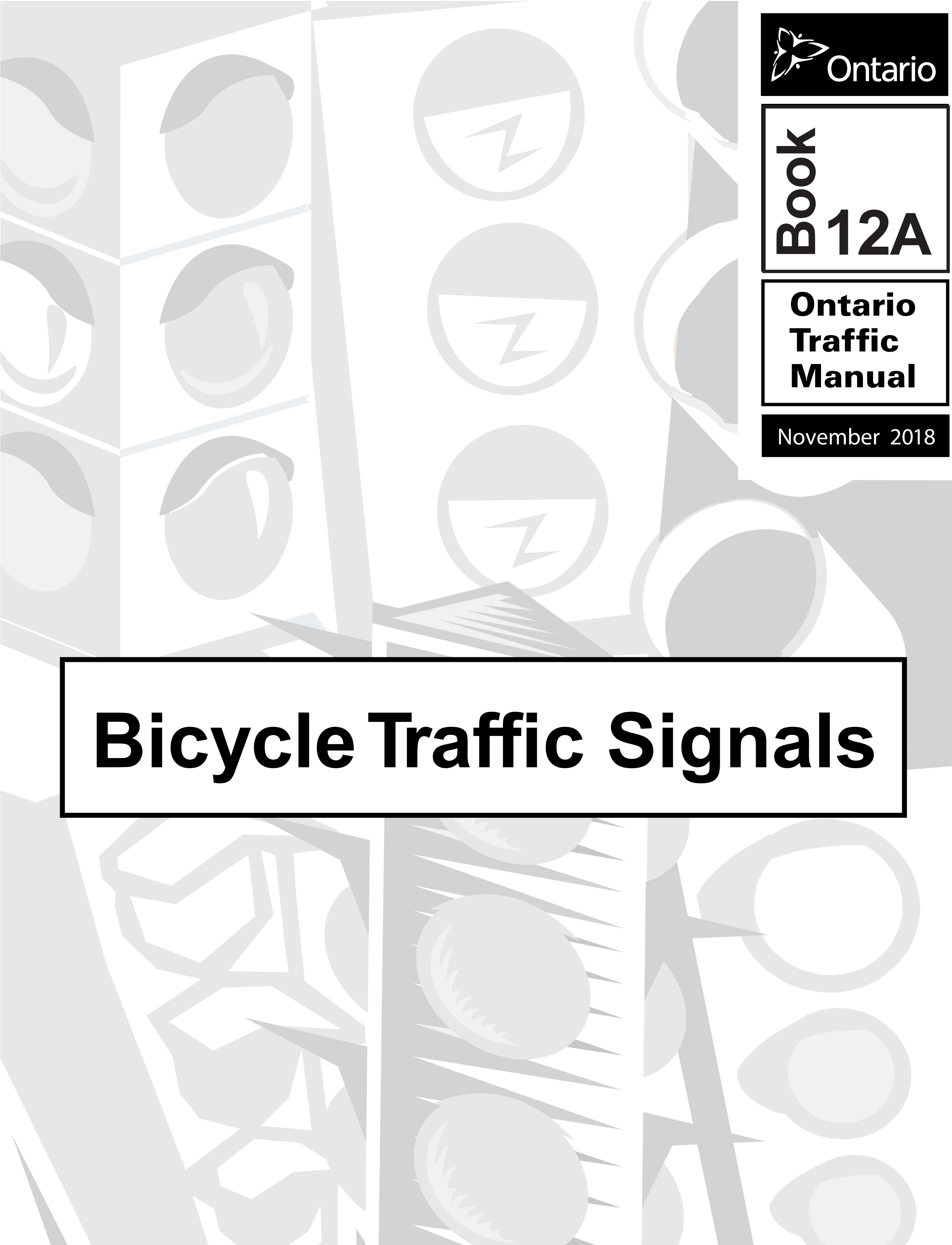

Ontario

Book 12A

Ontario Traffic Manual

November 2018

Bicycle Traffic Signals

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Ontario Traffic Manual

Foreword

The purpose of the Ontario Traffic Manual (OTM) is to provide information and guidance for transportation practitioners and to promote uniformity of treatment in the design, application and operation of traffic control devices and systems across Ontario. The objective is safe driving behaviour, achieved by a predictable roadway environment through the consistent, appropriate application of traffic control devices. Further purposes of the OTM are to provide a set of guidelines consistent with the intent of the Highway Traffic Act and to provide a basis for road authorities to generate or update their own guidelines and standards.

The OTM is made up of a number of Books, which have been generated over a period of time and for which a process of continuous updating is planned. Through the updating process, it is proposed that the OTM will become more comprehensive and representative by including many traffic control devices and applications specific to municipal use. Some of the Books of the OTM are new, while others incorporate updated material from the Ontario Manual of Uniform Traffic Control Devices (MUTCD) and the King's Highway Guide Signing Policy Manual (KHGSPM).

The OTM incorporates current best practices in the Province of Ontario, and the Manual's primary users are traffic practitioners. The interpretations, recommendations and guidelines in the OTM are intended to provide an understanding of traffic operations and they cover a broad range of traffic situations encountered in practice. The interpretations and guidelines are based on many factors which may determine the specific design and operational effectiveness of traffic control systems. However, no manual can cover all contingencies or all cases encountered in the field. Therefore, field experience and knowledge of application are essential in deciding what to do in the absence of specific direction from the Manual itself and in overriding any recommendations in this Manual.

