibility and engineering judgment, as each intersection is unique in terms of the angles of the approach and departure, the number of travel lanes, the presence of a median, and a number of other features that fundamentally impact corner design.

One of the most important aspects of corner design is the selection of a curb radius that is as small as possible while accommodating the appropriate design vehicle for the intersection. Small curb radii benefit pedestrians by creating sharper turns requiring motorists to slow down, increasing the size of waiting areas, allowing for greater flexibility in the placement of curb ramps, and reducing pedestrian crossing distances.

Two of the most important corner design elements are the effective curb radius and the actual curb radius. Actual curb radius refers to the curve that the curb line makes at the corner, while effective curb radius refers to the curve which vehicles follow when turning, which may be affected by on-street parking, bicycle lanes, medians, and other roadway features. The effective curb radius can in some cases be quite small, while the actual curb radius is bigger and can accommodate large vehicles, especially in locations with on-street parking.

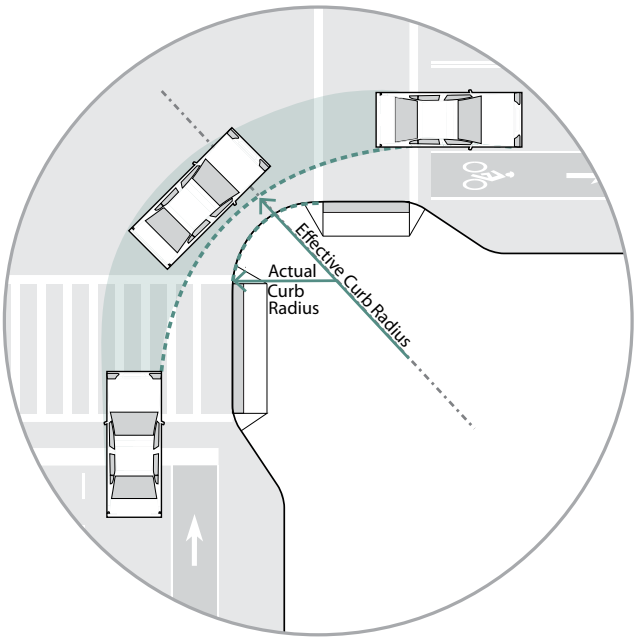
CORNERS AND CURB RADII



DESIGN

- The design vehicle should be selected according to the types of vehicles using the intersection with considerations to relative volumes and frequencies. In most cases, the City of Alexandria will evaluate the curb radii based on a Single Unit vehicle with a 42' turning radius. If the City anticipates the need to accommodate a larger design vehicle, a radius evaluation based on this larger vehicle would be required. Examples of typical turning templates would include a SU, WB-40, WB-50, WB-60 and WB-62.
- Intersection design should strive for an actual curb radii that is between 10' to 25'. The default curb radii for two intersecting Neighborhood Residential Streets is 10' (exceptions apply for angled streets). For all other street classifications, including streets that intersect with Neighborhood Residential Streets, corner design should strive for an actual curb radius that is no more than 15' (exceptions apply for angled streets). Methods to minimize curb radii are described below.

CORNERS AND CURB RADII



- While pedestrian safety is negatively impacted by wide crossings, pedestrians are also placed at risk if the curb radius is too small and the rear wheels of a truck track over the pedestrian waiting area at the corner. Maintenance problems are also caused when trucks must regularly drive over street corners to make turns.
- Channelized right turn lanes at intersections encourage faster motor vehicle turning speeds and should generally be avoided, however, in locations where a channelized right turn lane is necessary, it should be designed to encourage drivers to yield to pedestrians. The lane should approach the intersecting road with a “merge” condition (vehicles in the channelized right turn lane should be required to either yield or stop before turning right onto the receiving roadway).
- As described elsewhere in these guidelines, curb extensions are beneficial to pedestrians. It is acceptable to have a larger curb radius to properly design a curb extension that shortens crossing distances while accommodating large vehicles.

CONSIDERATIONS

A variety of strategies can be employed to minimize curb radii:

- On-street parking and bicycle lanes may provide the larger effective radii to accommodate the appropriate design vehicle.
- On low volume (less than 4,000 vehicles per day), two-lane streets, corner design should assume that a large vehicle will use the entire width of the departing and receiving travel lanes, including the oncoming traffic lane.
- At signalized intersections, corner design should assume the large vehicle will use the entire width of the receiving lanes on the intersecting street.
- At signalized intersections where additional space is needed to accommodate turning vehicles, consideration can be given to recessing the stop bar on the receiving street to enable the vehicle to use the entire width of the receiving roadway (encroaching on the opposing travel lane).
- In some cases, it may be possible to allow a large turning vehicle to encroach on the adjacent travel lane on the departure side (on multi-lane roads) to make the turn.
- A compound curve can be used to vary the actual curb radius over the length of the turn so that the radius is smaller as vehicles approach a crosswalk and larger when making the turn.
- In some cases where there are alternative access routes, it may be possible to restrict turning movements by large vehicles at certain intersections and driveways to enable tighter curb radii. Turn restrictions and alternate access routes should be properly signed and must be approved by T&ES.

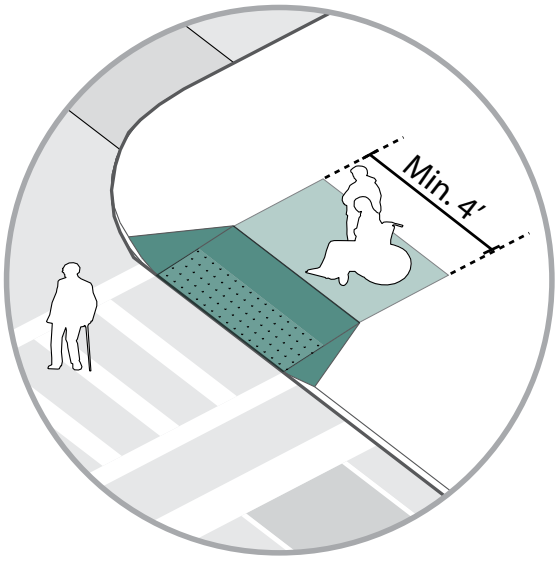
CURB RAMPS

OVERVIEW

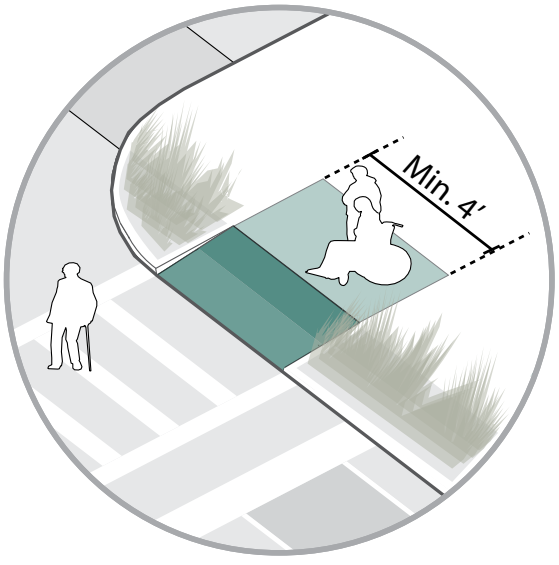
The transition for pedestrians from the sidewalk to the street is provided by a curb ramp. The designs of curb ramps are critical for all pedestrians, but particularly for people with disabilities. The ADA Standards require all pedestrian crossings be accessible to people with disabilities by providing curb ramps at intersections and midblock crossings as well as other locations where pedestrians can be expected to enter the street. Curb ramps also benefit people pushing strollers, grocery carts, suitcases, or bicycles.

DESIGN

- Curb ramps should be provided at every marked crosswalk.
- A consistent approach is needed when it comes to materials used in curb ramps, depending upon the character of the street or neighborhood where they are being installed.
- Wherever feasible, curb ramp locations should reflect a pedestrian's desired path of travel through an intersection. In general, this means providing two separate perpendicular curb ramps at a corner instead of a single ramp that opens diagonally at the intersection. The City of Alexandria discourages the use of diagonal ramps.
- Curb ramps should be designed with drainage inlets to avoid the accumulation of water or debris. During winter, snow should be cleared from curb ramps to provide an accessible route.
- A level landing pad must be provided on the sidewalk. It should be the same width as the sidewalk but no less than 4' in width, with no greater than 2% slope in any direction.
- Curb ramps should generally be as wide as the pedestrian zone on the approaching sidewalk. The curb ramp should lie within the area of the crosswalk; however, flares may extend beyond it.



Flared Curb Ramp

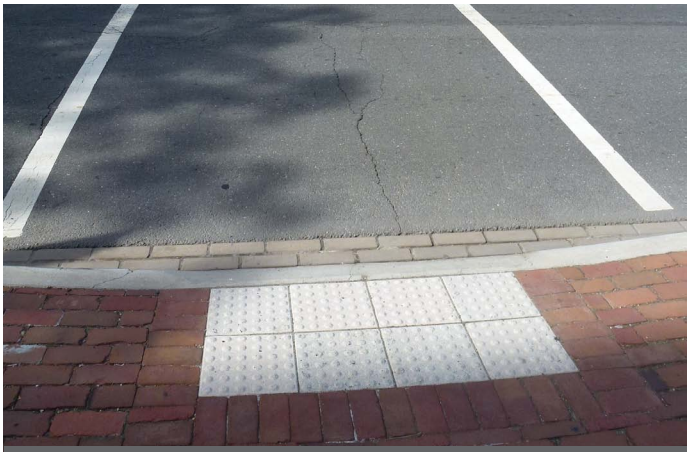


Non-flared Curb Ramp

CURB RAMPS

Curb ramp designed without flares. Note: detectable warning strips must be provided

Curb ramp with truncated dome tactile warning



Brick curb ramp with tactile warning near King Street Metro

- Curb ramps must include ADA compliant detectable warning strips to alert people who have visual disabilities that they are about to enter a roadway. Detectable warning strips include a series of truncated domes. Detectable warning strips must ensure a 70% contrast in color with the surrounding pavement. Detectable warning strips must be designed according to specifications determined by T&ES.

- Detectable warning strips are required at all roadway crossings, regardless of whether there is grade separation, such as at raised crossings and raised intersections, at crossing islands, or at crossings along Shared Streets.

- If used, pedestrian pushbuttons should be easily activated and conveniently located near each end of the crosswalk, between the edge of the crosswalk line, and the side of a curb ramp.

CONSIDERATIONS

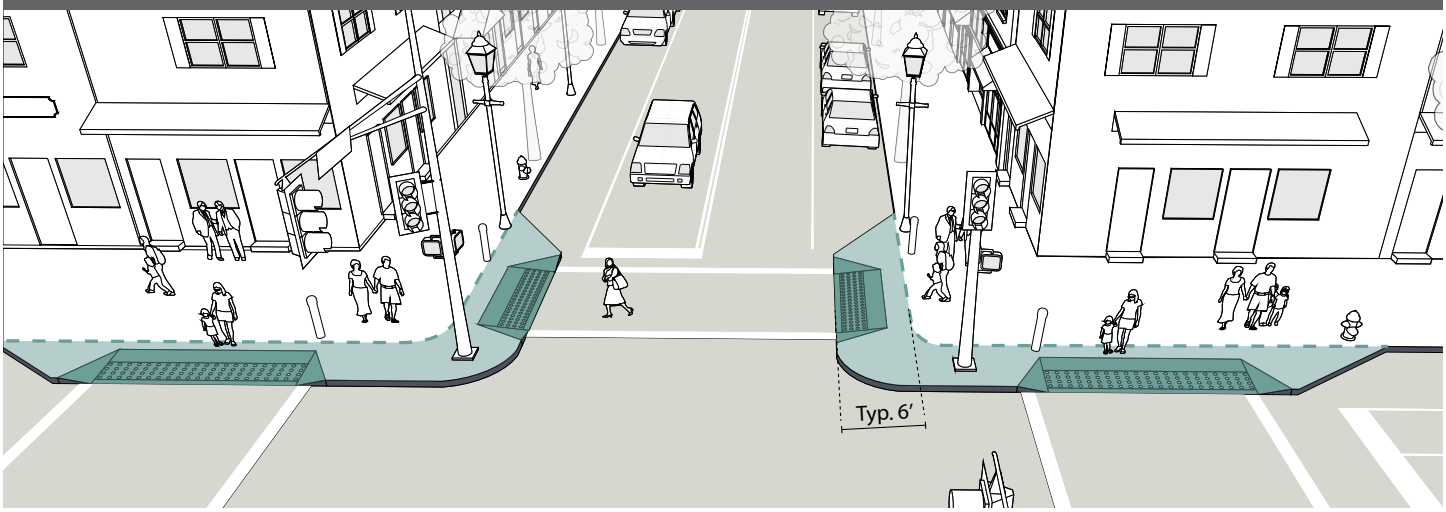
- There are a variety of standard curb ramp designs, including perpendicular ramps and parallel ramps. Perpendicular ramps slope perpendicular to the curb line, and parallel ramps slope parallel to the curb line. The appropriate design should be determined on a site-by-site basis. Key factors to consider include pedestrian crossing distances, desire lines, sidewalk width, and proximity to traffic, curb height, street slope, and drainage.

- Consider providing wider curb ramps in areas of high pedestrian volumes and crossing activities.

- Flares are required when the surface adjacent to the ramp's sides is walkable, however, they are unnecessary when this space is occupied by a landscaped buffer. Excluding flares can also increase the overall capacity of a ramp in high-pedestrian areas.

- Consider installing raised crossings or raising the entire intersection. Raising the crossing or intersection eliminates the need for curb ramps because a continuous sidewalk realm is provided across the intersection. Detectable warning strips still must be provided at raised crossings and intersections. For more information, refer to **Raised Crossings and Intersections** later in this chapter.

