



Bicycle Facility Design: GuidelineTool Box for Intersections

**Cycling and Pedestrian
Advisory Committee**

May 24, 2012



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Purpose of the Guideline Tool Box for Intersections

A Bicycle **Facility Selection Guide** was developed in 2011 to assist Town staff in selecting appropriate bicycle facilities for Town-owned local and collector road rights-of-way.

The **Design Guideline Tool Box for Intersections** is meant to supplement the Facility Selection Guide and assist Town staff in making decisions about bicycle facility designs at intersections of Town-owned local and collector road rights-of-way. Note however that this Tool Box is not intended to be all inclusive. There are variations and enhancements that are not addressed in this Tool Box that the Town could also consider.



Background References

This design Tool Box is a compilation of current best practice guidelines from a number of cycling facility design manuals, and these can be consulted for further information.

- TAC Bikeway Traffic Control Guidelines, Draft 2012
- OTM Book 15 – Pedestrian Crossing Facilities, 2011
- NACTO Urban Bikeway Design Guide, 2010
- ASSHTO Guide for the Planning, Design, and Operation of Bicycle Facilities, 2010
- Crow Design Manual for Bicycle Traffic, 2007
- TAC Bikeway Signal Guidelines, Draft 2004
- TAC Geometric Design for Canadian Roads, 1999
- MTO Bikeway Planning and Design Guidelines 1996

Town practitioners should also consider OTM Book 18 – Bicycle Facilities which is due to be complete in late 2012 or early 2013.



Purpose of the Guideline Tool Box for Intersections

Similar to bicycle facility selection for sections of road between intersections, there is no “formula” or template that can be universally applied for the design of intersections.

Facility design through intersections should be based on an analysis and understanding of the characteristics of a specific intersection combined with good engineering judgement.

This analysis includes consideration of factors such as traffic/pedestrian volumes, type and density of adjacent land-uses and future conditions.



Bicycle Facilities at Intersections

Things to Consider

- Most conflicts between cyclists and motorists occur at intersections
- Conflicts can be mitigated using innovative design solutions that incorporate elements such as pavement markings and signage, pavement colour, designated holding areas for cyclists, medians and bicycle traffic signals etc.
- Engineers need to gather information on existing and future conditions in order to identify cyclist needs and safety concerns for a given location
- Intersections are complex and designs should consider many factors including but not limited to traffic volume, available pavement width, available right-of-way and level of pedestrian use etc.



When designing an intersection for the integration of cyclists the main **goals** are to:

- Increase roadway user safety by mitigating conflict points;
- Increase visibility for cyclists, motorists and other roadway users;
- Designate and clearly mark travel paths;
- Minimize complex manoeuvres for cyclists; and
- Facilitate awareness and understanding between competing modes of transportation.



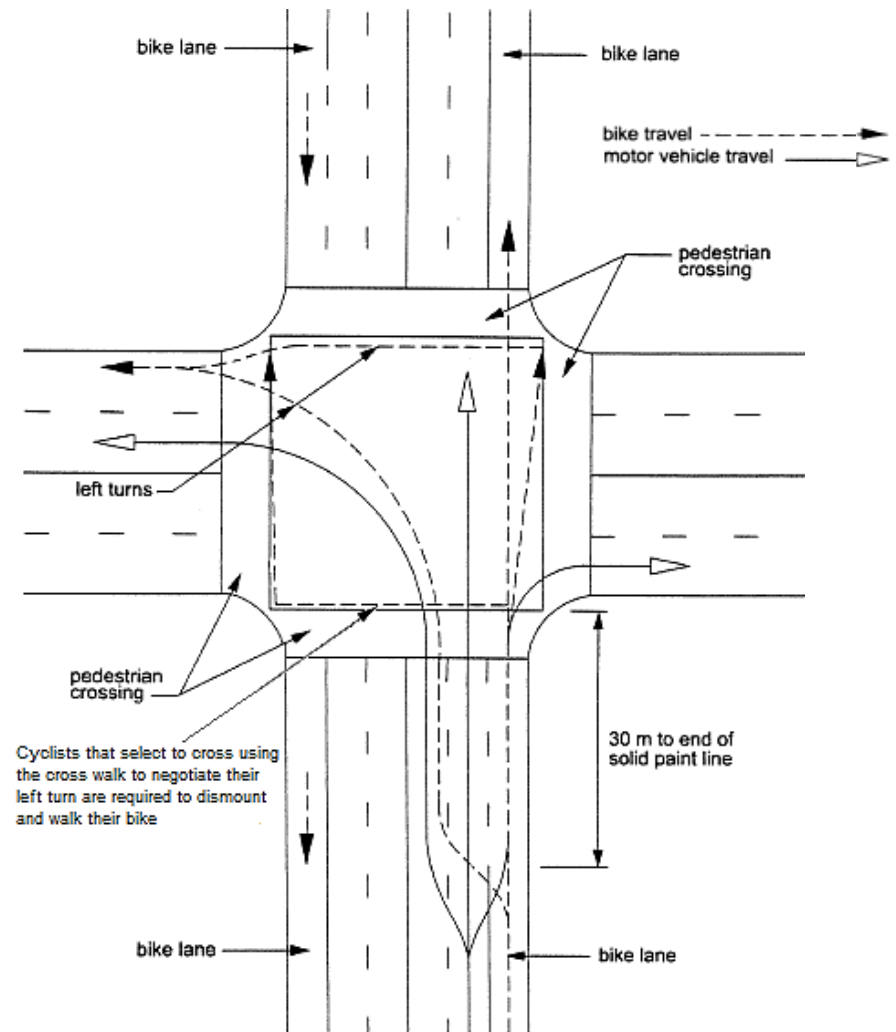
Typical Movements at an Intersection

Motor vehicle-bicycle conflicts are categorized between:

- Right-turn Conflicts
- Left-turn Conflicts

Right-turn conflicts may occur when a cyclist is trying to make a through movement while a motorist is trying to make a right turn and to do so the motorist must cross over the cyclist's intended path of travel.

Left-turn conflicts may occur when a cyclist is trying to merge across one or more lanes of through-moving vehicles in order to turn left using the same path as motorized vehicles.

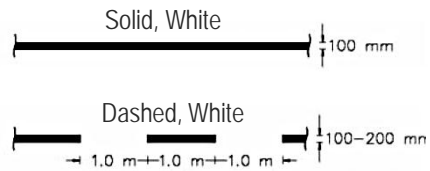


Credit: TAC Geometric Design Guide for Canadian Roads, 1999 (modified)

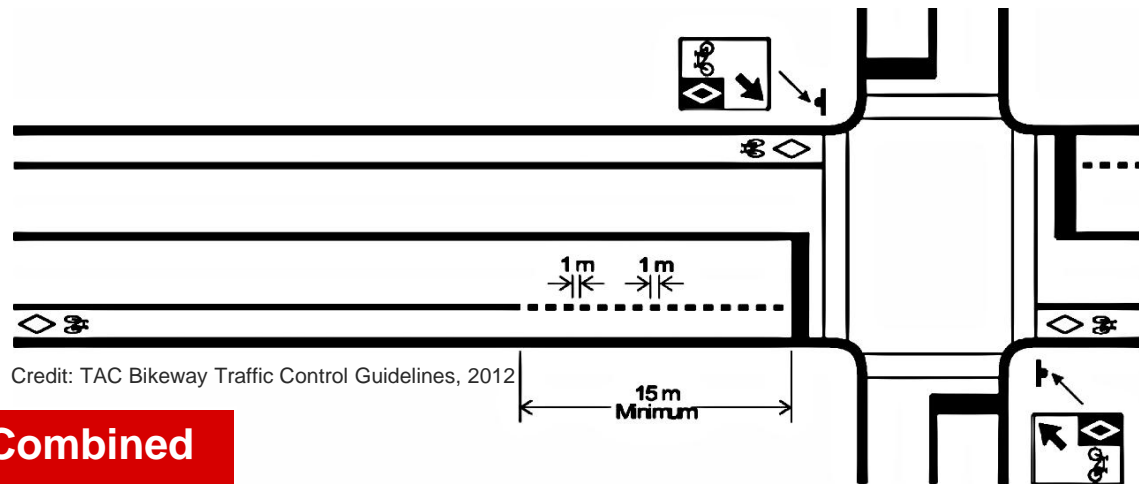


Design Options for Mitigating Right-Turn Conflicts

Longitudinal Pavement Markings for Bicycle Lanes (Line Delineation Details)



Credit: TAC Bikeway Traffic Control Guidelines, 2012



Credit: TAC Bikeway Traffic Control Guidelines, 2012

Bicycle Lane Adjacent to Combined Through/Right Turn Lane

A bicycle lane, adjacent to a combined through/right turn lane is generally designed with a dashed white line approaching the intersection in order to permit motorists to enter the bicycle facility to make a right turn movement. However, there are variations to this design option as the solid line of the bike lane can be carried through to the intersection. Furthermore, an advance stop line can be provided for cyclists (as shown on slide 10).