The traffic practitioner's fundamental responsibility is to exercise engineering judgement and experience on technical matters in the best interests of the public and workers. Guidelines are provided in the OTM to assist in making those judgements, but the guidelines should not be used as a substitute for judgement.

Design, application and operational guidelines and procedures should be used with judicious care and proper consideration of the prevailing circumstances. In some designs, applications, or operational features, the traffic practitioner's judgement is to meet or exceed a guideline while in others, a guideline might not be met for sound reasons, such as space availability, yet still produce a design or operation which may be judged to be safe. Every effort should be made to stay as close to the guidelines as possible in situations like these, and to document reasons for departures from them.

Custodial Office

Inquiries, suggestions or comments regarding the Ontario Traffic Manual may be directed to:

Ministry of Transportation, Ontario
Traffic Office
301 St. Paul Street, 2nd Floor South
St. Catharines, Ontario
L2R 7R4
Phone: (905) 704-2960
Fax: (905) 704-2888
e-mail: otm@mto.gov.on.ca

Consulting Team Members:

Alireza Hadayeghi, CIMA+

Brian Applebee, CIMA+

Hart Solomon, CIMA+

MTO Technical Advisory Committee Members:

Roger De Gannes, Ministry of Transportation

Ousama Shebeeb, Ministry of Transportation

Desktop Publishing:

JLM Studio

Hope and Hoppen Design + Communications
hopeandhoppen.com

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1. General Information

1.1 Introduction

Ontario Traffic Manual (OTM), Book 12 – Traffic Signals contains information about all aspects of traffic signal operation. Book 12 currently contains several references to bicycles at signalized intersections. However, the existing manual contains only limited information, guidance and direction with regard to the use of traffic signals or special signal phasing for bicycles.

This document is intended as a companion to OTM, Book 12 and therefore is to be used in conjunction with Book 12. Unless otherwise specifically stated, all of the information and guidance contained in Book 12, particularly that contained in Section 1 of the Book, is deemed to apply to this volume. This guide is also intended to be used in conjunction with OTM, Book 18[6] – Cycling Facilities and in conjunction with OTM, Book 15 – Pedestrian Crossing Facilities.

The purpose of OTM, Book 12A – Bicycle Traffic Signals is to provide practical guidance and application information on the planning, design and operation of intersections under traffic signal control through which bicycle traffic operates and to promote uniformity of approaches across Ontario. The set of guidelines provided within this manual are consistent with the intent of the Highway Traffic Act (HTA)[1] with respect to cycling and traffic signal operation and provide a basis for road authorities to generate or update their own guidelines and standards. OTM, Book 12A – Bicycle Traffic Signals includes consolidated references to relevant material that is provided in other OTM Books as applicable to cyclist and traffic signal treatments. For newly established practices, Book 12A will supersede the Manual of Uniform Traffic Control Devices (MUTCD) for Ontario, and update previously released OTM Books. A complete listing of the planned and currently available OTM volumes is found in Book 1. A new edition of Book 1 will be produced to coincide with the production of each new Book or Books in the OTM. This is necessary in order to have a master table of contents and indexes which are up-to-date at any given time. Book 1 should be read prior to the use and application of any of the other Books in the OTM. The use of any of the devices and applications discussed in those Books should be considered in conjunction with the contents of other related OTM Books as appropriate.

The OTM incorporates current best practices in Ontario. The guidelines are intended to provide an understanding of traffic operations and they cover a broad range of traffic situations encountered in practice. They are based on many factors which may determine the specific design and operational effectiveness of traffic control systems. However, no manual can cover all contingencies or all cases encountered in the field. Therefore, field experience, knowledge of application and engineering judgement are essential in deciding what to do in the absence of specific direction from the Manual itself or in overriding any recommendations in the Manual. Similarly, municipalities may need to adopt policies that reflect local conditions.

The traffic practitioner's fundamental responsibility is to exercise engineering judgment on technical matters in the best interests of the public and workers. Guidelines are provided in the OTM to supplement professional experience and assist in making those judgments.

This manual also refers to various publications produced by the Ministry of Transportation Ontario (MTO) and other agencies such as the Institute of Transportation Engineers (ITE), the Transportation Association of Canada (TAC) and the Ontario Traffic Council (OTC).

1.2 Relationship with OTM, Book 12

Except in very specific instances, information contained in OTM, Book 12 will not be reproduced in this guide. The practitioner is reminded to ensure that appropriate reference to OTM, Book 12 is made when considering new or revised signal installations.

OTM, Book 12 currently contains a reference to bicycle signals in section 2.5, Proposed Future Legislated Items. At the time of publication of Book 12 in 2012, traffic signal heads with bicycle outlines were contained in the Manual of Uniform Traffic Control Devices for Canada and were in use in several provinces. They were not, at that time, recognized for use in Ontario. With the passage of Bill 31 and associated regulations, these signal heads may be used in Ontario starting in 2017 and specific regulations regarding their use have been established.

In section 3.10 of Book 12, there is information about bicycle signal indications, timing and phasing. This guide will reproduce and elaborate on that information.

1.3 Relationship with OTM, Book 18

OTM ,Book 18 provides information about bicycle facilities. Book 18 provides detailed information about signage and pavement markings near signalized crossings in section 5.8. This guide provides detailed operational information about signal displays, timing, phasing and detection. Therefore, this guide and Book 18 are companion guides and are to be used together when necessary.