CURB EXTENSIONS



OVERVIEW

Curb extensions, also known as neckdowns, bulb-outs, or bump-outs, are created by extending the sidewalk at corners or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities.

Curb extensions have a variety of potential benefits including:

- Additional space for pedestrians to queue before crossing
- Improved safety by reducing motor vehicle speeds and emphasizing pedestrian crossing locations
- Less pedestrian exposure to motor vehicles by reducing crossing distances
- Space for ADA compliant curb ramps where sidewalks are too narrow
- Enhanced visibility between pedestrians and other roadway users
- Restricting cars from parking too close to the crosswalk area
- Space for utilities, signs, and amenities such as bus shelters or waiting areas, bicycle parking, public seating, street vendors, newspaper stands, trash and recycling receptacles, and planting and landscape elements

It is noted that maintenance of curb extensions are an important consideration, primarily during the winter months. Extensions should be identified (i.e., flagged) to avoid damage during snow removal.

DESIGN

- Curb extensions should be considered only where parking is present or where motor vehicle traffic deflection is provided through other curbside uses such as bicycle share stations or parklets.
- Curb extensions are particularly valuable in locations with high volumes of pedestrian traffic, near schools, at unsignalized pedestrian crossings, or where there are demonstrated pedestrian safety issues.
- A typical curb extension extends the approximate width of a parked car (or about 6' from the curb).
- The minimum length of a curb extension is the width of the crosswalk, allowing the curvature of the curb extension to start after the crosswalk, which should deter parking; NO STOPPING signs should also be used to discourage parking. The length of a curb extension can vary depending on the intended use (i.e., stormwater management, transit stop waiting areas, restrict parking).
- Curb extensions should not reduce a travel lane or a bicycle lane to an unsafe width.
- Curb extensions at intersections may extend into either one or multiple legs of the intersection, depending on the configuration of parking.
- Street furniture, trees, plantings, and other amenities should not interfere with pedestrian flow, emergency access, or visibility between pedestrians and other roadway users.

CURB EXTENSIONS

- Curb extensions may be located at corners or midblock locations.

CONSIDERATIONS

- The turning needs of emergency and larger vehicles should be considered in curb extension design.
- Care should be taken to maintain direct routes across intersections aligning pedestrian desire lines on either side of the sidewalk. Curb extensions often make this possible as they provide extra space for grade transitions.
- Consider providing a 20' long curb extension to restrict parking within 20' of an intersection.
- Curb extensions should be proposed on snow emergency routes only after consultation with T&ES. Because of the added complexity that curb extensions propose for snow removal, they should be identified or flagged on snow routes to ensure that removal vehicles do not damage curbs.
- In order to move traffic more efficiently, curb extensions should not be installed on arterials with peak hour parking restrictions.
- When curb extensions conflict with turning movements, the reduction of width and/or length should be prioritized over elimination.
- Emergency access is often improved through the use of curb extensions as intersections are kept clear of parked cars.
- Curb extension installation may require the relocation of existing storm drainage inlets and above ground utilities. They may also impact underground utilities, parking, delivery access, garbage removal, snow plows, and street sweepers. These impacts should be evaluated when considering whether to install a curb extension.
- Curb extensions at transit stops are called “bus bulbs.” See **Transit Accommodations** later in this chapter for more information.

Curb extension in Old Town

RECLAIMING SPACE AT INTERSECTIONS

There are opportunities in many intersections to reclaim space. The additional space can be used for multiple purposes including improving safety, widening sidewalks, adding bicycle facilities. Additionally, reclaiming space provides room for traffic control devices, utilities, plantings, green infrastructure, street furniture , vending, and public art. Reclaiming space for non-motorized use at intersections can be accomplished with both short-term and long-term solutions:

- **Short-term** ways to creatively redistribute space at intersections include reclaiming parking spaces for parklets, bicycle share stations, temporary plazas, and mock curb extensions. The reclaimed space can be redefined with seating, planters, and paint. Redefinition does not have to involve major capital project funds.
- **Long-term** options include tightening corner radii, narrowing of travel lanes, curb extensions, removal of turn lanes or parking lanes, closure of slip lanes, and incorporating the space into the sidewalk.

The location of reclaimed space can be in the middle of an intersection, extended from corners, or legs of an intersection can be closed to motor vehicle traffic and converted for other purposes such as a pedestrian plaza.

"Mock" curb extension offers a method to test ways of reclaiming space at intersections

CROSSING ISLANDS

Crossing island on Stevenson Avenue

OVERVIEW

As the number of travel lanes increases, pedestrians feel more exposed and less safe entering the intersection. Crossing islands are raised islands that provide a pedestrian refuge while crossing multilane roadways. These features allow pedestrians to find gaps in traffic and make a two-stage crossing movement. At mid-block crossings, islands should be designed with a stagger, or in a "z" pattern, forcing pedestrians to face oncoming traffic before progressing through the second phase of the crossing.

» ***Crossing islands must be approved by T&ES and must comply with all accessibility requirements.***

DESIGN

Crossing islands should:

- Use where there is a demand for pedestrians to cross the road, but where the numbers of pedestrians are not high enough to warrant a signalized pedestrian crossing.
- Include at-grade pedestrian cut-throughs as wide as the connecting crosswalks, detectable warnings, and be gently sloped to prevent standing water and ensure adequate drainage.
- Be at least 6' wide, preferably 8–10'. Where a 6' wide median cannot be attained, a narrower raised median is still preferable to nothing. The minimum protected width is 6', based on the length of a bicycle or a person pushing a stroller. The refuge is ideally 40' long.

CROSSING ISLANDS

- Accommodate turning vehicles. Crossing islands at intersections or near driveways may affect left-turn access.
- All crossing islands at intersections should have a "nose" that extends past the crosswalk. The nose protects people waiting on the crossing island and slows turning drivers.
- Safety islands should include curbs, bollards, or other features to protect people waiting.
- Illuminate or highlight islands with street lights, signs, or reflectors to ensure that motorists see them.
- Crossing islands may be enhanced using plantings or street trees. Plantings may require additional maintenance responsibilities and need to be maintained to ensure visibility.
- Signalized intersections with crossing islands should be designed to allow pedestrians to cross in one stage. Please refer to T&ES's Transportation Division for more information.

CONSIDERATIONS

- Crossing islands should be considered where crossing distances are greater than 50'.
- To guide motorists around crossing islands, consider incorporating diverging longitudinal lines on approaches to crossing islands.
- If there is enough width, center crossing islands and curb extensions can be used together to create a highly visible pedestrian crossing and effectively calm traffic.
- Where possible, stormwater management techniques should be used on crossings islands with adequate space. Plantings should be low growing to maximize visibility and ideally involve minimum maintenance in accordance with the **Green Sidewalk, BMP Design Guidelines.**

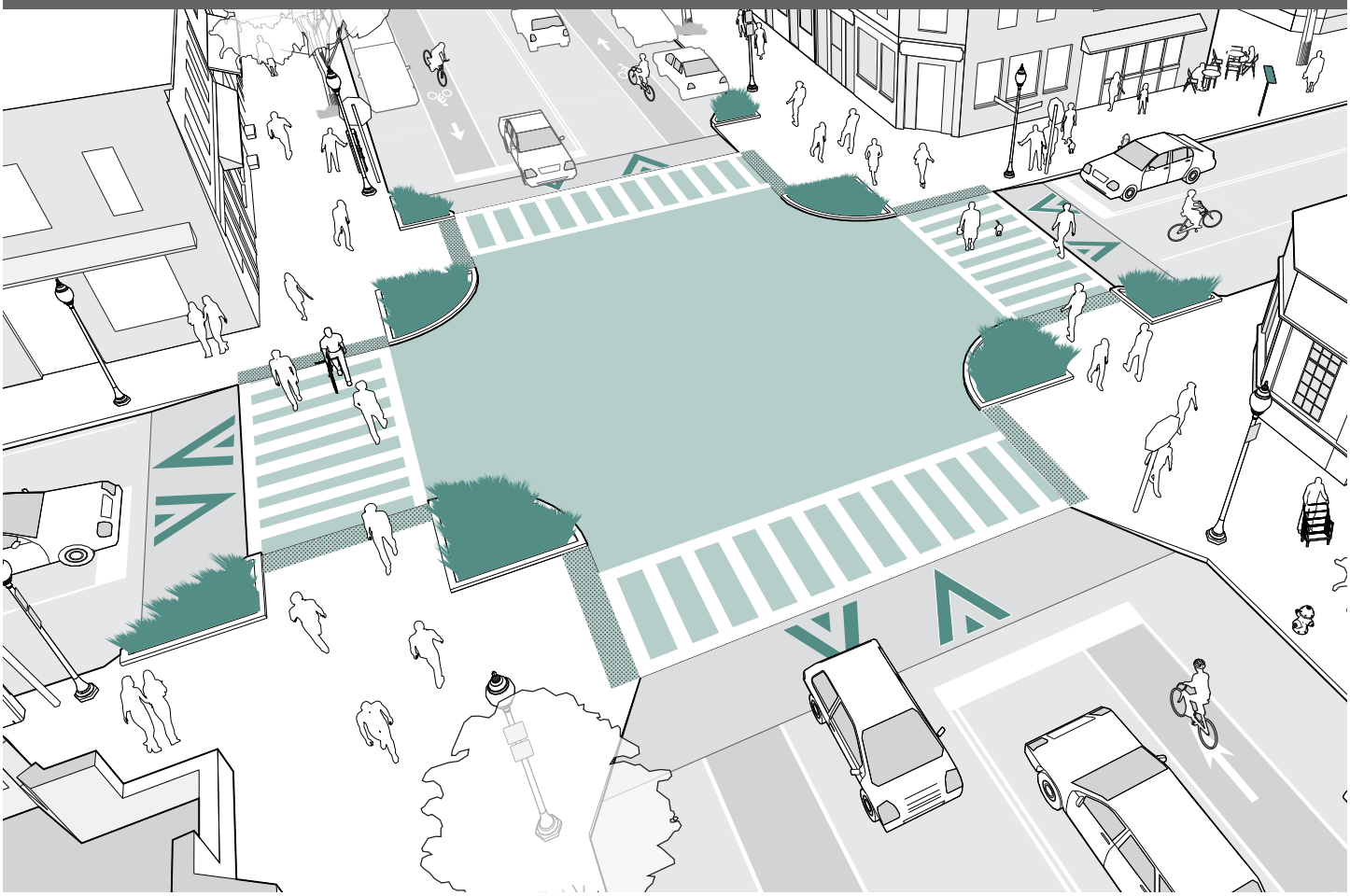
LINKS

Green Sidewalk, BMP Design Guidelines
http://alexandriava.gov/uploadedFiles/tes/info/GreenSidewalksBMPDesignGuidelines%20.pdf

Local Motion- Crosswalks 101
http://alexandriava.gov/localmotion/info/default-11528.html

NACTO Urban Street Design Guidelines- Pedestrian Safety Islands
http://nacto.org/usdg/intersection-design-elements/crosswalks-and-crossings/pedestrian-safety-islands/

RAISED CROSSINGS AND INTERSECTIONS



OVERVIEW

Raised crossings and intersections create a safe, slow-speed crossing and public space at minor intersections. They are created by raising the level of the roadway to the same level as the sidewalk. Raised intersections are a similar concept to speed tables but are applied to the entire intersection. These treatments provide an array of benefits especially for people with mobility and visual disabilities because there are no vertical transitions to navigate.

» ***Raised crossings and intersections must be approved by T&ES, in consultation with the Commission on Persons with Disabilities and the Alexandria Fire Department. Please refer to the State's Traffic Calming Guidelines for Local Residential Streets.***

Raised crossings and intersections:

- Make it physically more difficult for drivers to go through crossings and intersections at unsafe speeds.
- Improve drivers' awareness by prioritizing pedestrian crossings and helping define locations where pedestrians are expected.
- Eliminate standing water and debris collection at the base of ramps.
- Increase visibility between drivers and pedestrians by raising pedestrians in the motorists' field of view and giving pedestrians an elevated vantage point from which to look for oncoming traffic.
- Create pedestrian crossings that are more comfortable, convenient and accessible since transitioning between the sidewalk and roadway does not require negotiating a curb ramp.

RAISED CROSSINGS AND INTERSECTIONS

DESIGN

- Raised crossings and intersections are appropriate in areas of high pedestrian demand, including Main Streets, Mixed Use Boulevards, and Neighborhood Connectors. They should also be considered in school zones and locations where pedestrian visibility and motorist yielding have been identified as concerns.
- Care should be taken to maintain direct routes across intersections aligning pedestrian desire lines on either side of the sidewalk.
- Raised crossings can be provided along side streets of major thoroughfares to slow traffic exiting the main street.
- Raised crossings should provide pavement markings for motorists and appropriate signage at crosswalks per the MUTCD.
- Design speeds and emergency vehicle routes must be considered when designing approach ramps.
- Raised crossings and intersections require detectable warnings at the curb line for persons with visual disabilities.