Credit: www.livininthebikelane.blogspot.com, 2010



Credit: John Luton, 2007 (Flickr) - Vancouver



Design Options for Mitigating Right-Turn Conflicts

Advance Stop Line for Bicycle Lane Adjacent to Combined Through/Right Turn Lane

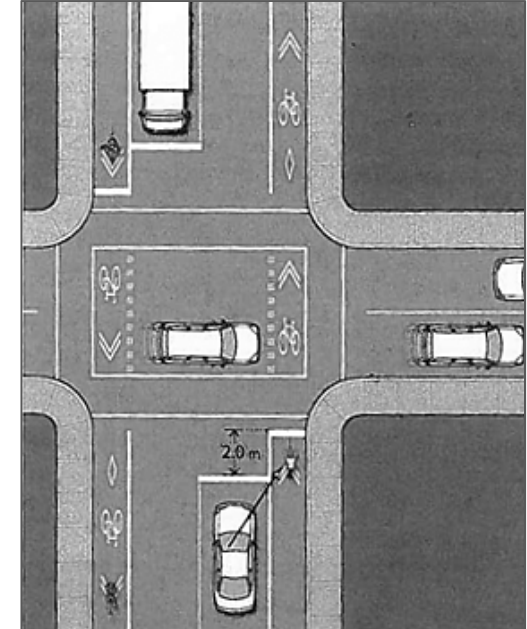
A bicycle lane, adjacent to a combined through/right turn lane, with a solid white line approaching the intersection is intended to discourage motorists from entering the bicycle facility to make a right turn movement. They are expected to make a right turn from the vehicle lane at the intersection. In some cases, an advance stop line may be provided. The advance stop line positions cyclists ahead of motorists making them more visible to right-turning vehicles and giving them a “head start” in crossing the intersection.



Credit: Flickr, 2010



Credit: European Cycling Federation, 2011



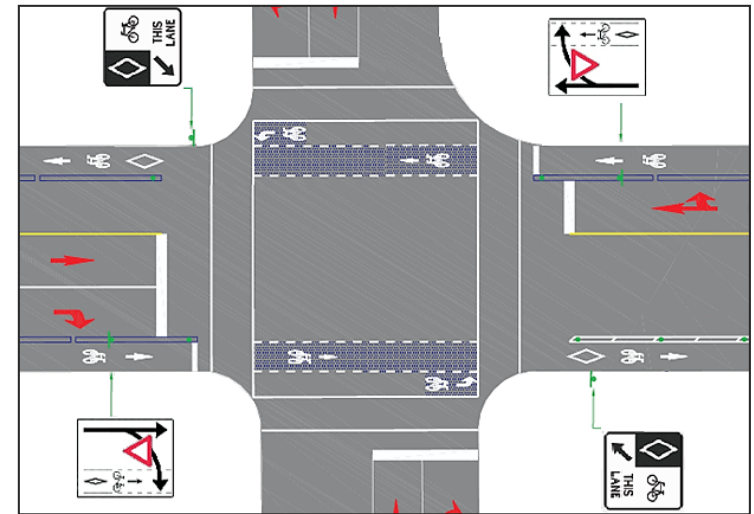
Credit: Velo Quebec Planning and Design for Pedestrians and Cyclists, 2010



Design Options for Mitigating Right-Turn Conflicts

Separated Bicycle Lane Adjacent to Combined Through/Right or Exclusive Right Turn Lane

A separated bicycle lane restricts motorists from entering the bicycle lane. A Turning Vehicles Yield To Bicycles Sign (as illustrated in the figure to the right) should be implemented at intersections where motorists are required to cross a bicycle facility and approach to warn motorists of the potential presence of through moving cyclists when making a right-turn movement.



Credit: City of Ottawa, 2010 – Laurier Ave, Ottawa

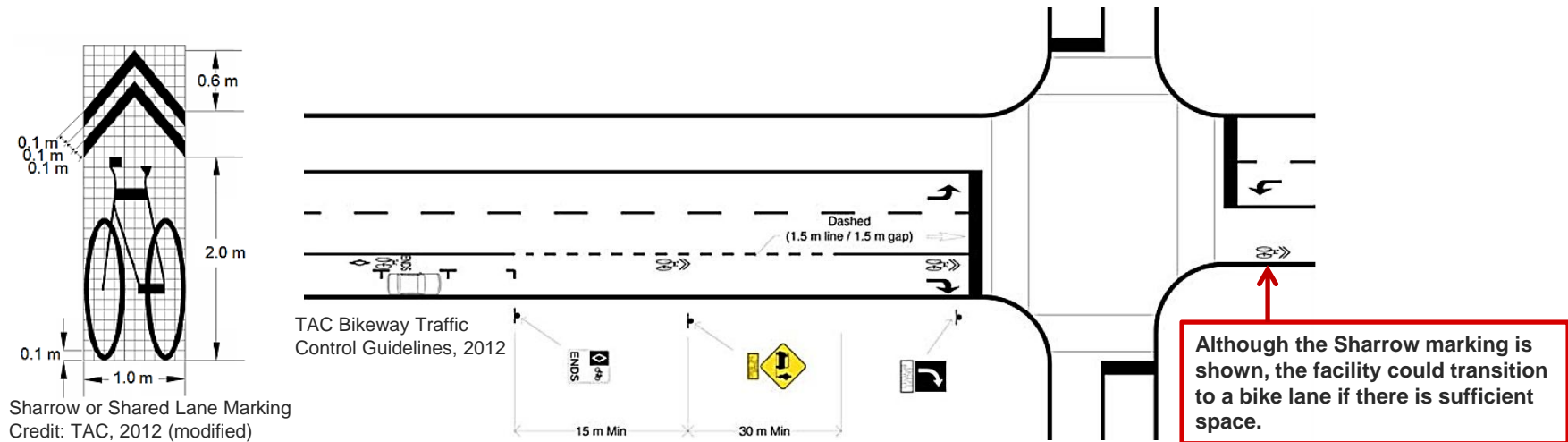


Credit: City of Ottawa, 2010 – Laurier Ave, Ottawa

In this conceptual design blue pavement colouring was used. In the final design (right) green was chosen as the preferred colour as this is consistent with current guidelines.

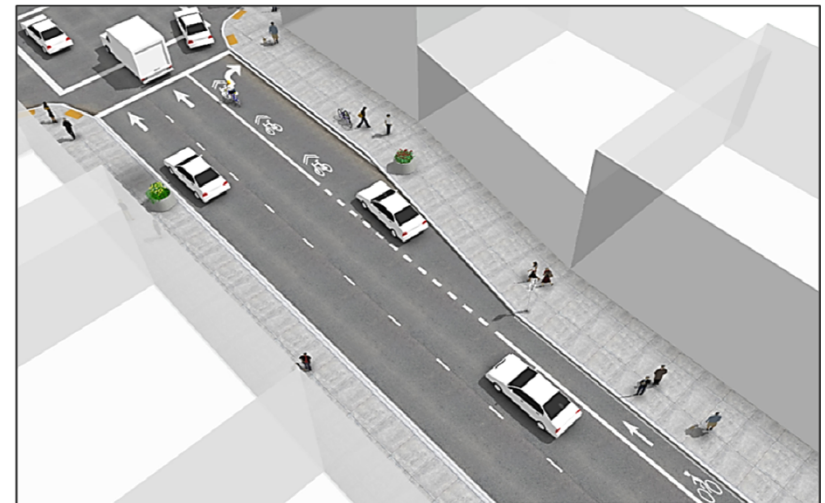


Design Options for Mitigating Right-Turn Conflicts



Combined Bicycle Lane / Right Turn Vehicular Lane

The Combined Bicycle Lane/Right Turn Vehicular lane positions the potential conflict point before the intersection by navigating right-turning motorists to the right side of cyclists at the approach mitigating 'right hook' collisions. Cyclists ride on the left side of the shared use right-turn vehicular lane and proceed through the intersection to connect to the bicycle facility on the opposite side of the intersection.