1.4 Sections of This Book

This manual is organized in the following order:

- **Section 1, General Information** — this section provides the general introduction about the OTM Books including this manual and an introduction on the specific use of terms when reading this book.
- **Section 2, Legal Framework** — this section outlines the relevant legal requirements and interpretations as they pertain to cycling and traffic signal operation, specifically the HTA Regulations about the use of the bicycle signal head, the interpretation of careless driving as it pertains to cyclist right-of-way, yielding to traffic in signalized intersections, obeying traffic control signals, riding in or beside crosswalks and traffic control signal operation. The authority of municipalities under the Municipal Act to make decisions affecting the operation of traffic signals used by cyclists is also discussed.
- **Section 3, Traffic Signal Timing** — this section provides information about minimum green, amber and red clearance signal timings and how these may be altered to serve cyclists. This is based on the understanding that cyclists are vehicles, but with different performance characteristics and needs.
- **Section 4, Bicycle-Specific Signal Displays** — this section provides Information on the options available for signal displays specific to cyclists and how to best differentiate these from motor vehicle signal heads, in terms of placement, size, shape and colour.
- **Section 5, Bicycle Signal Phasing** — this section outlines the typical types of special phasing which may be used to manage bicycle traffic at a signalized crossing. Included are configurations for intersection and mid-block locations. Operational options include a range

of phasings from no special bicycle control up to bicycle-exclusive phasing. Special discussions include Intersection Pedestrian Signals and contraflow locations.

- **Section 6, Decision Criteria** — this section provides a range of criteria which may suggest when the use of bicycle-specific signals and phasing may be appropriate or beneficial. Criteria include traffic volumes/delay, collisions/conflicts, planning, geometric, signal timing/phasing or demographic/geographic.
- **Section 7, Bicycle Detection** — this section highlights the different types of detectors that can be employed to specifically detect the presence of bicycles and the required signing and pavement markings to accompany the detection equipment.

1.5 Use of Terms in This Book

In Ontario, many aspects of traffic control devices are specified in law (for example, the meaning of specific signal indications or traffic signs). Others are based on standards intended to establish consistency throughout the province, while some other aspects are founded on recommendations established through experience. In this publication, specific terms are adopted to convey intended differences in meaning. These terms and the corresponding meanings are as follows:

- **"Legal Requirement(s)", "Legally Required", "Legal"** and equivalent terms mean that the requirement is the law of Ontario as established under the HTA[1] and its Regulations, or Accessibility for Ontarians with Disabilities Act (AODA), 2005[2] and its Regulations, or is a legal requirement under municipal by-laws. The requirement is typically described by the use of "shall" or "must".
- **"Must"** or "Shall" indicates that the requirements of the design or application of the device as described in this manual are mandatory. Some of the requirements that are necessary in principle for the safe operation of bicycle facilities are considered mandatory. They are also described in this manual by the use of "Shall" or "Must" for providing uniformity across the province, although not legally required. The term "required" used in this manual in tables of components is associated with the mandatory requirement.
- **"Interpretation"** means the interpretations and emphasis of the legal requirements. The interpretations are not necessarily the precise wording of the Acts[1] and Regulations. Interpretations are given in lay language and may include some industry jargon. The requirement is typically described by the use of "shall". "**Shall**" means the same as "must".
- **"Recommended Practice"** suggests a consistent manner in which the legal requirements and interpretations are applied using the typical procedures and equipment in use in Ontario. The recommended practices are not necessarily the only practices available based on the interpretation of the legal requirements or the selection of equipment or methods of operation. The recommendation is typically described by the use of "should". **"Should"** indicates that the action is advised; recommended but not mandatory. This term is meant to suggest good practice in most situations, but also to recognize that in some situations, for good reasons, the recommended action cannot or need not be followed. The term "desired" or "desirable" used in this manual is associated with the recommended practice and is used for components or practices that may improve the overall performance of the treatment system; however, they are not mandatory.

- **"Guideline"** suggests a method of practical application of the legal requirements and interpretations using the typical procedures, equipment and methods of operation in use in Ontario. The guidelines are meant to provide guidance to those road authorities that may be unsure of the methods of application. A guideline has no legal connotation and several alternate methods of achieving the same result may be available. A guideline is typically described by the use of "may". **"May"** indicates a permissive condition. No requirement for design or application is intended. The term "optional" used in this manual indicates a permissive condition and is used for components and practices that may be required under certain situations or may have potential to further improve the effectiveness of a treatment system.

Symbols used on layout drawings may be found in Ontario Provincial Standard Specifications Volume 4, Electrical Drawings, Division 2000[3].

1.6 Functions of Traffic Control Signals

The function of a traffic control signal is to alternate the right-of-way between conflicting streams of vehicular traffic, or vehicular traffic and pedestrians crossing a roadway, with maximum safety and efficiency. Safety requires that the traffic control signals operate at the minimum hazard to all road users, including motor vehicle occupants, cyclists and pedestrians. Practitioners should consider both safety and efficiency when identifying elements of design or selecting operational practices. In some cases, decisions can result in a benefit to both safety and efficiency (such as properly timed clearance intervals). In other cases, greater efficiency may result in a reduction in safety and vice versa.

Practitioners should also consider provincial and/or municipal policy objectives in their decision-making. For example, a bicycle-specific phase may reduce collision frequencies, but increase delays.