CONSIDERATIONS

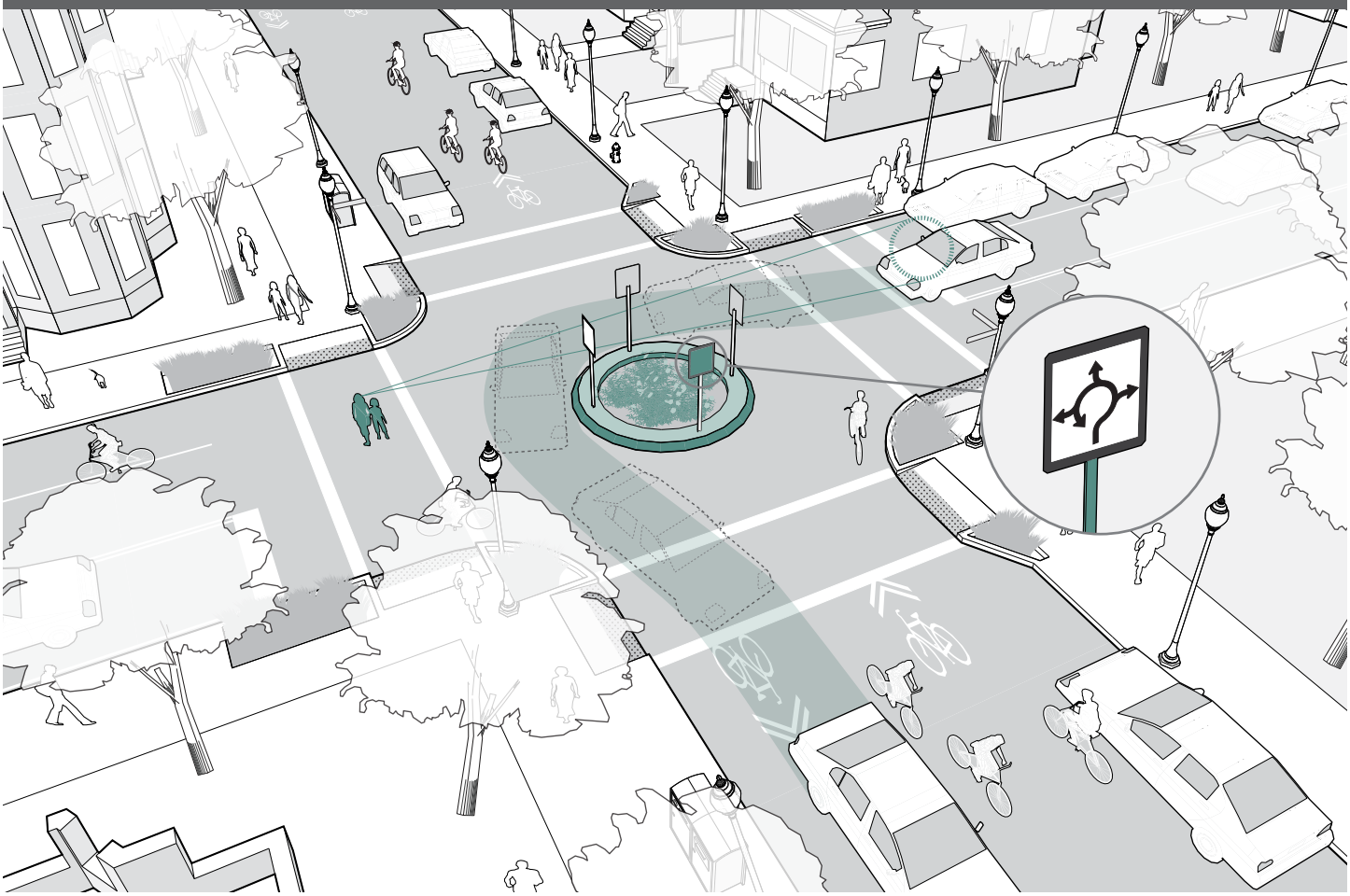
- Raised crossings are particularly valuable at unsignalized mid-block locations where drivers are less likely to expect or yield to pedestrians.
- Raised intersections and crossings can be used as gateway treatments to signal to drivers when there are transitions to a slower speed environment that is more pedestrian-oriented.
- High-visibility or textured paving materials can be used to enhance the contrast between the raised crossing or intersection and the surrounding roadway.
- Installation of raised crossings and intersections may affect snow removal operations. Snow plow operators should be adequately warned and trained.
- Designs should ensure proper drainage. Raised intersections can simplify drainage inlet placement by directing water away from the intersection. If the intersecting streets are sloped, catch basins should be placed on the high side of the intersection at the base of the ramp.

LINKS

State's Traffic Calming Guidelines for Local Residential Streets

http://www.virginiadot.org/programs/resources/TrafficCalmingGuideOct2002.pdf

NEIGHBORHOOD TRAFFIC CIRCLES



OVERVIEW

Traffic circles, or mini roundabouts, can reduce speeds and crashes in low-volume areas and are ideal treatment for uncontrolled intersections. They can be installed using simple markings or raised islands, but they also provide great opportunities to include BMPs or pieces of art.

Traffic circles on Neighborhood Residential streets, Neighborhood Bikeways, and Shared Streets provide advantages for bicyclists and vehicles as they reduce the need for a full stop and enable continuous progression when conflicting traffic is not present.

DESIGN

- Traffic circles are a good alternative to stop-controlled intersections, and are usually preferred to four-way stops.
- Incorporate intersection crossing markings to guide bicyclists through the intersection.
- A mountable curb/curb apron should be provided at traffic circles where large trucks or emergency vehicles require access in constrained spaces.
- Careful attention should be paid to the available lane width and turning radius used with traffic circles.

NEIGHBORHOOD TRAFFIC CIRCLES

Traffic circle in Arlington, VA

- Crosswalks should be marked to clarify where pedestrians should cross and that they have priority. ADA-compliant ramps and detectable warnings are required.
- Provide approximately 15' of clearance from the corner to the widest point on the circle.
- If plantings are incorporated, they should require minimal maintenance and access paths for maintenance crews should be incorporated into the overall design.

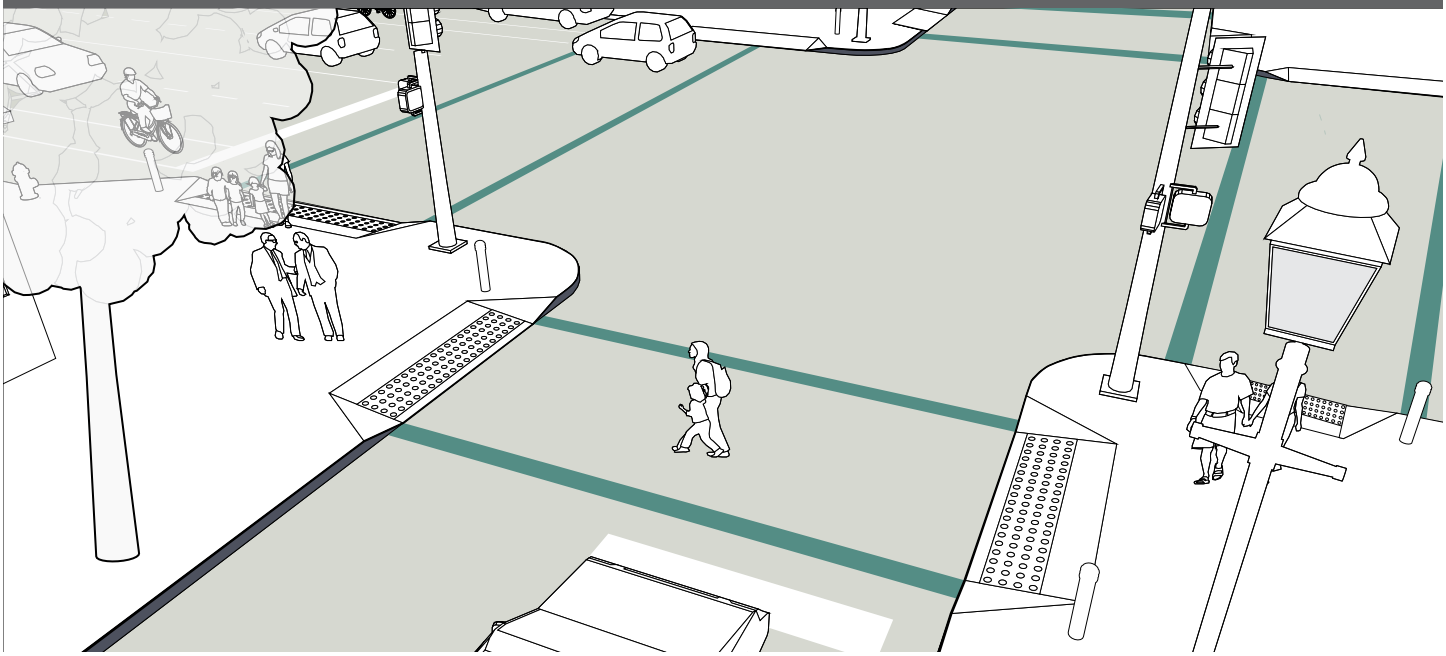
CONSIDERATIONS

- Designs should consider the speed of the roadway.
- Access to underground utilities should be considered.
- A neighborhood partner should be identified for maintenance of any plantings.
- Circles are ideal locations for art or neighborhood gateway treatments; however, elements must not obstruct visibility.
- Maintain circle visibility with paint and reflectors.
- Regulatory and/or warning signage should be provided to remind traffic to proceed counterclockwise around the circle.

Crosswalk Design

Well-designed crosswalks are an important component of a pedestrian-friendly city. Safety for all pedestrians, especially for those with limited mobility and disabilities, is the single most important criteria informing crosswalk design.

STANDARD CROSSWALKS



OVERVIEW

The City of Alexandria's standard crosswalk consists of parallel 6" wide reflective white lines placed 10' apart. This type of crosswalk is sufficient for most signalized intersections. The continental style or "high-visibility" crosswalk should be used at uncontrolled crossings or locations with heavy pedestrian volumes. High visibility crosswalks should be designed to comply with the MUTCD. Textured pavement and colored crosswalks are discouraged as they often fade over time and lack sufficient retro-reflectivity.

USE

- Crosswalks should be at least 10' wide or the width of the approaching sidewalk if it is greater. In areas of heavy pedestrian volumes, crosswalks can be up to 25' wide.
- Crosswalks should be aligned with the approaching sidewalk and as close as possible to the parallel street to maximize the visibility of pedestrians while minimizing their exposure to conflicting traffic.

STANDARD CROSSWALKS

- Designs should balance the need to reflect the desired pedestrian walking path with orienting the crosswalk perpendicular to the curb; perpendicular crosswalks minimize crossing distances and therefore limit the time of exposure.

- ADA-compliant curb ramps should direct pedestrians into the crosswalk. The bottom of the ramp should lie within the area of the crosswalk (flares do not need to fall within the crosswalk).

- Stop lines at stop-controlled and signalized intersections should be striped no less than 4' from the approach of crosswalks.

CONSIDERATIONS

- Crosswalk markings should consist of non-skid, thermoplastic, retro-reflective material. On new pavement, thermoplastic markings should be recessed when possible so that the surface of the marking is flush with the pavement to reduce maintenance needs and provide a smooth, accessible surface.

- Unit pavers and materials that differ from the surrounding pavementsuch as concrete placed on an asphalt street, may not be used in crosswalks. Pavers can be susceptible to settling and damage and can become uncomfortable and unsafe over time.

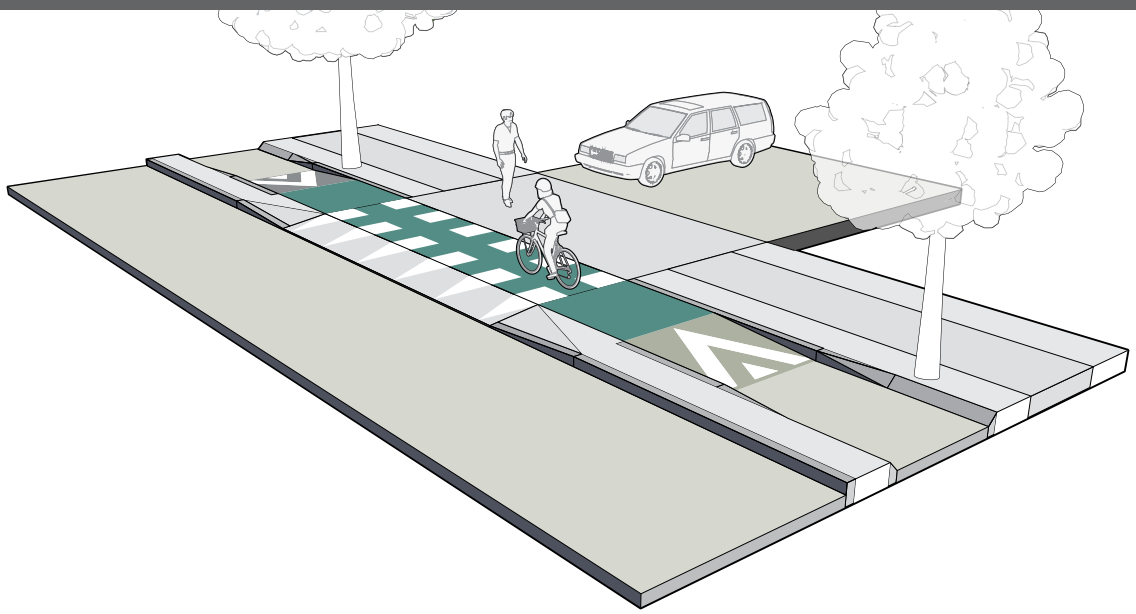
- Raised crosswalks further promote driver yielding behavior by slowing their speed before the crossing and increasing visibility of pedestrians.

LINKS

Local Motion- Crosswalks 101

http://alexandriava.gov/localmotion/info/default.aspx?id=11528

BICYCLE CROSSING



Protected bike lane crossing a driveway

A bicycle crossing is a marked crossing of an intersection with a street, driveway, or alley. The purpose of the crossing is twofold: 1) to delineate a preferred path for people bicycling through the intersection, and 2) to encourage driver yielding behavior, where applicable. The bicycle crossing may be supplemented with dashed green pavement, yield lines, or regulatory signs.