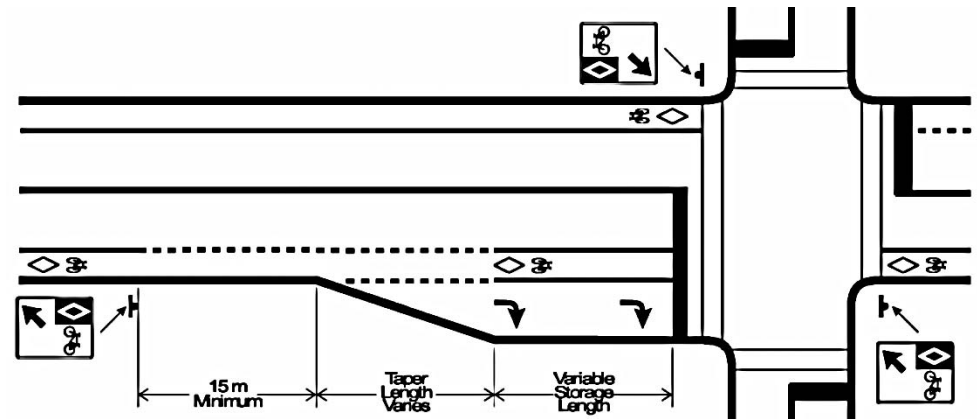
Credit: NACTO, 2011



Design Options for Mitigating Right-Turn Conflicts

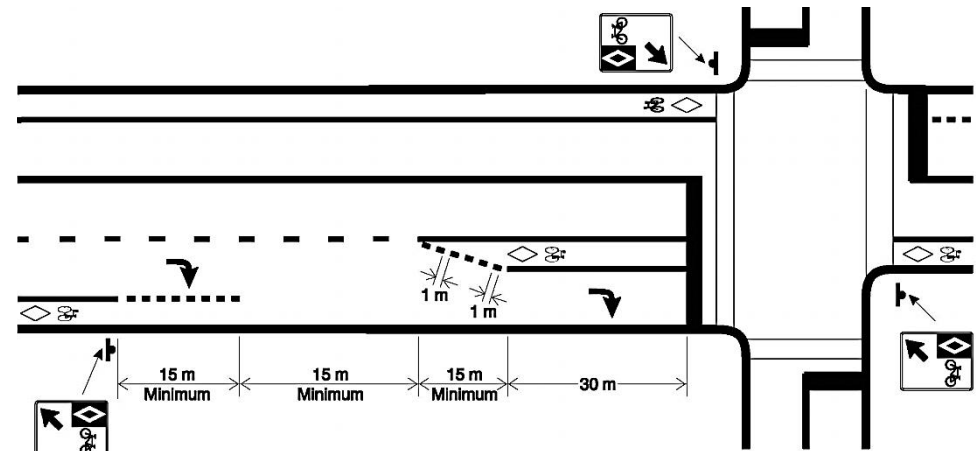
Through Bike Lane with Dedicated Right -Turn Vehicular Lane

The Through Bike Lane positions the potential conflict in advance of the intersection by navigating right-turning motorists to the right side of the bike lane. A solid line delineates the space that is exclusively reserved for cyclists proceeding straight through the intersection.



Bicycle Lane Adjacent to Introduced Right Turn Lane

Credit: TAC Bikeway Traffic Control Guidelines, 2012



Bicycle Lane Adjacent to Curb Lane Transition

Credit: TAC Bikeway Traffic Control Guidelines, 2012



Photo Credit: NACTO, 2011 – Portland, OR



Photo Credit: NACTO, 2011 – Los Angeles, CA



Photo Credit: John Luton, 2006 (Flickr)



Design Options for Mitigating Left-Turn Conflicts

Left Turn Movements

There are two types of left turn movements which can be made by a cyclists at an intersection: the normal left turn and the two-stage movement.

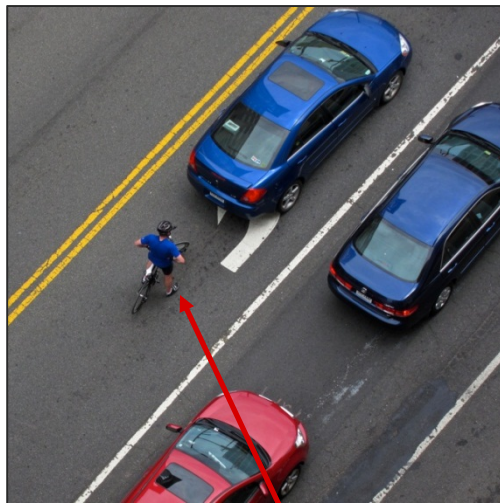


Photo Credit: Robert Mooney, 2011 (Flickr)

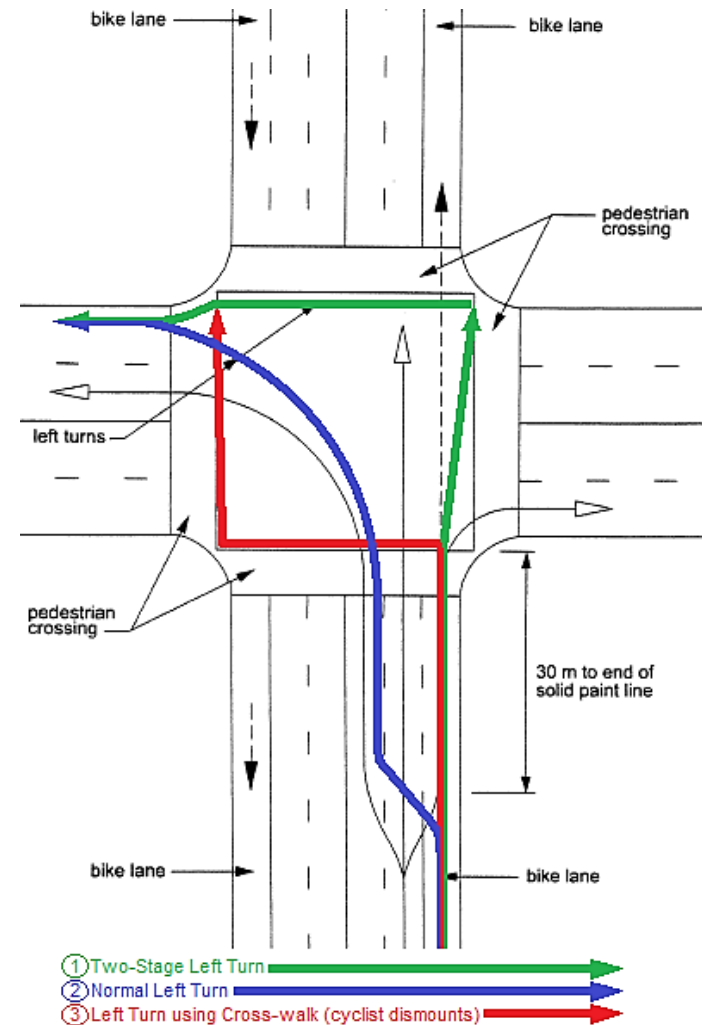
Cyclist making a normal left turn with no bicycle facility present.

Normal Left Turn

The normal left turn movement is where a cyclist follows the path of motorized vehicles to make a left turn movement.

Two-Stage Left Turn Movement

The two-stage left turn movement is where a cyclist follows a path similar to the pedestrian. The cyclist rides through the intersection, waits until the signal turns green for the opposite direction and then rides through the intersection again in a perpendicular direction.