2. Legislative Framework

2.1 General

This section provides an overview of various sections of the Highway Traffic Act (HTA) and regulations under that act, associated with traffic control signal systems, traffic control signals, bicycle signals and bicycle movements. The current HTA sections and regulation which are relevant include:

- Section 1 – Interpretation;
- Section 130 – Careless Driving;
- Section 144 – Traffic Signals;
- Section 195 – Effect of by-laws; and
- Regulation 626 – Traffic Signal Heads.

As well, portions of the Municipal Act may be found useful in some circumstances. Those are detailed in this section as well.

2.2 Definitions

This document refers to various terms and relies on their definitions as provided in the HTA. Specific terms defined in the HTA and used in this document are:

- "bicycle" includes a tricycle, a unicycle and a power-assisted bicycle but does not include a motor-assisted bicycle; ("bicyclette");
- "vehicle" includes a *bicycle* (emphasis added) and any vehicle drawn, propelled or driven by any kind of power, including muscular power;
- "traffic control signal system" means the entire signalized intersection, which includes all electrical components, signage and pavement markings. The system also includes the "traffic control signals", which are the actual traffic signal heads.

2.3 Existing Relevant HTA Regulations

2.3.1 HTA Section 130 Careless Driving

1. Legal Requirements

Every person is guilty of the offence of driving carelessly who drives a vehicle or street car on a highway without due care and attention or without reasonable consideration for other persons using the highway and on conviction is liable to a fine of not less than $400 and not more than $2,000 or to imprisonment for a term of not more than six months, or to both, and in addition his or her licence or permit may be suspended for a period of not more than two years.

2. Interpretation

Anyone operating a vehicle must take due care and attention to ensure that they do not endanger the safety of other roadway users.

3. Specific Applicability

Drivers and cyclists within an intersection or on a road section must ensure that they take specific action to ensure the safety of all other road users, including pedestrians.

2.3.2 HTA Section 133 Traffic Control Signals

1. Legal Requirements

"indication" means a signal lens display that is activated by internal illumination; ("indication").

"traffic control signal" means that part of a traffic control signal system that consists of one set of no less than three coloured lenses, red, amber and green, mounted on a frame and commonly referred to as a signal head; ("signalisation de la circulation") and includes a bicycle traffic control signal.

"traffic control signal system" means all of the signal equipment making up the installation at any location. ("système de panneaux de signalisation") R.S.O. 1990, c. H.8, s. 133; 1994, c. 27, s. 138 (11).

"bicycle traffic control signal" means a traffic control signal where the coloured lenses each display a prescribed bicycle symbol; ("signalisation de la circulation pour bicyclettes")

2. Interpretation

Bicycle symbol signal heads are permitted for use on Ontario roads, subject to Regulation 626.

3. Specific Applicability

The design of the symbols is defined in Regulation 626 (as authorized by HTA 144 (32) (e), and is the same as the symbol used in the Manual of Uniform Traffic Control Devices for Canada.

2.3.3 HTA Subsection 144 (8) Yielding to Traffic

1. Legal Requirements

When under this section a driver is permitted to proceed, he or she shall yield the right of way to traffic lawfully using an intersection or, where traffic control signals are erected where a private road or driveway meets a highway, lawfully using the area controlled by the traffic control signals.

2. Interpretation

Any road user facing a green signal indication must first yield the right-of-way to other users lawfully using an intersection, such as may have entered on a previous signal phase or during the signal clearance period.

This also implies that right- or left-turning vehicles must yield to oncoming bicycles travelling straight ahead.

3. Specific Applicability

A motorist must yield the right-of-way to any cyclist that may be within the confines of an intersection during the red signal indication who first legally entered it during the green or amber indications.

Turning vehicles must yield to straight through bicycles, such as parallel movements with a bike lane/bike track. Straight through motor vehicles must yield to bicycles that have been released earlier, such as from a bike box, or leading bicycle phase.

2.3.4 HTA Subsection 144(10) Obeying Lane Lights

1. Legal Requirements

Every driver shall obey every traffic control signal that applies to the lane that he or she is in and, for greater certainty, where both a traffic control signal that is not a bicycle traffic control signal and a bicycle traffic control signal apply to the same lane,

(a) a person riding or operating a bicycle in that lane shall obey the bicycle traffic control signal; and

(b) a person driving a vehicle other than a bicycle in that lane shall obey the traffic control signal that is not a bicycle traffic control signal.

2. Interpretation

Traffic signal indications may be configured to be given specific displays for individual or specific lanes. Where there are signals for specific users, the cyclists and general purpose traffic drivers must obey the signals that are specific to their movements.

3. Recommended Practice

Bicycle-specific traffic signals may be used to give direction to designated bicycle lanes, cycle tracks, bicycle paths or multi-use trails and to specific movements for different types of vehicles.

2.3.5 HTA Subsection 144(29) Riding in Crosswalks Prohibited

1. Legal Requirements

No person shall ride a bicycle across a roadway within a crosswalk at an intersection or at a location other than an intersection which location is controlled by a traffic control signal system.

2. Interpretation

Riding a bicycle in the crosswalk at a full traffic signal or an intersection pedestrian signal is prohibited. Riding beside ("along") a crosswalk is specifically permitted.