DESIGN

- The bicycle crossing is bounded by 12" (perpendicular) by 24" (parallel) white pavement dashes, otherwise known as elephant's feet. Spacing for these markings should be coordinated with zebra, continental, or ladder striping of the adjacent crosswalk.

- The bicycle crossing should be a minimum of 6' wide for one-way travel and 10' wide for two-way travel, as measured from the outer edge of the elephant's feet. Bicycle lane symbol markings should be avoided in bicycle crossings. Directional arrows are preferred within two-way bicycle crossings.

- Dashed green colored pavement may be utilized within the bicycle crossing to increase the conspicuity of the crossing where permitted conflicts occur. Green color may be desirable at crossings where concurrent vehicle crossing movements are allowed and where sightlines are constrained, or where motor vehicle turning speeds exceed 10 mph.

CONSIDERATIONS

- Supplemental yield lines, otherwise known as shark's teeth, can be used to indicate priority for people bicycling and may be used in advance of unsignalized crossings at driveways, at signalized intersections where motorists may turn across a bicycle crossing during a concurrent phase, and in advance of bicycle crossings located within roundabouts.

- Raised bicycle crossings further promote driver yielding behavior by slowing their speed before the crossing and increasing visibility of people bicycling.

Guidelines for Crosswalk Installation

Legal crosswalks exist at all locations where two streets cross, including T-intersections, regardless of whether pavement markings are present. In other words, motor vehicles are legally required to yield to pedestrians at intersections even when there are no pavement markings.

Crosswalks should be used only at locations where significant pedestrian activity is occurring or anticipated to help ensure that motorists associate crosswalk and pedestrian activity. In order to create a convenient, connected, and continuous walking network. The first step is identifying location for marked crosswalk. Begin by identifying desire lines and destinations such as schools, parks, civic buildings, retail areas, and transit stops. Then, identify where it is safest for people to cross. These observations should inform location and prioritization of crossing improvements.

Marked crosswalks help guide pedestrians to locations where they should cross the street as well as inform drivers of pedestrian movements. In addition to intersections, marked crosswalks are used in locations where pedestrians may not be expected, such as at mid-block crossings or uncontrolled crossings (crossings where motorists do not have signals or stop signs).

As with any installation of traffic control devices, the most essential tool for crosswalk installation is the use of engineering judgment. Engineering judgment should be used and, if applicable, an engineering study performed when considering the marking of crosswalks.

MARKED CROSSWALKS AT CONTROLLED LOCATIONS

Intersection controls are one of the most important factors in intersection design. The goal of controlling intersections is to provide the safest, most efficient means to move people across an intersection, whether walking, riding a bicycle, taking transit, or driving. Specific attention should be given to vulnerable users, such as pedestrians and bicyclists.

East Howell Avenue at Potomac Avenue crosswalk

Engineering judgment should be used to establish the most appropriate controls on a site-specific basis. The following factors should be considered when determining intersection controls:

- Vehicular, bicycle, and pedestrian traffic volumes on all approaches
- Number and angle of approaches
- Approach speeds
- Sight distance available on each approach
- Reported crash experience

Depending on the type of intersection and the selected control devices, it may not always be appropriate to mark crosswalks at all legs of an intersection. Alternate treatments may be necessary to optimize safety and visibility, which are discussed in the sections that follow.

MARKED CROSSWALKS AT SIGNALIZED INTERSECTIONS

Typically, marked crosswalks should be installed at each leg of all signalized intersections, unless otherwise determined by an engineering study. Stop lines should be striped at signalized intersections no less than 4' and no more than 30' from the crosswalk to deter motorists from encroaching in the crosswalk. Signalized intersections are discussed in further detail later in this chapter.

MARKED CROSSWALKS AT CONTROLLED LOCATIONS

East Windsor Avenue at Mount Vernon Avenue crosswalk

A bus yields to a pedestrian as it exits the roundabout

MARKED CROSSWALKS AT STOP-CONTROLLED INTERSECTIONS

Stop-controlled approaches are easiest for pedestrians to cross because motorists and bicyclists must stop and yield the right-of-way to pedestrians. Stop-controlled intersections also help reduce pedestrian delay; however, the use of stop signs must balance safety with efficient traffic flow for all modes, including bicycles and transit vehicles. Stop sign installation requires **specific warrants** be met as determined by the MUTCD.

Typically, marked crosswalks should be installed at each leg of all stop-controlled intersections near pedestrian generators, unless otherwise directed by T&ES. For Neighborhood Residential Streets, marked crosswalks should be used at locations where pedestrian crossings are more frequent, such as school walking routes, park entrances, or other locations. Stop lines should be striped at stop-controlled intersections **no less than 4' and no more than 30'** from the approach of crosswalks, unless determined otherwise by an engineering study.

MARKED CROSSWALKS AT CIRCULAR INTERSECTIONS

Circular intersections, such as roundabouts and traffic circles, permit traffic to travel in one direction around a center island. Traffic circles, which are typically larger than roundabouts, can be difficult for pedestrians and bicyclists to navigate but should incorporate crosswalk facilities where appropriate.

Roundabouts have different design specifications; the important difference is the reduction in speeds and diameters, as well as yield-controlled entry. Circles and roundabouts require channelization of vehicles into the circular part of the roadway. In general, multilane roundabouts are not recommended because of safety concerns for pedestrians, especially those with visual disabilities, and bicyclists.

For traffic circles and roundabouts, marked crosswalks are required to be set back at least 20' from the entry of the roundabout. Sight distance for drivers entering the roundabout should be maintained to the left so that drivers are aware of vehicles and bicycles in the circle, as well as to the right when exiting the roundabout for pedestrian crossings.

MARKED CROSSWALKS AT UNCONTROLLED LOCATIONS

High visibility crosswalk on King Street

Marked crosswalks are an important feature of uncontrolled locations, because they are a reminder to motorists that they must yield to pedestrians. In accordance with the **Code of Virginia, Section 46.2-924**, when traffic control signals are not in place or not in operation, motorists shall yield the right-of-way to a pedestrian within a crosswalk marked in accordance with the MUTCD if:

- The pedestrian has entered the crosswalk after having regarded oncoming traffic.
- The speed of the road or street being crossed does not exceed 35 miles per hour.

Motorists shall not pass any other vehicle stopped at a marked crosswalk to permit a pedestrian to cross, and shall not enter a marked crosswalk while a pedestrian is crossing.

This section presents guidance for when and where it is appropriate to provide marked crosswalks at uncontrolled locations (intersections that are not controlled by signage or signalization). The following sections discuss when installing crosswalks alone is insufficient, and additional safety enhancements are required to increase visibility, awareness, and yielding to pedestrians.

USE

- An engineering study should be performed to determine the feasibility of a marked crosswalk at an uncontrolled location. Marked crosswalks at uncontrolled locations must provide adequate sight distances to enable drivers to slow down and yield to a pedestrian in the crossing.
- Multiple marked crosswalks or crossing treatments in close proximity may desensitize motorists and decrease the effectiveness of the treatment. In general, crosswalks at uncontrolled locations should not be placed within 200' of another intersection with traffic control devices.

MARKED CROSSWALKS AT UNCONTROLLED LOCATIONS

- It is important to prioritize new marked crosswalks at uncontrolled locations based on trip generators, pedestrian volumes, pedestrian delay, crash history, and other issues. Studies should also consider the age and mobility of pedestrians at a particular location.
- If multiple crossing locations are identified in close proximity, it may be possible to consolidate these into one marked crosswalk based on trip generators, pedestrian volumes, and the most visible location.
- The proposed crosswalk location should have adequate lighting or have lighting installation planned.
- Drainage structures can impact the ability to provide curb ramps and other changes that are necessary at crosswalks.

CONSIDERATIONS

- There are some locations where installing marked crosswalks alone are insufficient to address pedestrian safety without providing additional measures to increase visibility and reduce traffic speeds. The MUTCD provides specific guidance on when additional safety treatments should be provided at uncontrolled locations with marked crosswalks based on speeds, traffic volumes, number of travel lanes. These locations include any street where speeds exceed 40 mph and either:
  - The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an average daily traffic (ADT) of 12,000 vehicles per day or greater; or
  - The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater.
- There are a number of measures that can complement marked crosswalks at uncontrolled locations to improve pedestrian safety. The topics below are covered in detail following sections:
  - Reducing the effective crossing distance for pedestrians by:
  - Providing curb extensions
  - Providing raised pedestrian refuge islands
  - Completing road diets or lane diets
  - Installing traffic calming measures to slow vehicle speeds
  - Providing adequate nighttime lighting for pedestrians
  - Using various pedestrian warning signs, advanced yield lines, rapid flash beacons, and other traffic control devices to supplement marked crosswalks
  - Providing traffic signals (with pedestrian signals) where warranted

LINKS

Local Motion Crosswalks 101

http://alexandriava.gov/localmotion/info/default.aspx?id=11528

Local Motion All About Pedestrian and Traffic Signals

http://alexandriava.gov/localmotion/info/default.aspx?id=11414

VDOT Guidelines for the Installation of Marked Crosswalks

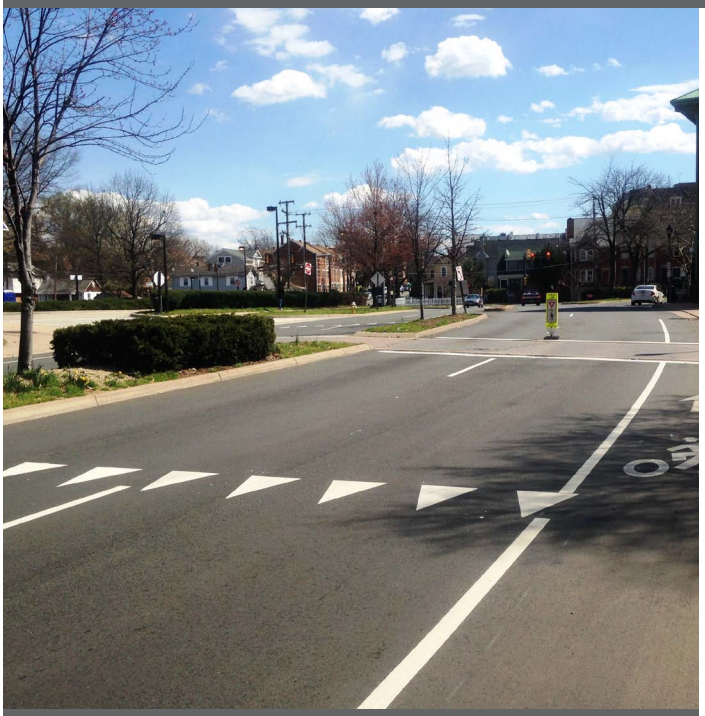
http://www.virginiadot.org/business/resources/marked_20crosswalks_20final_20guidelines_2012-14-05.pdf

Guidelines for the Installation of Marked Crosswalks

http://mutcd.fhwa.dot.gov/htm/2009/part4/part4c.htm

http://nacto.org/docs/usdg/guidelines_for_installation_marked_crosswalks_dougald.pdf

ADVANCED YIELD MARKINGS AND SIGNS



Advanced yield markings

OVERVIEW

Advance yield lines with coordinated YIELD HERE TO PEDESTRIAN signs are used at uncontrolled and yield-controlled mid-block locations and intersections to encourage drivers to stop further back from crosswalks. Advanced yield lines can make it easier for pedestrians and motorists to see one another, discouraging motor vehicles from encroaching on the crosswalk, and thereby preventing multiple-threat collisions. Multiple-threat collisions occur when there are multiple lanes of travel in the same direction and the vehicle in the near lane yields to the pedestrian while the motor vehicle in the far lane does not yield because the pedestrian is blocked from their view.

Effectiveness depends on motorist compliance with the marked stop line. If placed too far in advance of the crosswalk, motorists might ignore the line.

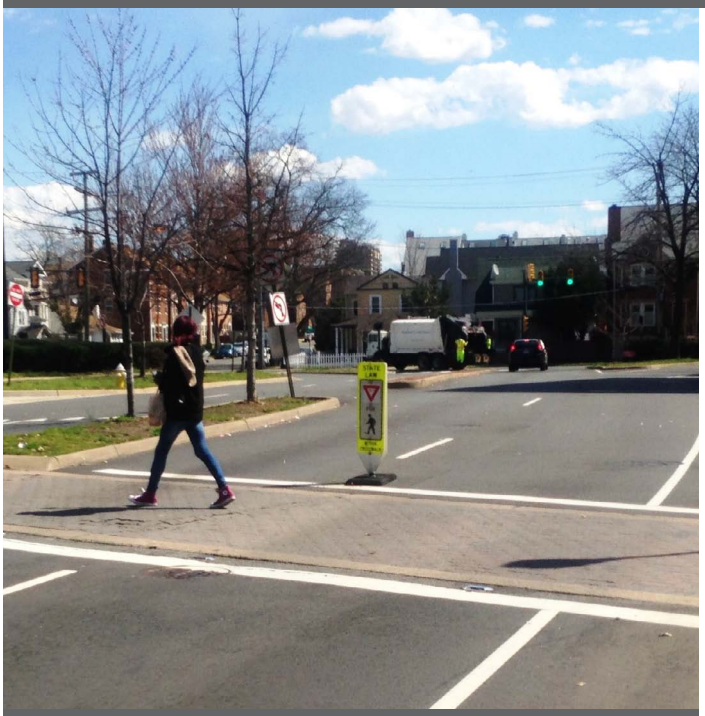
USE

- Advanced yield lines should not be used at locations where drivers are required to stop in compliance with a STOP sign or a signal.
- Advanced yield lines and signs can be used on two-lane, three-lane, and four-lane roadways; however, they are less effective on four-lane roadways unless vehicle operating speeds are 25 mph or less. On four-lane roads with higher speeds, rapid flash beacons are typically a more effective solution. See **Rectangular Rapid Flash Pedestrian Beacon** later in this section.
- Yield lines at unsignalized crossings should be accompanied by YIELD HERE TO PEDESTRIAN signs.
- Advance yield lines and signs should be placed 20' to 50' in advance of crosswalks on uncontrolled multilane approaches, and parking should be prohibited in the area between the yield line and the crosswalk. Pavement markings can be used to reinforce NO PARKING signage.