Credit: TAC Geometric Design Guide for Canadian Roads, 1999 (modified)



Designs Option for Mitigating Left-Turn Conflicts



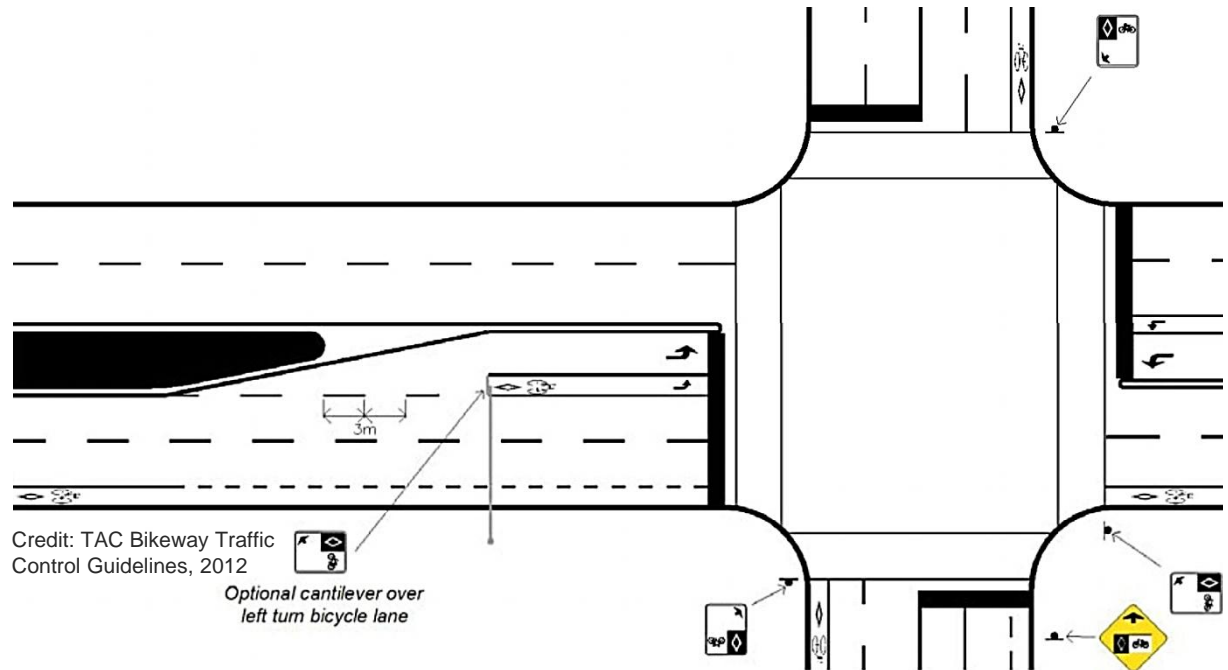
Photo Credit: Hilary Reeves (Bike Walk Twin Cities), 2010



Photo Credit: Eliezer Appleton, 2011 (Flickr)

Exclusive Left Turn Bicycle Lane

Where space is available and there is demand, a separate left turning lane slot should be provided to guide cyclists and motorists during the left turn movement.



Credit: TAC Bikeway Traffic Control Guidelines, 2012

Optional cantilever over left turn bicycle lane



Photo Credit: Frank Chan, 2009 (Flickr) – San Francisco, CA



Photo Credit: John Luton, 2006 (Flickr) - Vancouver, BC



Design Options for Mitigating Left-Turn Conflicts

Bike Box

An extension of a Bike Lane in front of motorists where cyclists are expected to position themselves in the direction that they will be travelling. A Bike Box makes it possible for a large number of cyclists to proceed through the intersection at the same time as well as take advantage of priority left-turn indications. Cyclists are able to safely transition from the right side to the left side of the lane group during a red signal to make a safe left turn ahead of motorists. Coloured pavement can also be used to enhance the visibility of a Bike Box. The Bike Box also mitigates right-turn conflicts as right turns on red are restricted for motorists.



Photo Credit: SFBC Operations, 2010 – San Francisco, CA



Photo Credit: NACTO, 2011 – Victoria, BC

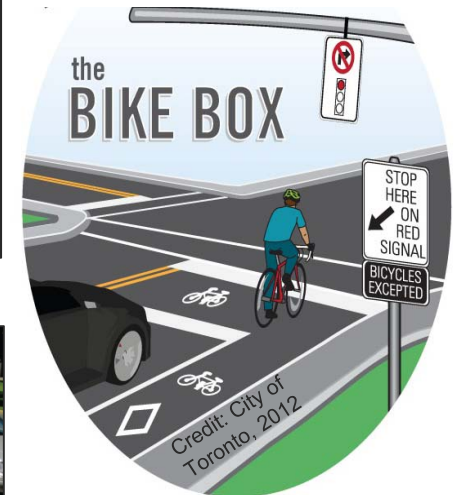
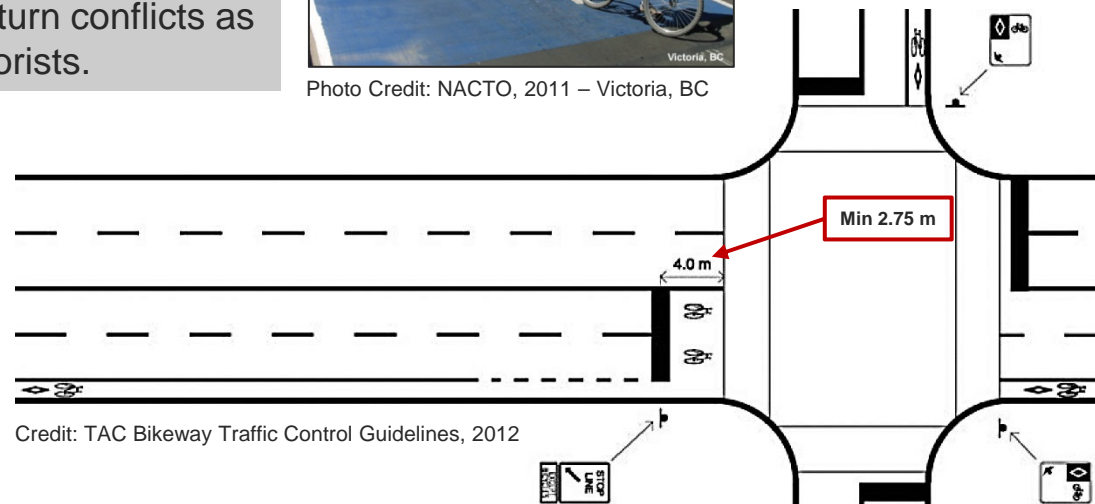


Photo Credit: Jay Cranstone (MMM Group), 2012 – Guelph, ON



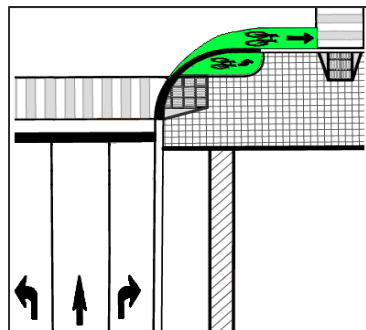
Credit: TAC Bikeway Traffic Control Guidelines, 2012



Design Options for Mitigating Left-Turn Conflicts

Two-Stage Turn Queue Box

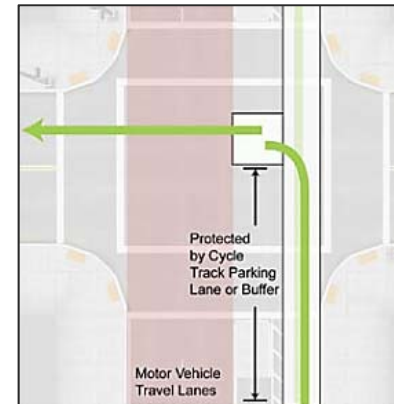
The Two-Stage Turn Queue Box offers cyclists an easier way to make left turns at multi-lane signalized intersections. It provides cyclists with a dedicated space (marked with a curved arrow and bicycle marking) protected by a crosswalk setback or parking lane. Green coloured pavement may be used to enhance the visibility of a Two-Stage Turn Queue Box. Right turns on red are prohibited for typical Two-Stage Turn Queue Box designs. The image on the bottom left shows an example of an innovative Two-Stage Turn Queue Box design which places the dedicated space beside the sidewalk curb cut to allow right turns on red by motorists.