3. Recommended Practice

Where a formal bicycle facility merges with a traffic signal, such as at a mid-block signalized path crossing or where a multi-use trail parallel to a sidewalk ("boulevard path") merges at a full signal, one treatment is to erect "Dismount and Walk" signs and require the cyclist to become a pedestrian when using the crosswalk. The alternative is to separate the pedestrian and bicycle crossings by providing separate crosswalk and crossride (described in detail later) areas. In order that this does not leave the bicycles without any form of protected crossing, this suggests the need for a form of traffic control for the bicycles and/or the parallel traffic whenever crossing volumes are significant.

2.3.6 HTA Section 147 Keeping to the Right

1. Legal Requirements

Any vehicle travelling upon a roadway at less than the normal speed of traffic at that time and place shall, where practicable, be driven in the right-hand lane then available for traffic or as close as practicable to the right hand curb or edge of the roadway. R.S.O. 1990, c. H.8, s. 147 (1).

Exception

(2) Subsection (1) does not apply to a driver of a,

(d) bicycle in a lane designated under subsection 153 (2) for travel in the opposite direction of traffic.

2. Interpretation

Contraflow bicycle lanes are specifically recognized and enabled in the HTA.

3. Specific Applicability

Single or bi-directional contraflow bicycle lanes are one option for maintaining good continuity in a bicycle network.

2.3.7 HTA Regulation 626 – Bicycle Signals

1. Legal Requirements

As of January 1, 2017, revisions to Regulation 626 under the Highway Traffic Act come into force. The revised regulation contains the following specific references to bicycle traffic signal heads:

(2.1) Despite subsection (1), a bicycle traffic control signal shall consist of three opaque circular indications, each with a coloured translucent bicycle symbol, arranged vertically from the bottom as follows: green, amber, red O. Reg. 408/15, s. 1 (2).

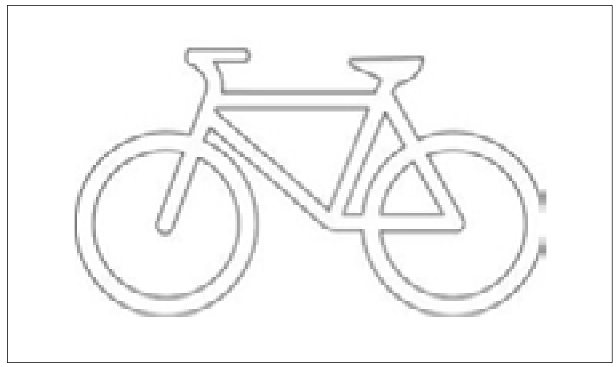
(2.2) A green arrow indication on an opaque circular indication may be used for bicycle traffic control signals and, where it is used, it shall be arranged vertically below the three opaque circular indications described in subsection (2.1). O. Reg. 408/15, s. 1 (2).

(2.3) An amber arrow indication, on the same opaque circular indication that is used for the green arrow indication described in subsection (2.2) or on a separate opaque circular indication, may be used for bicycle traffic control signals and, where a separate opaque circular indication is used, it shall be arranged vertically above the green arrow indication. O. Reg. 408/15, s. 1 (2).

(4.2) A bicycle traffic control signal installed at an intersection shall be located on the far side of the intersection from which vehicles are approaching and an additional bicycle traffic control signal may be located on the near side of the intersection from which vehicles are approaching. O. Reg. 408/15, s. 1 (2).

(5.1) Despite subsection (5), a bicycle traffic control signal, where installed, shall be not less than 2.5 metres above the level of the roadway when adjacent to the travelled portion of the roadway and not less than 4.5 metres above the level of the roadway when suspended over the travelled portion of the roadway. O. Reg. 408/15, s. 1 (2).

(2.4) For the purpose of subsection (2.1), the bicycle symbol shall be as illustrated in the following Figure:



2. Interpretation

i. The bicycle outline symbol may be used in a specific signal head to direct cyclists.
ii. The exact symbol as shown in the Regulation must be used
iii. Green and amber arrows may be used in conjunction with the bicycle signal head to define the bicycle signal head as applying to a specific direction of bicycle travel
iv. A minimum of one bicycle signal is required for each direction
v. At least one bicycle signal shall be far-side, but an additional near-side signal is allowed
vi. Bicycle signals shall be installed a minimum of 4.5m above the travelled roadway or 2.5m clear otherwise.

3. Recommended Practice

Recommended practice for installing and using bicycle traffic signals is discussed in detail in Section 4.

2.4 Bill 130, Respecting the Municipal Act of Ontario

The Municipal Act defines the powers municipalities possess with regard to setting rules and by-laws. These may include by-laws pertaining to signs, markings or bicycle movements.

1. Legal Requirements

Scope of powers

8 (1) The powers of a municipality under this or any other Act shall be interpreted broadly so as to confer broad authority on the municipality to enable the municipality to govern its affairs as it considers appropriate and to enhance the municipality's ability to respond to municipal issues.

Ambiguity

8 (2) In the event of ambiguity in whether or not a municipality has the authority under this or any other Act to pass a by-law or to take any other action, the ambiguity shall be resolved so as to include, rather than exclude, powers the municipality had on the day before this Act came into force.

Scope of by-law making power

8 (3) Without limiting the generality of subsections (1) and (2), a by-law under sections 10 and 11 respecting a matter may,

(a) regulate or prohibit respecting the matter;

(b) require persons to do things respecting the matter;

(c) provide for a system of licences respecting the matter.