CONSIDERATIONS

- When determining where to place advance yield lines and signs within the 20' to 50' range, consideration should be given to the number of lanes pedestrians must cross, motor vehicle speeds, sight lines, on-street parking, and turning movements.
- Advance yield lines may be staggered, so that yield lines in one lane are closer to the crosswalk than the yield lines in an adjacent lane. Staggered yield lines can improve drivers' view of pedestrians, provide better sight distance for turning vehicles, and increase the turning radius for left-turning vehicles.

IN-STREET YIELD TO PEDESTRIAN SIGNS



Yield to Pedestrian sign

OVERVIEW

In-street YIELD TO PEDESTRIAN signs are signs placed in the roadway at crosswalk locations to remind roadway users of the laws regarding the right-of-way at unsignalized mid-block locations and intersections. They also increase awareness and visibility of pedestrians crossing. They are often used in commercial districts, at school crossings, or other locations where high pedestrian volumes occur in unexpected locations. In-street signs can be used in conjunction with advanced warning signs and pedestrian crossing signs at crosswalks.

In addition to in-street YIELD TO PEDESTRIAN signs, a variety of signs may be used to indicate locations where drivers must yield to pedestrians, including YIELD HERE TO PEDESTRIAN signs, previously discussed in Advanced Yield Lines and Signs, TURNING TRAFFIC YIELD TO PEDESTRIAN signs, and overhead YIELD TO PEDESTRIAN signs. More information on these signs can be found in the MUTCD.

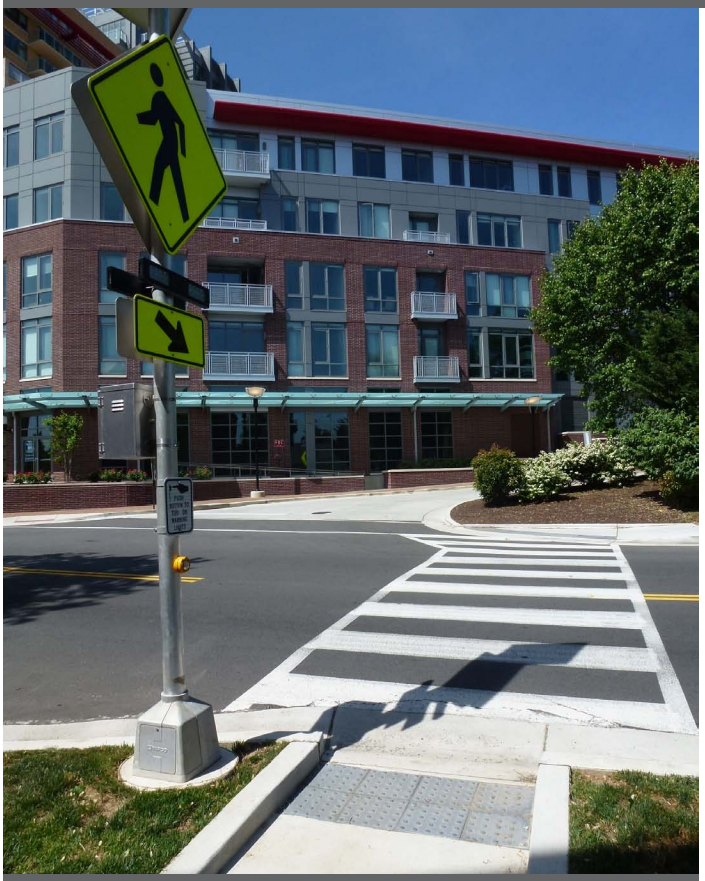
USE

- In-street YIELD TO PEDESTRIAN signs should only be used at uncontrolled intersections. They are prohibited from use at signalized, stop-controlled, or yield-controlled intersections.
- In-street YIELD TO PEDESTRIAN signs should be placed in the roadway close to the crosswalk location on the center line, on a lane line, or on a median island. They should not obstruct the crosswalk. In-street signs should also be placed to avoid turning vehicles from knocking over the sign, and should be designed to bend over and bounce back when struck.
- In-street YIELD TO PEDESTRIAN signs work best on low speed, two lane roads. They are not recommended for roads with high speeds or volumes where drivers are less likely to see them.

CONSIDERATIONS

- May be permanent or temporary. It may be preferable to remove them during winter for snow removal operations.
- Require regular monitoring and should be replaced when damaged. Damaged signs send the message to pedestrians that a crossing is not safe.
- Are typically not used at yield-controlled intersections, and should only be installed using engineering judgment.
- May be used in combination with pedestrian warning signs. Warning signs should be placed on the right side of the road on the sidewalk or mounted on a mast arm above the crosswalk.

RECTANGULAR RAPID-FLASH BEACONS (RRFBs)



RRFB midblock on Mount Vernon Avenue

OVERVIEW

At some uncontrolled crossings, particularly those with four or more lanes, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds and poor pedestrian visibility combine to create conditions in which very few drivers are compelled to yield.

One type of device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs are a pedestrian crossing sign combined with an intensely flashing beacon that is only activated when a pedestrian is present. RRFBs are placed curbside below the pedestrian crossing sign and above the arrow indication pointing at the crossing. They should not be used without the presence of a pedestrian crossing sign. The light-emitting diode (LED) flash is a “wig-wag” flickering pattern at a rate of 190 flashes per minute. The beacons are activated by a pedestrian call button.

Another LED panel should be placed facing the pedestrian to indicate that the beacon has been activated. The pushbutton and other components of the crosswalk must meet all other accessibility requirements.

» ***The use of an RRFB is subject to review and approval by T&ES.***

USE

- The design of RRFBs should be in accordance with FHWA’s Interim Approval 11 (IA-11) for Optional Use of Rectangular Rapid Flashing Beacons issued July 16, 2008 and the Interpretation Letter 4(09)-41 (I) - Additional Flash Pattern for RRFBs issued July 25, 2014.

- RRFBs can be used when a signal is not warranted at an unsignalized crossing. They are not appropriate at intersections with signals or STOP signs.

- RRFBs are installed on both sides of the roadway at the edge of the crosswalk. If there is a pedestrian refuge or other type of median, an additional beacon should be installed in the median.

CONSIDERATIONS

- RRFBs are considerably less expensive to install than mast-arm mounted signals. They can also be installed with solar-power panels to eliminate the need for a power source.

- RRFBs should be limited to locations with critical safety concerns, and should not be installed in locations with sight distance constraints that limit the driver’s ability to view pedestrians on the approach to the crosswalk.

- RRFBs should be used in conjunction with advance yield pavement lines and signs, which are discussed on the previous page.

- Usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route crossings or locations where bike facilities cross roads at mid-block locations.

Signalized Intersections

T&ES operates nearly 250 traffic signals located in the City of Alexandria through the Transportation Engineering Division. The City of Alexandria's policy is to prioritize the safety, comfort, and convenience of all users at signalized intersections. All signalized intersections should contain indications for motor vehicles and pedestrians, and signals for bicyclists and transit where appropriate. By optimizing signal phasing and timings, multiple modes are able to safely move through the intersection with limited conflicts, low delay, and more comfort.

» ***All signal designs must be approved by the Transportation Engineering Division of T&ES. For additional signal design guidance, reference the MUTCD, and the HCM.***

» ***The installation of Pedestrian Hybrid Beacons (also called "HAWK signals") is determined on a case-by-case basis by T&ES. Pedestrian Hybrid Beacons are expensive to install and maintain, and depending on surrounding travel patterns and traffic conditions, may not be the most effective solution. Where used, the design of Pedestrian Hybrid Beacons should be in accordance with the Manual on Uniform Traffic Control Devices and T&ES direction.***

SIGNAL TIMING FOR PEDESTRIANS

OVERVIEW

Signal timing for pedestrians is provided through the use of pedestrian signal heads. Pedestrian signal heads display the three intervals of the pedestrian phase:

The Walk Interval, signified by the WALK indication—the walking person symbol—alerts pedestrians to begin crossing the street.

The Pedestrian Change Interval, signified by the flashing DON'T WALK indication—the flashing hand symbol accompanied by a countdown display—alerts pedestrians approaching the crosswalk that they should not begin crossing the street. The countdown display alerts pedestrians in the crosswalk how much time they have left to cross the street.

The Don't Walk Interval, signified by a steady DON'T WALK indication—the steady upraised hand symbol–alerts pedestrians that they should not cross the street. The beginning of the Don't Walk Interval is called the Buffer Interval, which should be displayed for a minimum of a three seconds prior to the release of any conflicting motor vehicle movements.

The total time for the pedestrian change interval plus the buffer interval is called the pedestrian clearance time, or the time it takes for a pedestrian to clear the intersection leaving at the onset of the DON'T WALK indication.

Pedestrian signal heads should be provided at all signalized intersections for all crosswalks. Additionally, it is highly recommended to install crosswalks on all

SIGNAL TIMING FOR PEDESTRIANS

legs of a signalized intersection unless it is determined to be unnecessary due to pedestrian travel patterns. Signal timing for pedestrians should be provided at all newly constructed signalized intersections and incorporated into all signalized intersection improvements. For information on requirements for accessible pedestrian signals, see Accessible Pedestrian Signals on the next page. The following design goals can help improve pedestrian crossing safety and comfort at signalized intersections:

- Reduce vehicle speeds
- Minimize crossing distance
- Minimize delay for WALK indication
- Minimize conflicts with turning vehicles
- Provide sufficient signal time to cross the street

USE

- Pedestrian signals should allocate enough time for pedestrians of all abilities to safely cross the roadway. The MUTCD specified pedestrian walking speed is 3.5 feet per second to account for an aging population and is endorsed by the City. The pedestrian clearance time, which is the total time for the pedestrian change interval plus the buffer interval, is calculated using the pedestrian walking speed and the distance a pedestrian has to cross the street.

- Countdown pedestrian displays inform pedestrians of the amount of time in seconds that is available to safely cross during the flashing Don't Walk interval. All pedestrian signal heads should contain a countdown display provided with the DON'T WALK indication.

- In areas with higher pedestrian activity, such as near transit stops, along Main Streets, and in neighborhood centers, pedestrian push-button actuators may not be appropriate. Pedestrians should expect to get a pedestrian cycle at every signal phase, rather than having to push a button to call for a pedestrian phase.

- At more complex intersections (e.g., where there is more than one signal phase for each direction), where pedestrian volumes are lower, or uneven or variable volumes of users, pushbuttons should be provided. The responsiveness of the actuated signal should be as prompt as possible (as low as 5 seconds) based on the necessary transition time for approaching motorists to come safely to a stop.

- Along corridors where traffic signals are synchronized, they should be designed to meet target speeds to maintain safe vehicular travel speeds and discourage speeding.

- Refer to the **NACTO Urban Street Design Guidelines** for more information on signalization principles and strategies to accommodate pedestrians.

CONSIDERATIONS

- One of primary challenges for traffic signal design is to balance the goals of minimizing conflicts between turning vehicles with the goal of minimizing the time required to wait at the curb for a WALK indication.

- Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians.

- Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (e.g., jay-walking) after waiting longer than 30 seconds at signalized intersections.

- Opportunities to provide a WALK indication should be maximized whenever possible. Vehicular movements should be analyzed at every intersection in order to utilize non-conflicting phases to implement Walk Intervals. For example, pedestrians can always cross the approach where vehicles cannot turn at a four-leg intersection with the major road intersecting a one-way street when the major road has the green indication.

ACCESSIBLE PEDESTRIAN SIGNALS (APS)

Accessible Pedestrian Signal on Mount Vernon Avenue

OVERVIEW

Accessible pedestrian signals (APS) and accessible detectors are devices that communicate information in non-visual formats about the pedestrian phase to pedestrians with visual and/or hearing disabilities. APS and detectors may include features such as audible tones, speech messages, detectable arrow indications and/or vibrating surfaces.

The major functions of the APS are to provide information for:

- Location of pushbuttons, if used
- Beginning of WALK interval
- Direction of crosswalk
- Location of destination sidewalk
- Intersection signalization with speech messages

Non-visual pedestrian signal features, such as audible signals, should be provided at signalized intersections based on engineering judgment as outlined in the MUTCD. The practice in Alexandria today is for these to be installed at new or reconstructed signals and to be added upon request.

Vibrodetectable devices vibrate to communicate information through touch. Vibrodetectable arrows indicate when the WALK indication is in effect and which direction to cross.

Pushbutton locator tones are used for locating the pedestrian pushbutton needed to actuate the WALK interval. Detectable arrows should be located on pushbuttons to point in the same direction as the crosswalk. At corners of signalized locations where two pushbuttons are present, they should be separated by at least 10'.

For automatically-called pedestrian phases, pushbuttons can be used to activate accessible pedestrian signal features such as detectable arrow indications and/or speech messages.

» ***All accessible pedestrian signal designs must be approved by T&ES and conform to the guidelines outlined by the MUTCD and the U.S. Access Board.***

USE

- When new pedestrian signals are installed, APS with pushbuttons are required.
- For existing pedestrian signals, the APS and pedestrian pushbuttons should be provided when the signal controller and software are altered, or the signal head is replaced.
- At new locations where the pedestrian phase is automatic (pushbutton activation is not required as the pedestrian phase recalls every signal cycle), accessible pedestrian pushbuttons only call accessible features, not the pedestrian WALK signal indication.