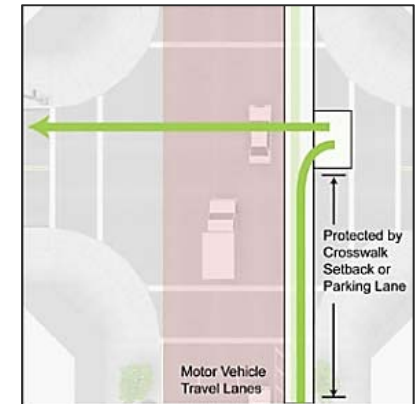
Credit: MMM Group Limited, 2011
Hwy 7 Pilot Solution, Markham



Credit: NACTO, 2010



Credit: NACTO, 2010



Credit: NACTO, 2010



Photo Credit: saltcycle.com, 2011

The Bike Box can be wider where the space is protected by a parking lane on the opposite side of the intersection.



Photo Credit: Flint Trading, 2012 –
Laurier Ave, Ottawa



Design Options for Guiding Cyclists through an Intersection



Photo Credit:
www.overthebarsinmilwaukee.wordpress.com, 2010

Guide Line Markings through an Intersection

Guide line markings that continue through an intersection are useful in guiding cyclists across especially when bicycle lane facilities on either side do not line up. They also alert motorists of the presence of a bikeway. Guide line markings can be coupled with chevrons, sharrows or bike lane pavement markings and can be further enhanced with green coloured pavement.

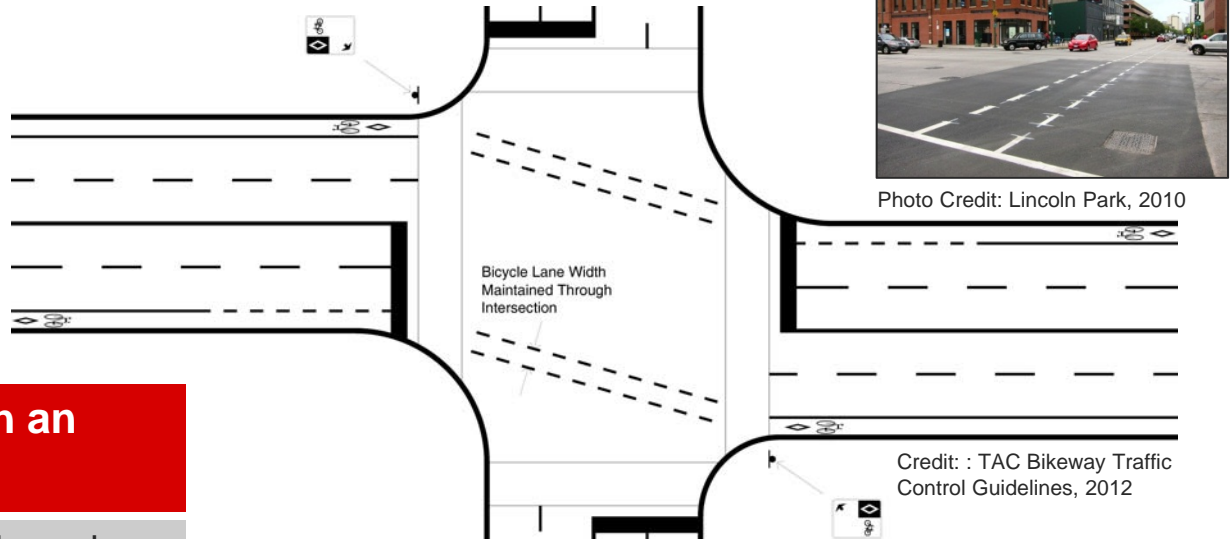


Photo Credit: Lincoln Park, 2010



Photo Credit: Payton Chung, 2011 (Flickr) – New York



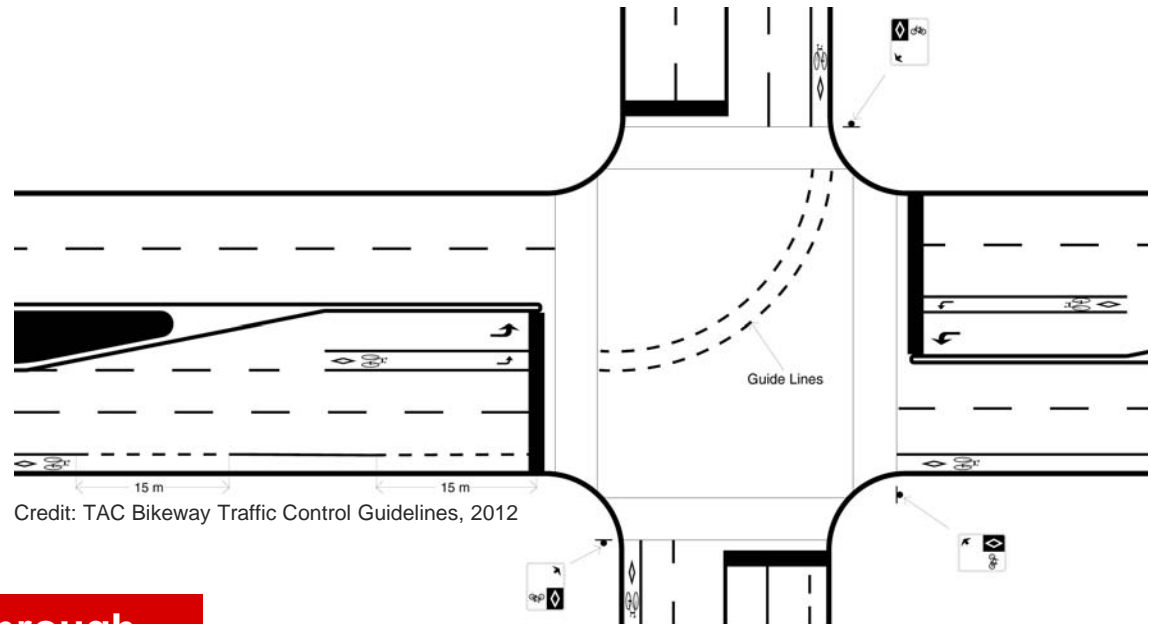
Photo Credit: NACTO, 2010 – Seattle, WA



Design Options for Guiding Cyclists through an Intersection



Photo Credit: Jym Dyer, 2011 - Flickr



Credit: TAC Bikeway Traffic Control Guidelines, 2012

Left-Turn Guide Line Markings through an Intersection

In combination with a separate left turning lane slot, guide line markings through the intersection is an option that provides guidance to motorists and cyclists during the left-turn movement.



Design Options for Mid-Block Pathway Intersections

Mid-Block Pedestrian Signal

The Mid-Block Pedestrian Signal allows cyclists and pedestrians to cross while motor vehicles are stopped. A mid-block pedestrian / pathway crossing of a multi-lane road should be considered only at locations with adequate sight lines and only if the nearest controlled intersection is too far to expect users to travel to it.



Photo Credit: MMM Group, 2012
– Mid-Block Pedestrian Signal without Median Refuge

Multi-use Path Crossing with Median Refuge Island

A protected space in the centre of the road enables allows cyclists pedestrians trying to cross traffic coming from one direction at a time. The median refuge may or may not include a Mid-block Pedestrian Signal. Where a mid block pedestrian signal is not provided the pedestrian crossing pavement markings should not be applied to avoid any confusion regarding right-of-way.

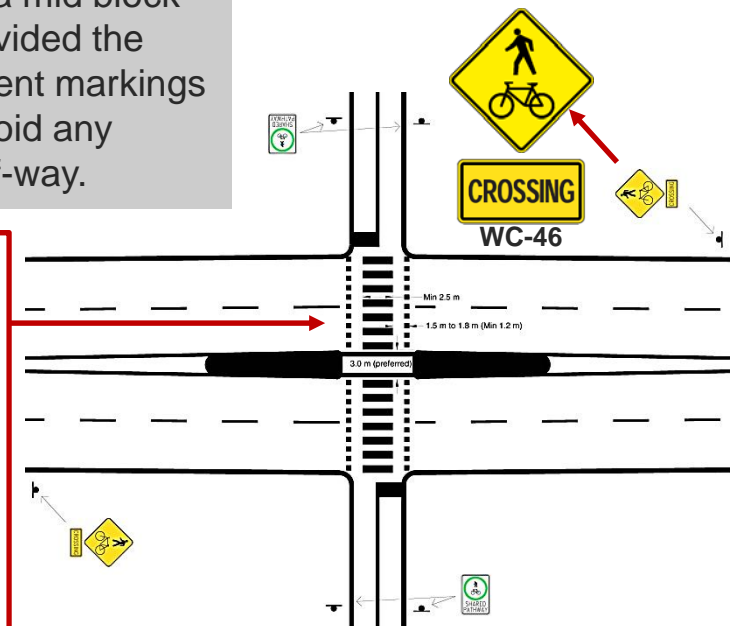


Photo Credit: MMM Group, 2010 – Mid-Block Pedestrian Signal with Median Refuge

OTM Book 15 – Pedestrian Crossing Facilities:

“Pavement markings to delineate pedestrian crossings are not recommended in the design of a refuge island.” Section 3.3.1.2

Also, “marked crosswalks with painted pavement markings are not recommended at uncontrolled crossings as they create a false sense of security on the part of pedestrians...” Section 3.3.1



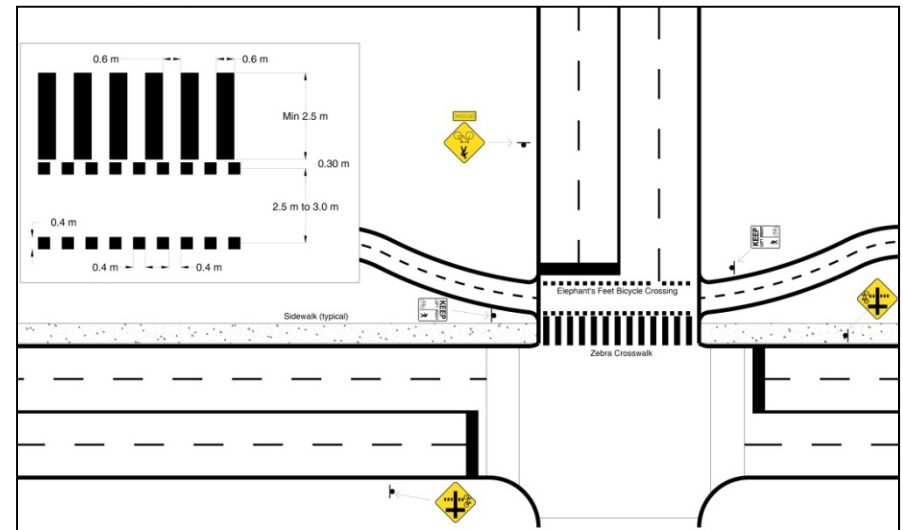
Credit: TAC Bikeway Traffic Control Guidelines, 2012



Design Option for Cross-Ride (Separate Crossing)

Separate Crossings (Cross-rides and Cross-walks)

A cross-ride is a bicycle crossing separate from but adjacent to the pedestrian cross-walk that allows a cyclist to cross the intersection without having to ride with vehicular traffic. Under the current regulations in the Highway Traffic Act (HTA), cyclists are not permitted to ride along or in a crosswalk; they must stop, dismount and walk their bicycle in the cross walk. The figure to the right shows the application of the cross-ride at an unsignalized intersection. The application of the cross-ride at signalized intersections is currently being piloted in Ontario.



Separate Bike Crossing at an Unsignalized Intersection ("Cross-Ride")

Credit: TAC Bikeway Traffic Control Guidelines, 2012



Photo Credits: John Luton, 2008 (Flickr) - Vancouver, BC
(Cycle Track)



Photo Credits: MMM Group, 2011 – City of Mississauga Cross-ride
(Multi-Use Path)



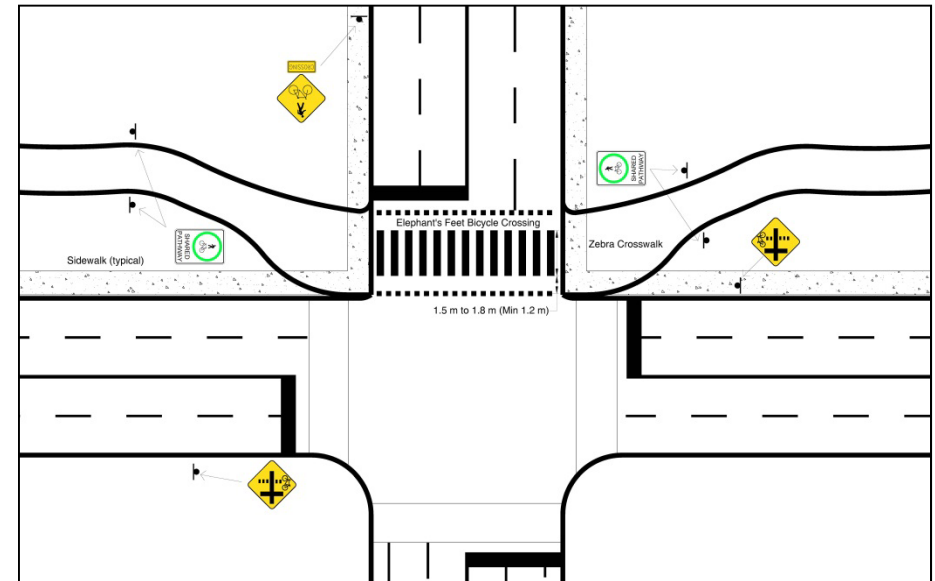
Photo Credits: MMM Group, 2011 – City of Mississauga Cross-ride (Multi-Use Path)



Design Option for Cross-Ride (Combined Crossing)

Combined Crossing

The Combined Crossings combines the pedestrian cross-walk and cross-bike. At unsignalized intersections “Elephant’s Feet” pavement markings are placed on either side of the pedestrian “Zebra” markings permitting both cyclists and pedestrians to use the same space for crossing the intersection. Cyclists are permitted to ride across combined crossings but must ride on between the “Elephant’s Feet” markings and the “Zebra” markings that define the pedestrian crossing.



Combined Multi-use Trail Crossing at an **Unsignalized** Intersection
Credit: TAC Bikeway Traffic Control Guidelines, 2012



Design Option for Integrating Cyclists at Roundabouts

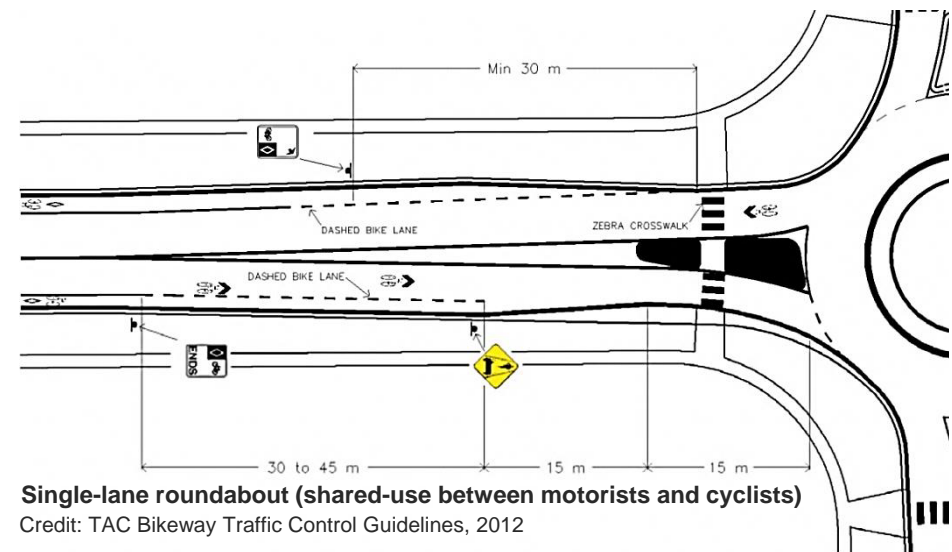
Cycling Facilities and Roundabouts

Roundabouts are increasing in popularity as an alternative to traditional intersection designs as they are considered to be safer because left-turn conflicts between users are eliminated since all users are directed to travel in the same counter-clockwise direction.

At single-lane roundabouts cyclists are expected to ride along with motorists. At multi-lane roundabouts if no cycling facilities are included in the design, cyclists may either ride with vehicular traffic or use the sidewalk and cross the road as a pedestrian. Alternatively, a multi-use Active Transportation path by-pass can be included in the design to accommodate cyclists at multi-lane roundabouts.