Scope of by-laws generally

8 (4) Without limiting the generality of subsections (1), (2) and (3) and except as otherwise provided, a by-law under this Act may be general or specific in its application and may differentiate in any way and on any basis a municipality considers appropriate.

Interpretation

If an action or intent is not expressly discussed in the Municipal Act, 2001, or the Highway Traffic Act, a municipality is free to make decisions and pass by-laws as it deems appropriate.

However, it should be noted that Section 195 of the HTA specifically speaks to conflicts between municipal by-laws and the HTA, stating that the HTA always take precedence by saying:

195(1) If a provision of a municipal by-law passed by the council of a municipality or police services board for,

(a) regulating traffic on highways... is inconsistent with this Act or the regulations, the provision of the by-law shall be deemed to be repealed upon the inconsistency arising. R.S.O. 1990 H.8, s.195(1); 1996, c.33, s.15 (1); 2002, c.17, Sched F, Table.

Recommended Practice

Some aspects of bicycle traffic signals and cyclist actions when directed by bicycle traffic signals are not addressed in the HTA. Location information is specific to the individual sites. Therefore, it appears that municipalities may make decisions, take actions and implement by-laws to:

(a) implement bicycle-specific signal phasing using bicycle symbol traffic signals or standard traffic signals, with appropriate signing;

(b) pass by-laws regulating the movement and behaviour of cyclists under bicycle-specific phasing; (as long as those regulations do not conflict with section 144 of the HTA).

For the above actions, it would be appropriate to have municipal by-laws in place, defining specifically the signs, cyclist responsibilities and penalties for failure to obey the by-laws.

3. Traffic Signal Timing

3.1 General

Specialized bicycle traffic signal timing must fit within the framework of the vehicular and pedestrian signal timing. Most aspects of standard traffic signal timing are unaffected by specialized bicycle timing, but, when required, there are two potential changes which might be implemented specifically for bicycles. These are: modified minimum green interval and revised vehicle intergreen intervals. This section will address these two specific issues.

3.2 Background Information

In order to undertake some of the assessments noted in this section, current information about bicycle volumes and movements are required. If possible, regular turning movement counts as undertaken at signalized intersections should specifically segregate the volume of bicycle traffic by movement. If this is not possible, special counts may have to be undertaken in order to properly evaluate conditions.

In addition, collision assessments may indicate specific issues which might be remedied through the use of bicycle specific signal timing.

3.3 Typical Cycling Operations and Roadway Configurations

The choice of traffic signal operational parameters for bicycles is dependent on the way in which the cycling traffic interacts with general purpose traffic at signalized intersections. A number of different situations are typically found which may suggest changes or special treatments involving the signal timing (Section 3), the signal displays (Section 4) and/or the signal phasing (Section 5). The possible impacts are described in the following sections and summarized in Table 1.

3.3.1 Shared Roadway (includes Signed Routes)

The most basic configuration is bicycle traffic mixed in with motorized traffic without any bicycle-specific lanes or facilities. In this situation, cyclists will respond to the same signal heads, signal timings and traffic control indications at signalized intersections as other traffic. No additional traffic signals for cyclists are used. If required, adjustments to signal timings, typically the minimum green or clearance intervals, may be deemed appropriate or beneficial to cyclists. Such changes will affect motorized vehicle operations, and must be considered in that context.

3.3.2 Bicycle Lane or Cycle Track

When a bicycle facility is immediately adjacent to the curb lane, but operating in a dedicated space, a range of options are available at signalized intersections. The most basic condition is that bicycles operate as if sharing the general purpose lanes with no changes to signal timing, phasing or displays. A slight upgrade would be the addition of bicycle-specific signal displays, but operating on the same phasing and timing as general purpose traffic. As with the shared roadway situation, adjustments to the signal timing may be appropriate in some situations. The most complex situations would provide a partial or complete separation in the operation of the bicycle facility from the parallel vehicular and/or pedestrian traffic, through the use of bicycle-specific signal displays, timing and phasing.

3.3.3 In-Boulevard Bicycle or Multi-Use Trail

When the cycling facility is in the boulevard, typical design for signalized intersections places the trail close to the parallel road or just behind the sidewalk, if one is present, when crossing perpendicular streets and roads. The trail becomes a part of the intersection and usually utilizes the same signal timing as the overall intersection. Options exist as to whether the cyclists will be managed by the pedestrian signals (dismount and walk only), by signing or by the addition of bicycle-specific signal displays, timing and phasing.

3.3.4 Contraflow Bicycle Facility

When a bicycle facility is constructed on a one-way street with bicycles travelling in a direction opposite to general purpose traffic, at a minimum, bicycle-specific signal displays are required at signalized intersections. The need for adjusted signal timing and/or separate bicycle phasing would be based on geometric and safety requirements.

3.3.5 Mid-Block Bicycle or Multi-Use Trail

The intersection of a major roadway and a multi-use or bicycle trail at a mid-block location may require the use of signal control. For a bicycle-only facility, the bicycle traffic will be managed by bicycle signals and the signal timing will be based solely on bicycle needs. For a multi-use trail, pedestrians will also be served by the crossing, and along with separate indications for the two user groups, the timings will be the longer of the two based on the user group needs.