CONSIDERATIONS

- Audible walk indications should have the same duration as the pedestrian walk indication unless the pedestrian signal rests during the pedestrian phase, in which the audible indication should be provided in the first seven seconds of the Walk interval.

LEADING PEDESTRIAN INTERVAL

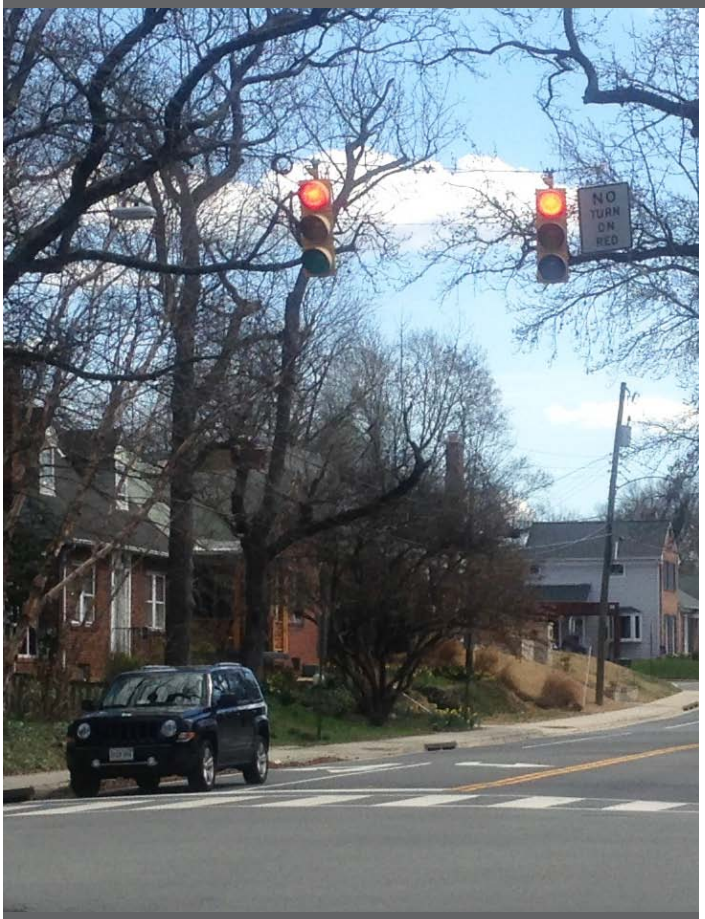
Leading Pedestrian Interval

The Leading Pedestrian Interval (LPI) initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This technique allows pedestrians to establish themselves in the intersection in front of turning vehicles, increasing visibility between all modes.

USE

- The LPI should be used at intersections with high volumes of pedestrians and conflicting turning vehicles and at locations with a large population of elderly or school children who tend to walk slower.
- The LPI should be at least three seconds to allow pedestrians to cross at least one lane of traffic to establish their position ahead of turning traffic.
- A lagging protected left arrow for vehicles should be provided to accommodate the LPI.
- Newly-installed LPIs should provide accessible pedestrian signals to notify visually-impaired pedestrians of the LPI. Additionally, without an accessible pedestrian signal, visually-impaired pedestrians may begin to cross with the vehicular movement when motorists are less likely to yield to them.

NO TURN ON RED



A No Turn on Red sign on Commonwealth Avenue

NO TURN ON RED signs are used to restrict vehicles from turning right, or left on intersecting one-way streets, during the red indication. Restricting this movement eliminates conflicts with pedestrians crossing in front of vehicles making turns. In locations with heavy pedestrian volumes, a leading pedestrian interval may be needed to reduce the resulting conflicts when vehicles get the green light and turn right across the perpendicular crosswalk.

USE

NO TURN ON RED signs should be considered when one or more of the following conditions apply:

- An exclusive pedestrian phase
- An LPI
- High volumes of pedestrian and turning vehicle conflicts
- Poor sight distances and visibility
- Geometry of the intersection may result in unexpected conflicts
- More than three accidents reported in a 12-month period between pedestrians and vehicles where turn-on-red is permitted
- Bicycle boxes

CONSIDERATIONS

NO TURN ON RED signs can be provided at all times or by a dynamic sign that changes when pedestrians are present, by time of day, by a call made by an emergency vehicle, and/or at rail or light transit crossings.

Transit Accomodations at Intersections

The design of intersections and the provisions for transit vehicles need to meet the goals of the transit system–primarily to retain and/or improve the reliability and efficiency of the service. Transit delays occur most often at intersections and are a key element in system and route planning. The delay at traffic signals can account for at least 10% of overall bus trip time and up to 50% or more of bus delay.

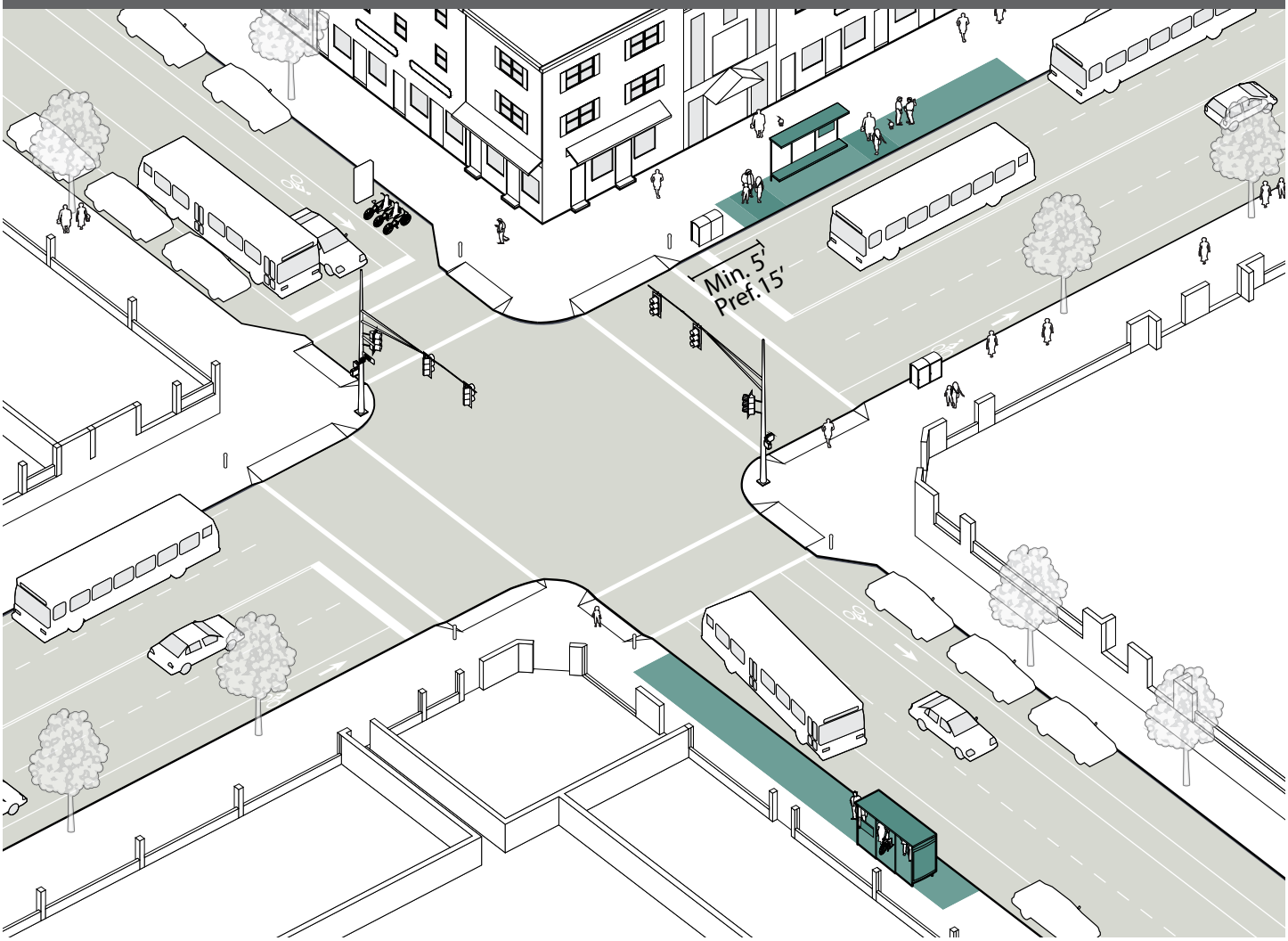
A vast majority of the WMATA and DASH transit stops are located at intersections on Alexandria streets. While many stops are demarcated only by signs, transit shelters and transit stop benches have been installed throughout Alexandria. The City of Alexandria's T&ES Department's transit stop accessibility and amenities program has a replacement initiative to replace Metrobus shelters installed in the 1970s and install new shelters at locations throughout the City.

On Jefferson Davis Highway in Potomac Yard, the new Metroway premium bus service includes median protected transit lanes, introducing a new feature to intersections with cross streets including transit-only signals and advance transit priority signals.

This section covers design strategies to improve transit operations and safety, and reduce delay for transit vehicles at intersections. While individual strategies can be implemented independently, in many cases a combination of strategies, including the appropriate location of the stop and signal prioritization, will be most effective. Implementation of these strategies should also be complemented by operational improvements being carried out by DASH, Fairfax Connector, and WMATA.

» ***Refer to the City Standard Treatments Appendix for information on mast arm standards. All transit accomodations at intersections must be approved by T&ES and WMATA utilizing the WMATA Bus Stop Planning and Design Guidelines and the City of Alexandria's Bus Stop and Bus Shelter Policy Guidelines. All bus shelter installations must be approved by T&ES and meet the design and specifications as approved by the City in May 2014.***

TRANSIT STOP LOCATION



OVERVIEW

Transit stops may be located on the "near-side" of an intersection before a signal or cross street, on the "far-side" after a bus has passed through an intersection, or at a mid-block location between intersections. Transit stop locations are determined based on a number of factors including intersection operations, bus routing, curbside conditions, transfer points, intersection geometry and sightlines, consideration of other street users, and major generators or destinations. The location of a transit stop can affect transit travel time, passenger safety, and roadway operations.

Regardless of location, all transit stops must be ADA compliant, and should be safe, convenient, well-lit, and clearly visible. Transit stops should be connected to the larger pedestrian network with continuous sidewalks, curb ramps, and safe pedestrian crossings.

» ***Transit stop locations should be determined on a site-by-site basis utilizing the WMATA Design and Placement of Transit Stop Guidelines and the City of Alexandria's Bus Stop and Bus Shelter Policy Guidelines and must be approved by the City's Office of Transit Services and WMATA or DASH.***

TRANSIT STOP LOCATION

USE

Transit stops should be located at the near-side or far-side of intersections wherever possible and not at midblock locations. Not only do mid-block bus stops require the most amount of curb side space, they also often require mid-block pedestrian crossings to ensure safe accommodation of passengers going to or from the stop. Intersections permit convenient transfer between transit services or lines, bike routes, and other mobility services. Intersections provide access to a greater portion of the immediate area and provide crosswalks that are familiar and predictable to most drivers and other travelers.

Where bus bulbs are provided, the length of the transit stop can be less than the prescribed minimums (see Transit Stop) because transit vehicles will not be required to pull out of traffic. The minimum transit stop length at bus bulbs should provide a clear and level landing pad at each door of the transit vehicle.

The frequency of stops should be a balance between passenger convenience and minimizing transit travel times. Spacing is typically determined by population density, with transit stops for local services generally located about one-fifth to one-quarter mile apart.

CONSIDERATIONS

- Selecting a location for a transit stop at an intersection depends on a variety of factors:
  - available curb side space
  - conditions of sidewalks
  - width of sidewalks
  - traffic and pedestrian volumes
  - number and width of travels lanes
  - turning movements
  - sight distances
  - presence of parking, bicycle facilities, and crosswalks
- At signalized intersections, far-side placement is generally recommended to permit the bus to pass through the intersection before stopping. This is particularly important where transit signal priority is provided.
- Additional advantages of locating stops on the far-side of an intersection include the following:
  - Pedestrians are encouraged to cross behind the bus, reducing conflict and bus delay.
  - Buses are allowed to take advantage of gaps in traffic flow, especially with signal prioritization, rather than needing to be at the front of the queue at an intersection for a near-side stop.
  - Conflicts between buses and right turning vehicles are minimized and additional right-turn capacity is provided on the near-side of the intersection. This advantage should be weighed carefully at locations where there are heavy turning movements from cross streets.
- Where queue jumps are combined with transit signal priority, near side transit stops (located prior to initiation of the queue jump pocket and TSP sensor) provide the greatest advantage.
  - Location selection should be done on a site-by-site basis in consultation with DASH, WMATA, Fairfax Connector (where appliciable), and T&ES.

TRANSIT PRIORITIZATION AT INTERSECTION

A bus takes advantage of transit prioritization to pass stopped automobiles

OVERVIEW

By prioritizing transit at intersections, service can become more reliable, efficient, and environmentally friendly due to less queuing and stopping and starting, thus making transit a more attractive mode of transportation. Transit prioritization strategies include signal coordination, signal priority, transit only lanes, and queue jump or bypass lanes. These strategies can dramatically improve transit operations at a relatively low cost compared to corridor-wide modifications.

Signal coordination times a series of traffic lights along a corridor to permit smooth progression of traffic. This progression reduces overall traffic congestion thus aiding transit travel times together with other vehicular travelers. Signal coordination uses a pre-timed signal timing program.