Bicycle Lane Approaching a Single Lane Roundabout

Cyclists are expected to ride along with motorists in a single lane roundabout if they choose not to dismount and proceed as a pedestrian. "Single-lane roundabouts can provide significant safety benefits for bicyclists...[as they] are much simpler for bicyclists than multi-lane roundabouts, since they do not require a bicyclist to change lanes, and motorists are less likely to cut off bicyclists when they exit the roundabout" (AASHTO, 2010).





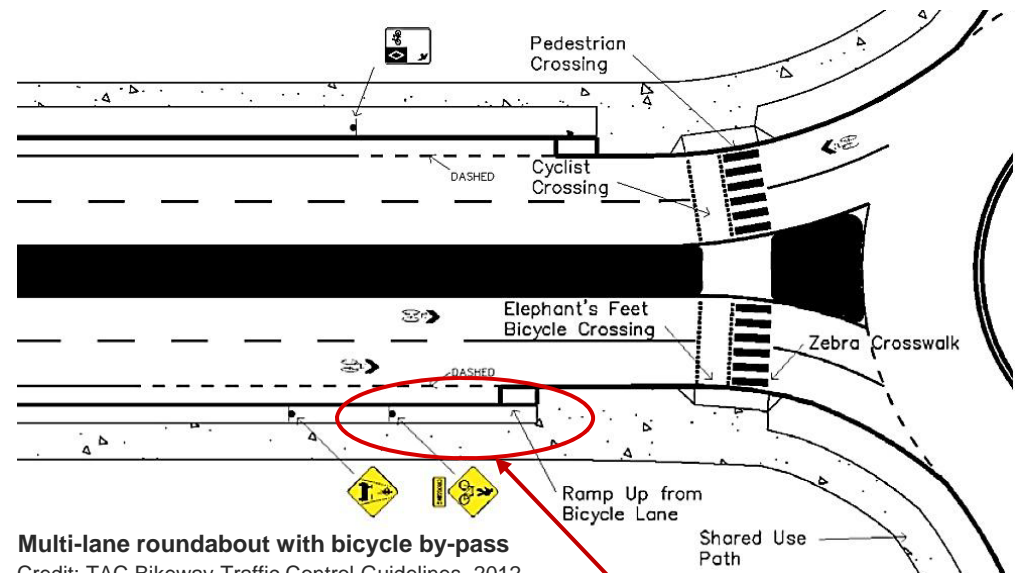
Design Option for Integrating Cyclists at Roundabouts

Bicycle Lane Approaching a Multi-Lane Roundabout

At multi-lane roundabouts with a bicycle by-pass cyclists can either ride with vehicular traffic or use the shared use path to by-pass the multi-lane roundabout.



Credit: Google Earth, 2012 – Highview Drive and Ira Needles Blvd, Waterloo



Credit: Google Earth, 2012 – Highview Drive and Ira Needles Blvd, Waterloo

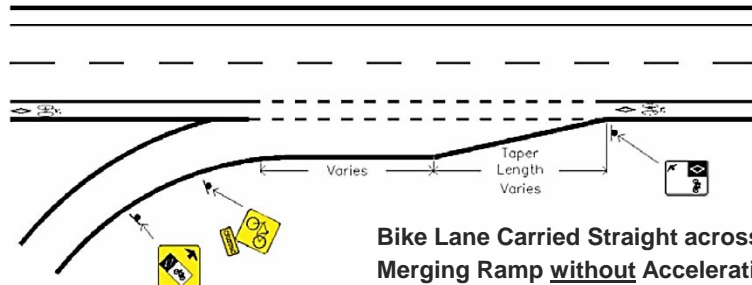


TAC Design Options for Highway Ramp Crossings

Ramp Crossings

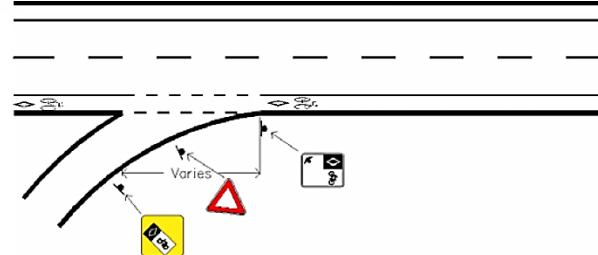
Bicycle lanes should be carried straight across the ramp using a white, dashed line pavement marking at low speed merging/diverging ramps. However, at high speed merging/diverging ramps, the crossing should be placed further up the ramp. Conflict zones can be enhanced through the application of green coloured pavement or more frequent pavement markings (i.e. sharrow markings).

Bike Lane Carried Straight across Low-Speed Merging Ramp with Acceleration Lane

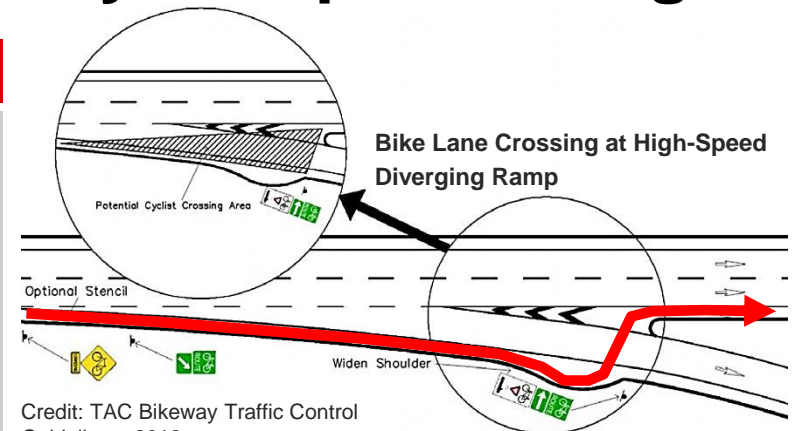


Credit: TAC Bikeway Traffic Control Guidelines, 2012

Bike Lane Carried Straight across Low-Speed Merging Ramp without Acceleration Lane

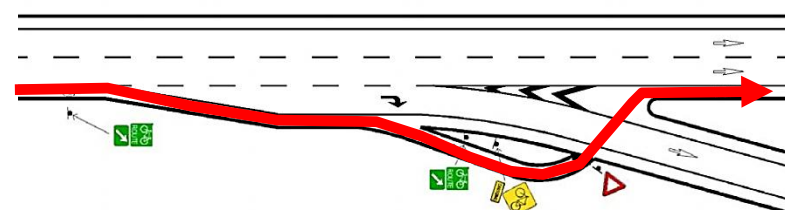


Credit: TAC Bikeway Traffic Control Guidelines, 2012



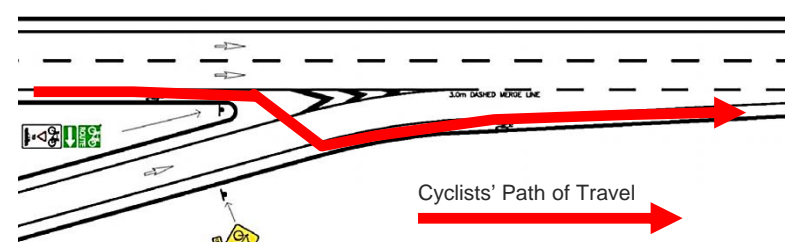
Credit: TAC Bikeway Traffic Control Guidelines, 2012