3.4 Factors Affecting the Choice of Parameters

There are a wide range of factors which impact cyclist performance and behaviour. As with vehicular traffic, intersection characteristics such as grade, visibility or travel speeds may have an impact on a cyclist decision-making and performance. Some literature also demonstrates that factors such as the type of rider (recreational, commuter) or whether the cyclist was in a group will impact behaviour. As such, if the practitioner decides to adjust traffic signal timings from those which would traditionally be used for motor vehicles, the practitioner should learn as much as possible about the specific operation of the intersection or intersections in question before implementing changes.

Table 1: Possible Signal Timing or Signal Phasing Impacts/Changes for Various Types of Cycling Facilities

	SIGNAL TIMING		SIGNAL DISPLAYS		SIGNAL PHASING	
FACILITY TYPE	Revised Vehicle	Bicycle-Specific	Additional Non-bicycle	Bicycle-Specific	Existing	Bicycle-Specific
Shared	✓		✓			
Lane/Track	✓	✓	✓	✓	✓	✓
In-Boulevard	✓	✓		✓	✓	✓
Contraflow	✓	✓		✓	✓	✓
Mid-Block		✓		✓		✓

3.5 Minimum Green Interval

3.5.1 Description and Justification

A cyclist at rest may not be able to accelerate as quickly as a motorized vehicle. In a typical signal timing designs, sufficient time is available at the start of the green interval to allow bicycles to accelerate from rest and cross the intersection prior to the conflicting phase being initiated. The one situation for which special treatment for bicycles might be necessary is at the sidestreet of an actuated intersection with a short minimum green interval. As with most of the recommendations in this guide, the justification for changing the signal timing would be based on a fairly heavy volume of bicycle traffic and/or a known condition or situation relating to bicycles crossing the intersection.

3.5.2 Formulae

The length of time for a cyclist to cross an intersection is based on three major components. These are: the perception reaction time, which includes the time to react to the change of signal to green and to commence pedaling – the Perception Reaction Time (PRT); a period of time to accelerate to regular travelling speed – the Start-Up Acceleration (ACC): and the remaining time to cross the intersection at normal cycling speed – the Clearance Time (TCLEAR).

The first two components can be combined and a constant provided as an alternate. The next section describes how the minimum green time is calculated.

3.5.2.1 Minimum Green Time Calculation

The minimum green plus amber plus red clearance must be greater than or equal to the total crossing time required. The basic formula is:

$$Gmin + Y + R_{clear} \geq SU + TCLEAR$$

Where:

Gmin = Length of minimum green interval (seconds)

Y = Length of amber interval (seconds)

R_{clear} = Length of red clearance interval (seconds)

SU is a start-up time incorporating both perception-reaction time and acceleration to normal speed (seconds), suggested value: 6 seconds

TCLEAR is the time (seconds) required to finish the crossing after accelerating to normal cycling speed, which in this formula does not consider the distance covered during start-up acceleration = (W + L)/V,

Where:

V is normal cyclist speed (metres/second), with suggested value: 4.0-5.6 m/s (14-20 km/hr)

W is the width of the intersection (metres), and;

L is the length of the bicycle (m), suggested value: 1.8m

The complete formula is:

$$Gmin \geq SU + ((W + L)/V) - (Y + R_{clear})$$

3.5.3 Parameters Used in Bicycle Signal Timing

It would appear the science of cycling is still in the developing stages and there have been few in-depth investigations into cyclist dynamics. As illustrated in Appendix A, there is a wide range of advice in the existing manuals and publications in regard to the specific values for parameters to be used in computational formulae. As such, a range of values have been provided in various guides and manuals for each of the parameters required to calculate this and other formulae.

Appendix A contains summary of parameters available in major guides with suggested typical values. While suggested values are provided for parameters for the formulae in this guide, the practitioner is encouraged to find as much information as possible about the cyclist population and behaviours in their own jurisdiction before choosing parameters. To ensure that a newly installed bicycle signal works for the greatest number of cyclists, the practitioner is encouraged to consider both existing and future cyclist demographics in their jurisdiction.

3.5.4 Application Guidance

The use of a longer than standard minimum green impacts an intersection's efficiency. If there are a large number of cyclists using the intersection on a regular basis and cyclists are left in the intersection when conflicting traffic is shown the green on a regular basis, it may be appropriate to lengthen the minimum green. Conversely, if there is special detection for bicycles, such as through the use of a pushbutton or non-intrusive detection, it may be possible to implement additional green time only on those occasions when bicycles are present.

3.6 Amber and Red Clearances

3.6.1 Description and Justification

Bicycles have very different performance characteristics than motor vehicles. They have a lower top speed and a shorter stopping time and distance. Conversely, if a bicycle enters the intersection just before or during the amber display, the lower speed may mean that the red clearance interval is insufficient.

This section defines the calculation of amber/red clearance times based on bicycle performance. Section 3.6.4 provides further insight into the need, impacts and alternatives to bicycle-specific clearance intervals.

In the case of a bicycle specific phase, where no motor vehicles are being served, clearance interval timing that is specific to bicycles should be implemented.