Transit signal priority (TSP) enables an approaching transit vehicle to communicate with a traffic signal and alter the signal timing in a way to advantage transit progression. Transit signal priority may extend the signal green time, truncate the red phase, swap signal phases, insert a transit-only phase, or skip signal phases. The margin of signal time prioritized for transit is typically made up in modifications to the remaining signal phases with the overall signal cycle length remaining generally unchanged and fully recovered in the following cycle. Signal priority is being considered for the WMATA Priority Corridor Network program, which includes the Route 7, Route 1, the West End Transitway, and the Little River Turnpike/Duke Street corridor.

During highly congested periods or on routinely congested corridors, TSP alone may be ineffective at improving transit service. In these cases, short transit only “queue-jumper” lanes at intersections provide an opportunity for transit vehicles to bypass stopped traffic and move forward through a congested intersection. Queue-jump lanes may be transit-only or combined with general purpose right turn lanes. They may continue on the far-side of an intersection to permit transit vehicles to remerge with through traffic. Queue jump lanes are often paired with a separate signal to permit the queue jump lane to advance and clear while other vehicles traveling in the same direction are given a red light.

» ***Transit only and queue jump lanes, as well as all signal coordination and prioritization, must be coordinated with and approved by T&ES and WMATA, DASH, and/or Fairfax Connector.***

TRANSIT PRIORITIZATION AT INTERSECTION

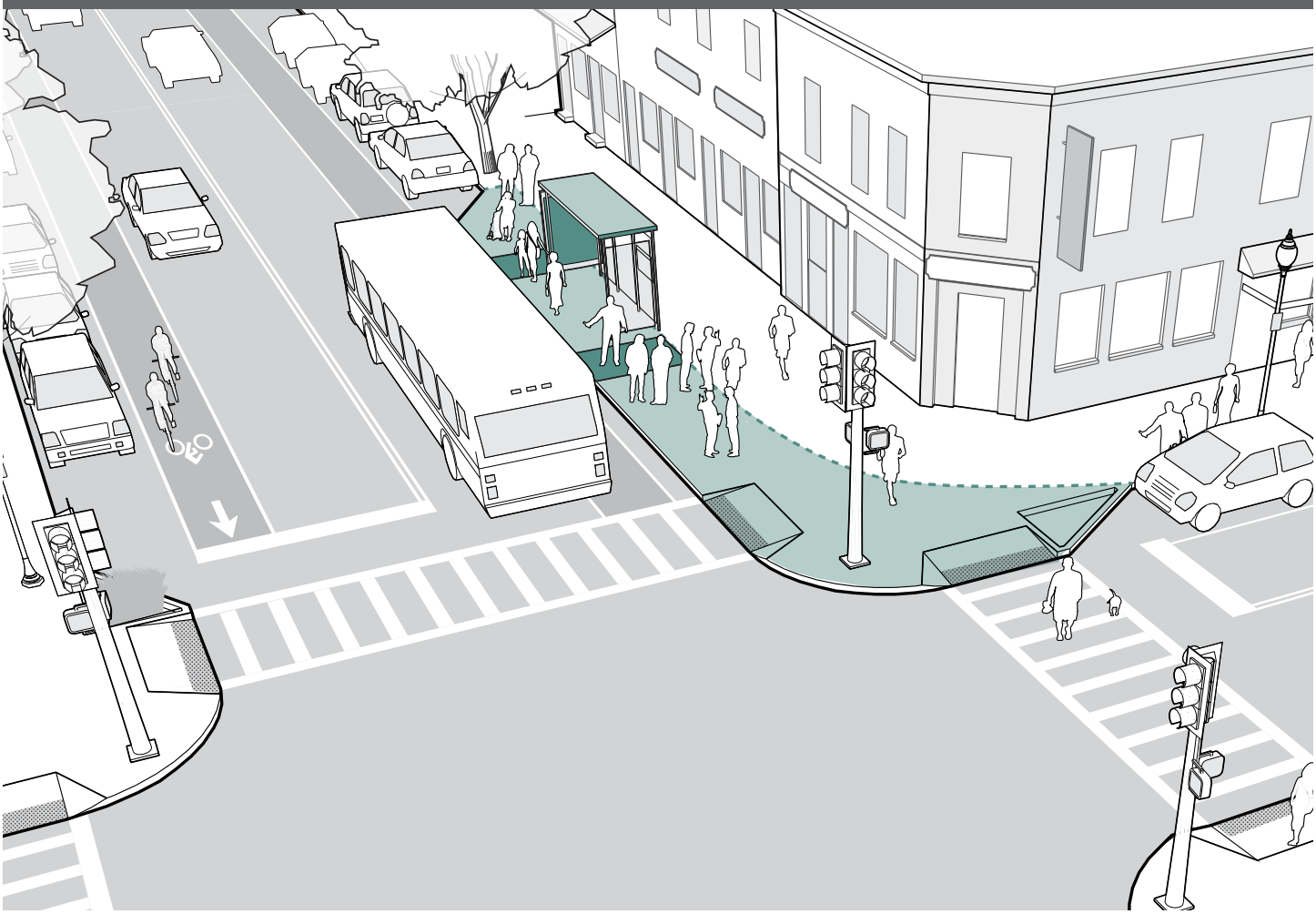
USE

- Signal coordination can reduce delay for transit as well as motor vehicles. Signal coordination uses a pre-timed signal program for traffic and pedestrian crossings.
- Transit signal priority requires special communication technology to permit communication between the signal and approaching transit vehicles. TSP may be used on either pre-timed or activated signals.
- Signal coordination and signal priority can be used with or without the presence of dedicated transit only lanes or queue jump and bypass lanes at intersections.
- Advanced stop bars may be used in combination with queue jump lanes to help transit vehicles re-enter the traffic stream or jump to the front of the queue. Advanced stop bars stop all traffic some distance back from the traffic signal.
- Transit-only queue jump lanes may be enhanced with colored pavement or striping to further define it as a transit only space.
- Queue jump lanes gain the greatest advantage when provided separate signal phasing to permit lanes to clear in advance of general traffic.
- Queue jump lanes can be used at intersections without a transit stop as well as with one at either the near- or far-side so long as there is enough space on the roadway.
- Traffic signal priority typically cannot be activated for more than two signal cycles in a row and then cannot be activated until two to three additional signal cycles have passed to enable overall intersection recovery.

CONSIDERATIONS

- Providing a queue jump lane with a leading signal phase should take into consideration the overall signal cycle lengths and impacts to delay for other users.
- If space is not available for a queue jump lane or bypass lane, consider using a right-hand turn lane to double as a transit advantage lane by allowing transit vehicles to move up in the queue at a signal where right turn on red is permitted. If right-turn lanes are used, appropriate signage such as RIGHT LANE MUST TURN RIGHT must be accompanied by EXCEPT BUSES placards.
- Transit signal priority should be considered on all priority transit routes. Studies should be conducted to understand the impact to traffic on cross streets and other corridor users. TSP should be installed only when there is documented schedule adherence issues.
- Signal coordination should take all modes into consideration including travel speeds of bicyclists and pedestrians along the corridor. Signal coordination should seek to optimize progression of all modes.
- Public and transit operator education is needed in how to use queue jump lanes in multimodal environments and how to manage transit vehicle, other or vehicle, pedestrian, and bicycle interactions.
- Compliance may be an issue if advance stop bars are used.

BUS BULBS



OVERVIEW

Bus bulbs are curb extensions along the length of a transit stop that eliminate the need for transit vehicles to pull in and out of traffic. Similar to normal curb extensions found at intersections, bus bulbs have the same advantages of reducing crossing distances for pedestrians and providing additional space for street furniture, landscaping, and pedestrian queuing.

» ***Bus bulbs will be installed on a case-by-case basis determined by an engineering study, and all designs must be approved by T&ES in consultation with WMATA, DASH, and/or Fairfax Connector.***

USE

- Bus bulbs are only appropriate on streets where on-street parking is present.
- Bus bulbs provide extra passenger queuing space and are most appropriate at stops with higher passenger volumes.
- Bus bulbs are effective in enforcing parking restrictions within bus stops and do not require as much space as curbside stops because the transit vehicle does not need space to pull in and out of the stop, but may cause occasional traffic delay behind them.

BUS BULBS

CONSIDERATIONS

- Since the transit vehicle remains in the travel lane while stopped, bus bulbs can result in traffic delays or unsafe maneuvers by drivers and bicyclists to steer around buses. In most cases, this delay is minor. Designs should consider the street type, traffic conditions, posted speed, number of travel lanes, and headways of buses.
- Bus bulbs can interfere with right-turning vehicle movements at near-side intersections. In these cases, bus bulbs should be designed to self-reinforce provisions precluding traffic from turning right in front of a stopped bus.
- Bus bulbs are most effective at reducing travel time if they are utilized throughout a corridor by eliminating the need for transit vehicles to pull in and out of traffic all together.
- WMATA and DASH operate different length buses varying from 35' City to 60' articulated vehicles. Bus bulbs will require different lengths depending on the service provided on the transit route. Bus bulbs should be long enough to permit all doors of transit vehicles utilizing the stop to open onto the flat, level surface.
- If multiple routes with frequent service utilize a stop, bus bulbs may need to be long enough to accommodate two or more transit vehicles.
- Bus bulbs, like curb extensions, typically extend the width of the curbside parking space less 1'-2' to avoid friction with the turn lane.
- On corridors with bicycle facilities, lanes for bicycles should be routed behind the bus bulb to remove conflicts between bicycle travel and passenger boarding and alighting activity.
- Bollards may be placed at the beginning of bus bulbs to protect the pedestrian space.
- Bus bulbs are good locations for amenities such as bicycle parking, street trees, and trash and recycling receptacles, so long as the requirements for waiting area, clear path, and the landing zone are met.
- Drainage should be considered when implementing bus bulbs. Stormwater catch basins may need to be relocated.
- Landscape areas within bus bulbs also offer opportunities for landscaping and BMPs.

Transit riders board a DASH bus from a bus bulb

OFF-BOARD FARE COLLECTION

Bus ticket machines in New York City

OVERVIEW

Passenger boarding can be a lengthy process that may be a significant cause of delay in transit travel times. Fare control is often limited to only the front door of vehicles requiring all passengers to load from a single door. Delay is also possible as passengers locate money or fare media or load value onto transit cards.

In addition to promoting “smart card” fares, pre-payment is the fastest method of fare collection. Off-board fare collection enables passengers to enter the vehicle from all doors without waiting in line to pay. Compared to a few additional seconds for exact fare or tap systems, off-board fare collection can save up to a minute per 10 passengers.

USE

Off-board fare collection can reduce transit dwell times and increase schedule reliability; therefore, it is commonly prioritized for use on priority transit corridors, and as a component of premium and/or high capacity transit services.

CONSIDERATIONS

- Off-board fare collection requires more space and infrastructure than standard transitstops.
- Electronic fare equipment may require staffing and cameras. If left unattended at stops, weather and compliance may become problems.
- An alternative to off-board fare collection methods could be additional electronic fare collector (e.g. SmartTrip targets) at all doors to allow patrons with SmartTrip cards to bypass cash-fare customers.
- Fare-free zones could be considered in extremely high-volume destinations.
- Off-board fare collection may require a change in policy and operation to implement systems to monitor compliance and conduct enforcement.

Bicycle Accommodations at Intersections

The majority of motor vehicle crashes involving bicycles in urban areas occur at intersections. In Virginia, on-street bicycles are operating vehicles and are required to follow the same rules of the road as motorists. Good intersection design makes bicycling more comfortable and attractive, reduces conflicts with motor vehicles and pedestrians, and contributes to reduced crashes and injuries. The following principles are applied to intersection design in order to accommodate bicyclists:

- Provide a direct, continuous facility to the intersection
- Provide a clear route for bicyclists through the intersection
- Reduce and manage conflicts with turning vehicles
- Provide signal design and timing to accommodate bicyclists
- Provide access to off-street destinations.

Guidance on different types of bicycle facilities is covered in Chapter 4.

Intersection improvements for bicycles should be considered during all roadway improvement projects, street redesign, and safety improvements or upgrades. Bicycle-related improvements should be coordinated with the 2016 Alexandria Pedestrian and Bicycle Master Plan.

» ***Bicycle facility designs must be approved by T&ES. Additional guidance for the design of bicycle facilities can be found in the MUTCD, the NACTO Urban Street and Bikeway Design Guides, and the AASHTO "Bike Guide."***

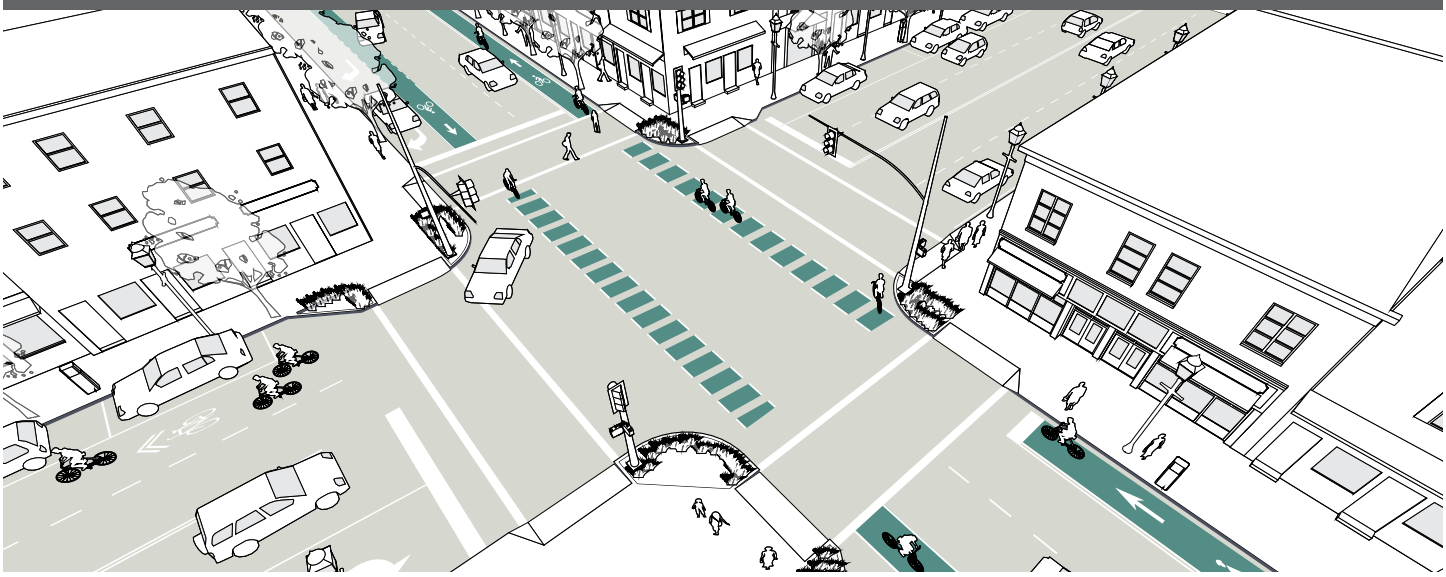
LINKS

Manual on Uniform Traffic Control Devices
http://mutcd.fhwa.dot.gov/

NACTO Urban Bikeway Design Guide
http://nacto.org/cities-for-cycling/design-guide/

AASHTO Bike Guide
http://www.pedbikeinfo.org/pdf/Webinar_PBIC_LC_081012_AASHTO_1.pdf

BICYCLE LANES AT INTERSECTIONS



OVERVIEW

Bicycle lanes provide a dedicated space for bicyclists to predictably ride along roadways and through intersections. When designing intersections for bicyclists, approaches should be evaluated and designs should maintain continuity of bicycle facilities to the maximum extent feasible.