Bike Lane “Jug Handle” Crossing at High-Speed Diverging Ramp



Credit: TAC Bikeway Traffic Control Guidelines, 2012

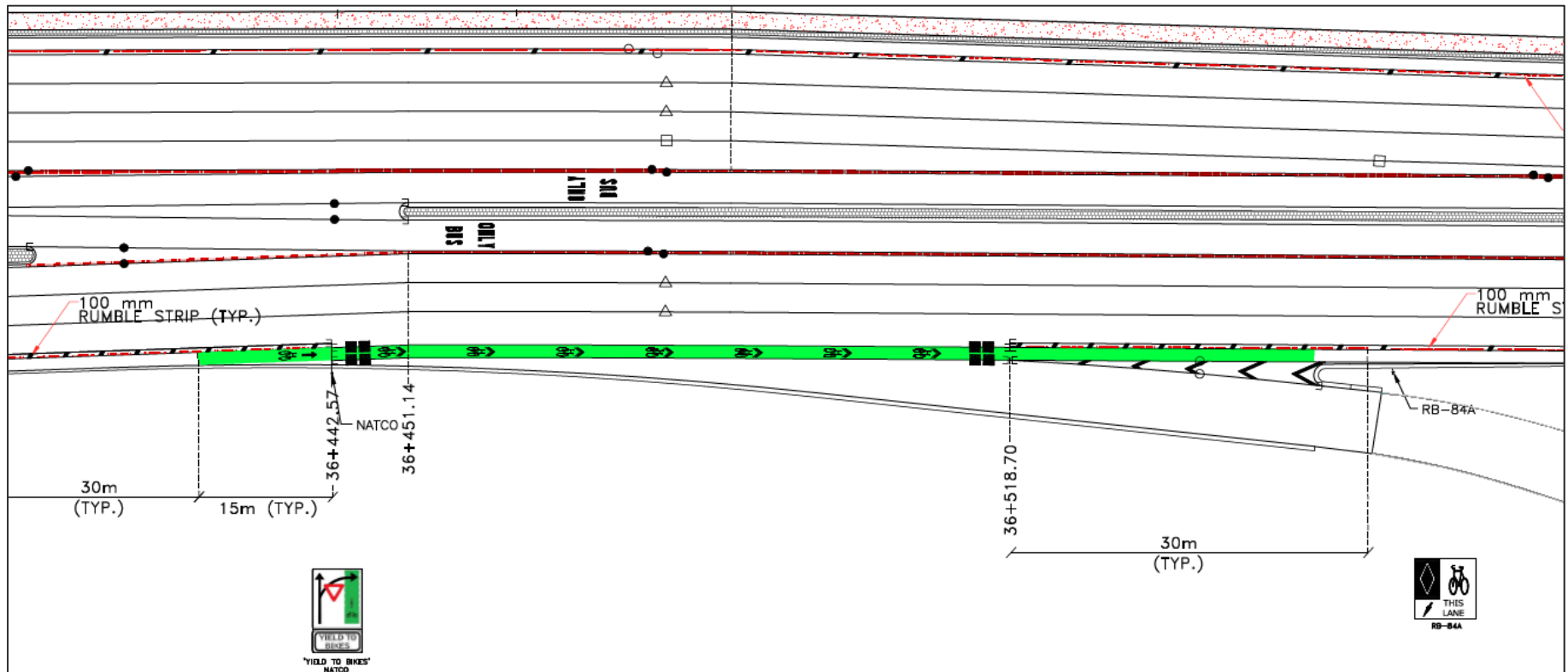
Bike Lane Crossing at High-Speed Merging Ramp



Credit: TAC Bikeway Traffic Control Guidelines, 2012



Highway Ramp Crossing Enhanced Design Solution



Highway 404/ Highway 7 Pilot Solution –
Buffered Bike Lane Design Concept
Location: Southbound on-ramp from
Hwy. 7 to Hwy. 404
Credit: MMM Group, 2011

Enhanced Ramp Crossings

This example includes a separated (buffered bike lane), green coloured pavement markings and “sharrows” to enhance the design for an on-ramp as part of the the Hwy 404 / Hwy 7 Pilot Solution here in York Region.



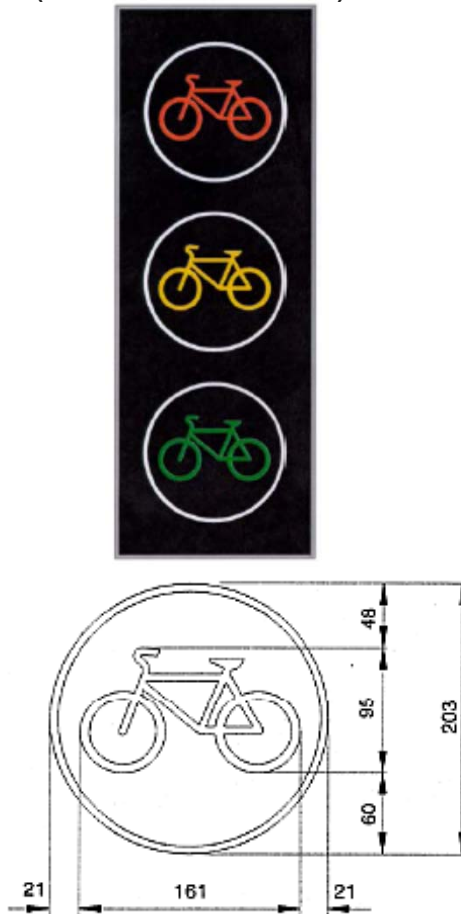
Traffic Signals for Cyclists

Traffic Signals for Cyclists

Generally, signal timings are governed by the pedestrian as this provides more than enough time to cross the intersection. However, in some cases it may be appropriate to provide cyclists with an exclusive signal phase.

The 2004 TAC Traffic Signal Guidelines for Bicycles (still to be adopted by TAC/MTO) recommends the adoption of the Quebec standard bike signal head as an appropriate traffic signal for this purpose. It is anticipated that this standard bike signal head will be endorsed in the near future.

Quebec Signal Head Design Details
(dimensions in millimetres)



Credit: Government du Quebec Standard Signal Head



Credit: Bicycle Federation of Wisconsin, 2010 – Bicycle Signal Head, NYC



Credit: NACTO, 2011 – Portland, OR

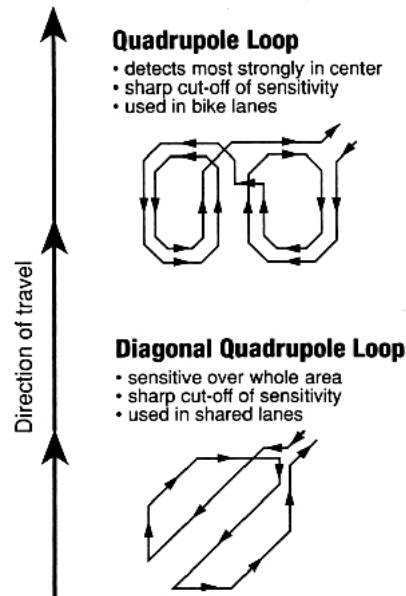


Signal Detection at Intersections for Cyclists

Signal Detection for Cyclists

The Quadrupole Detector Loop is the most appropriate at intersections with bike lanes because they are bicycle-sensitive over their entire area.

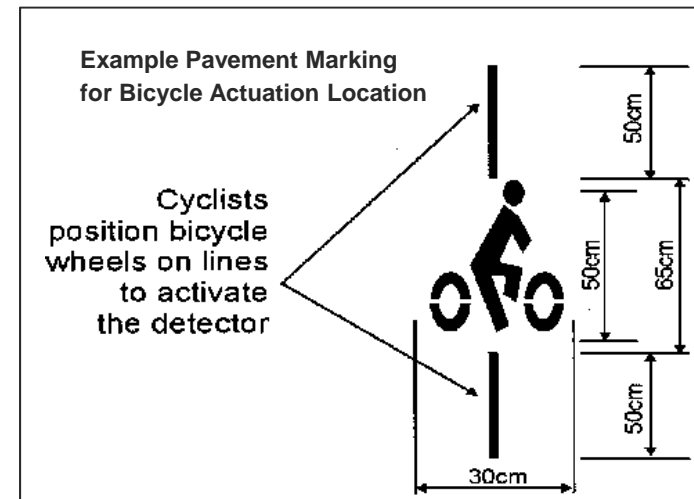
It is important to ensure that the detector loop is adjusted to be too sensitive as it may detect motor vehicles in adjacent lanes.



Credit: Traffic Signal Bicycle Detection Study, City of San Diego, 1985



Credit: TAC, 2009 – Bicycle Stencil Sign ID-20R



Credit: City of Nanaimo Bicycle Facility Design Guidelines, 2001 and TAC 2004



Credit: NACTO, 2011 – San Luis Obispo, CA



Credit: NACTO, 2011 – Portland, OR



Summary

The **Guideline Tool Box for Intersections** supplements the Town's Bicycle Facility Selection Guide. Facility design at intersections should be based on an analysis and understanding of the characteristics of a specific intersection and application of good engineering judgement. There is no "formula" or template that can be universally applied, and designs are evolving.

When designing an intersection for the integration of cyclists the main **goals** should be to:

- Increase roadway user safety by mitigating conflict points;
- Increase visibility for cyclists, motorists and other roadway users;
- Designate and clearly mark travel paths;
- Minimize complex manoeuvres for cyclists; and
- Facilitate awareness and understanding between competing modes of transportation.