Streets with dedicated bicycle lanes should continue striping through unsignalized and complicated intersections to provide additional guidance and safety measures for bicyclists. This design principle is especially important at intersections where there are conflicting vehicular movements, unsignalized crossings, and/or crossings of more than four travel lanes. Signalized intersections may not require striping through each intersection and should be evaluated on a case-by-case basis.

USE

- Standard details for bicycle lane markings at intersections are provided in the **NACTO Urban Bikeway Design Guide**. Additional guidance can also be found in the MUTCD and AASHTO "Bike Guide."
- Dedicated bicycle lanes should be provided on intersection approaches where space is available.
- At intersections with a dedicated right turn lane, bicycle lanes should be provided to the left of the right turn only lane unless bicycle signals and dedicated phasing is provided.

CONSIDERATIONS

- Bicycle lane markings, including green-colored pavement, shared lane markings, dashed bicycle lane lines, and signage may be provided through intersections per engineering judgment.
- Selective removal of parking spaces may be needed to provide adequate visibility and to establish sufficient bicycle lane width at approaches to intersections.
- Shared lane markings may be used where space is not available for bicycle lanes at intersections; however, this should only be done if no other design is possible.
- Although the minimum recommended width of a bicycle lane within the intersection is 5', 4' bicycle lanes can be provided in extremely constrained conditions.
- Bicycle lanes at the entrance and exit of a circular intersection should allow direct access to a shared use bicycle/pedestrian path around the perimeter of the intersection via curb ramps; ramps should be provided for bicyclists to mount the sidewalk prior to the intersection. Designs should also enable bicyclists to mix with traffic and proceed through the intersection.

BICYCLES AT SIGNALIZED INTERSECTIONS

A bicyclist stops on the loop detector at Commonwealth Avenue and Mount Vernon Avenue

OVERVIEW

Bicycles have different operating characteristics than motor vehicles and special consideration is necessary in designing traffic signals that accommodate both motorists and bicyclists. Bicyclists generally have the disadvantage of slower acceleration rates than motorists, and traffic signal design should include adjustment of minimum green intervals, clearance time, and extension time to account for the disadvantage. Signal progression should be designed in order to balance the needs of all users, with appropriate design speeds and traffic signal coordination settings.

Appropriate signal timing also can reduce delay, discourage bicyclists from running red lights, and help minimize conflicts.

The **AASHTO Guide for the Development of Bicycle Facilities** provides a specific formula to estimate minimum green time for bicycles from a standing position. It is based on the average adult bicyclists who can operate at 10 miles per hour. A slower speed or extended time may be appropriate at locations with young children such as near schools.

BICYCLES AT SIGNALIZED INTERSECTIONS

USE

- Where actuated signals are present, the signal system should automatically detect bicycles as well as motor vehicles. Typically, the City of Alexandria uses loop detectors at actuated or semi-actuated intersections. In order for bicyclists to prompt the green phase at these intersections, bicycle detection devices should be installed.
- Detection devices can also include:
  - Video detection
  - Infra-red detection
  - Microwave detection
  - Magnetometers (special locations such as on or under bridges)
- Detection devices should be located within bicycle lanes or bicycle boxes, marked with a bicycle detector symbol, and supplemented by appropriate signage.
- When it is not feasible for the detection device to be located within the bicycle lane or bicycle box, detection devices should be located prior to the stop bar and span an appropriate distance to provide for left, through, and right turning bicyclists.

CONSIDERATIONS

- Reference the latest edition of the AASHTO Bike Guide and the NACTO Urban Bikeway Guide for more details on the signal timing needs of bicycles at intersections. The AASHTO Bike Guide provides the technical information necessary to calculate minimum green time and other aspects of signal design to accommodate bicycles. The NACTO Urban Bikeway Design provides less technical detail, but provides information regarding bike signal heads.
- Where right-turn-only lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane.
- Special attention should be given to signal timing at locations with higher vehicular speeds and longer crossing distances. At these locations, bicyclists are more likely to have different signal timing needs than motorists, such as extending the green time to allow bicyclists to clear the intersection before the yellow/red phases. The AASHTO Bike Guide contains detailed guidance for bicyclists' signal timing needs at wide intersections.
- Bicycle signal heads provide dedicated signal indications to bicyclists and should be positioned to maximize visibility to bicycle traffic. They should be coordinated with pedestrian and non-conflicting vehicular movements to increase safety and minimize overall delay.
- Bicycle detection devices, particularly loop detectors, need regular testing to ensure the equipment is working correctly.

» ***Bicycle signal heads will be installed on a case-by-case basis determined by an engineering study and must be approved by T&ES.***

BICYCLE BOXES

OVERVIEW

A bicycle box is dedicated space located between the crosswalk and the vehicle stop line used to provide bicyclists a dedicated space to wait during the red light at signalized intersections. Placing bicyclists ahead of stopped vehicular traffic at a red light improves visibility and reduces conflicts among all users, which aids bicyclists making turning movements and improves safety and comfort due to the difference in acceleration rates between bicycles and motor vehicles. Bicycle boxes also provide more space for multiple bicyclists to wait at a red light as opposed to being constrained to a 5' wide bicycle lane. In all cases, the bicycle box allows a bicyclist to be in front of motor vehicles, which not only improves visibility and motorists awareness, but also allows bicyclists to “claim the lane” if desired.

BICYCLE BOXES

USE

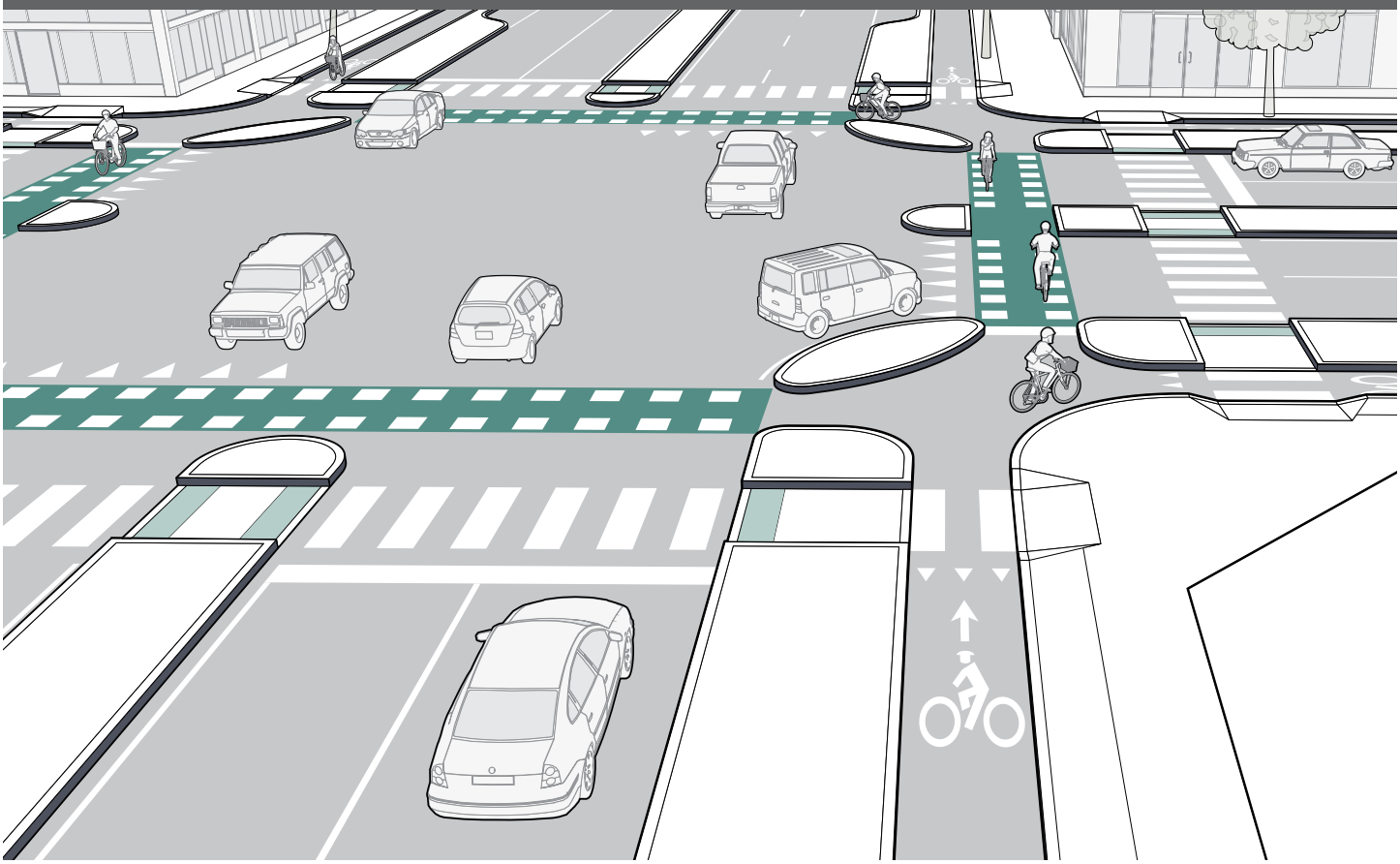
- In locations with high volumes of turning movements by bicyclists, a bicycle box should be used to allow bicyclist to shift towards the desired side of the travel way. Depending on the position of the bicycle lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.
- In locations where motor vehicles can continue straight or cross through a right-side bicycle lane while turning right, the bicycle box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning. Where designs place bicycle boxes in front of a vehicle lane that may turn right on red, NO TURN ON RED signs must be provided.

CONSIDERATIONS

- In the City of Alexandria, bicycle boxes are typically painted green and are a minimum of 10' in depth.
- Bicycle box design should be supplemented with appropriate signage according the latest version of the **MUTCD**.
- Bicycle box design should include appropriate adjustment in determining the minimum green time.
- Where right turn only lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane. If a right turn on red is desired, consider ending the bicycle box at the edge of the bicycle lane to allow motor vehicles to make this turning movement.

Bicycle box in Del Ray

PROTECTED BIKE LANES AT INTERSECTIONS



OVERVIEW

Protected bicycle lanes provide an exclusive travel way for bicyclists alongside roadways separate from motor vehicle travel lanes, parking lanes, and sidewalks. Protected bike lane designs at intersections should manage conflicts with turning vehicles and increase visibility for all users.

USE

- It is preferable to maintain the separation of the bike lane through the intersection rather than introduce the bicyclist into the street with a merge lane. Where this is not possible, merge zones should be designed to increase the visibility of bicyclists and reduce motor vehicle speeds. Other measures such as pavement color, shared lane markings and bike boxes should be incorporated where appropriate.
- Increasing visibility and awareness are two key design goals for protected bike lanes at intersections. In some cases, parking restrictions between 20' to 40' are needed to ensure the visibility of bicyclists at intersections.
- Protected bike lanes should typically be routed behind transit stops (i.e., the transit stop should be between the bike lane and motor vehicle travel lanes). If this is not feasible, the protected bike lane should be designed to include treatments such as signage and pavement markings to alert the bicyclist to stop for buses and pedestrians accessing transit stops.
- Markings and signage should be used at intersections to give priority to protected bicycle lanes.

PROTECTED BIKE LANES AT INTERSECTIONS

CONSIDERATIONS

- Protected bicycle lane designs at intersections should give consideration to signal operation and phasing in order to manage conflicts between turning vehicles and bicyclists. Bicycle signal heads should be considered to separate conflicts.
- Shared lane markings and/or colored pavement can supplement short dashed lines to demark the protected bike lane through intersections, where engineering judgment deems appropriate.
- At non-signalized intersections, design treatments to increase visibility and safety include:
  - Warning signs
  - Raised intersections
  - Special pavement markings (including colored surface treatment)
  - Removal of parking prior to the intersection

LINKS

Bicycle Facilities and the Manual on Uniform Traffic Control Devices
http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd/

NACTO Urban Bikeway Design Guide
http://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/

FHWA Separated Bike Lane Planning and Design Guide
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm

One leg of Davis, CA's protected intersection