3.6.2 Clearance Interval Calculation

The formula for the intergreen for a bicycle is similar to that contained in section 3.6 of OTM, Book 12. The formula for the clearance interval is as follows:

$$\text{Amber} + R_{clear} = [PRT + V / (2d)] + [(W+L) / V]$$

Where:

PRT is perception-reaction time (sec), suggested value: 1.0 sec minimum

V is typical cyclist speed (km/h), suggested value: 4.0 - 5.6 m/s (14-20 km/h)

d = bicycle deceleration rate (m/sec/sec), suggested value: 3.0 m/sec/sec

W is intersection width (m)

L is bicycle length (m), suggested value: 1.8m

Amber = [PRT + V / (2d)]

R_{clear} = [(W + L) / V]

3.6.3 Minimum Bicycle Signal Timing

Information on the values of the parameters used to calculate, the minimum green, amber and red clearance times is contained in Appendix A. The practitioner is encouraged to find as much information as possible about the cyclist population and behaviours in their own jurisdiction before deciding on suitable parameter values. Typical values for the minimum bicycle phase lengths are provided in Table 2. Bicycle speeds should be measured in the field to determine the appropriate clearance time. At intersections with level terrain, a default speed of 4.5 m/s may be used[4].

Table 2: Minimum Bicycle Signal Timing

INTERSECTION WIDTH "W"	MINIMUM PHASE LENGTH (Gmin + Y + R_{clear})
Metre	Seconds
12	9.1
15	9.7
20	10.8
25	12.0
30	13.1
35	14.2
40	15.3
45	16.4
50	17.5
55	18.6
Gmin + Y + R_{clear} ≥ SU + (W + L) / V Assumed: SU = 6 sec, L=1.8 m, V=4.5 m/s	

3.6.4 Application Guidance

The vehicle clearance interval timing is the most important safety component of traffic signal timing. It should be adjusted or modified only with extreme care and knowledge of the potential consequences. The 2012 AASHTO guide[4] states that "the yellow interval is based on the approach speeds of automobiles, and therefore, should not be adjusted to accommodate bicycles". This implies that any adjustment to the vehicle clearance intervals should be made only in the red clearance interval, which is the appropriate methodology given that the amber required for a bicycle is much shorter than for motor vehicle traffic and would create an unsafe condition for motor vehicle traffic. As noted in Chapter 2, the Ontario Highway Traffic Act makes more than one provision for a situation in which a vehicle or pedestrian which has legally entered the intersection but has not completed their movement retains the right of way over conflicting traffic even if that conflicting traffic is presented with a green indication. Therefore it is not absolutely necessary to have a full clearance interval for bicycles, and if the intersection is operating safely there may be no need to adjust signal timings specifically for bicycles.

The formula above will generate bicycle timings with very short ambers and very long red clearance intervals. These may be used as calculated, for bicycle-specific phases. However, in mixed traffic, the amber must remain as set for motor vehicle traffic. The overall clearance interval for very narrow intersections (12-15m) will be almost the same as required for bicycles. With larger intersections, if the red clearances were set based on the full cyclist requirement, the red clearance may be so long that motorists may consider the signal to be faulty. It is suggested that the maximum additional red clearance for bicycle purposes should be limited to 1.0 sec.

Alternative designs of detection, such as long-distance cyclist detection, may also serve to extend the green interval and minimize cyclist interaction with the clearance interval. Serious consideration should be given to any or all alternate techniques before considering modifying the current clearance interval timing.

4. Bicycle-Specific Signal Displays

4.1 Use of Bicycle-Specific Displays

Bicycles integrate with roadway traffic in many ways. Bicycles riding parallel to the flow of traffic may be in one of the general purpose traffic lanes, in a specific designated marked bike lane, in a separated cycle track beside the roadway or on a multiuse or bike trail. In the perpendicular direction, bicycles may cross the road at signalized intersections, at stop controlled intersections or at a mid-block location.

In the vast majority of cases, specialized signal displays specific to bicycles are not required at signalized intersections or special crossings. However, situations do occur in which specific information should be provided to cyclists to coordinate movements which are separate from those of the regular vehicular (including transit) and pedestrian traffic streams.

To communicate bicycle-specific information to cyclists at signalized intersections, the bicycle symbol signal head, shown in Figure 1, may be used. Traffic signal heads with special lenses containing the silhouette outline of a bicycle have been used to provide direction to cyclists in Europe and North America for some time. In Canada, this type of traffic signal was originally adopted in the province of Québec and subsequently was added to the Manual of Uniform Traffic Control Devices for Canada and is therefore a widely recognized, and unique, traffic control device. The version shown in Figure 1 is the approved Ontario standard as of January 1, 2017.

Figure 1 – Ontario Standard Bicycle Symbol Traffic Signal

The legal implications of a bicycle-specific signal display are detailed in Section 2.

When a bicycle signal head is used to provide direction to cyclists, a sign immediately adjacent to the signal head may be installed to improve visibility and conspicuity. The sign should have the words "Bicycle Signal" or the French equivalent and may be symbolized and/or bilingual. Figures 2 and 3 show two examples.

The Ontario standard bicycle signal head, shown in Figure 1, must be used for all new bicycle signal installations, and when conventional bicycle signals are due for upgrade/replacement.

Figure 2 – Conventional Bicycle Signals and English Sign – Bicycle Control

Figure 3 – Conventional Bicycle Signals and Bilingual Sign – Bicycle Control

4.2 Differentiating Bicycle Signal Heads

It is important to create differences between bicycle signals and the regular vehicular signals, to minimize motorist confusion, and thereby maximize safety. Where bicycle specific traffic signal heads are used, the bicycle signal heads should be differentiated from the motor vehicle signal heads through one or more of the following options:

- the signal head housing may be a different colour than the jurisdiction's standard colour, preferably one that is less visible to motorists such as dark green or black;
- the signal head may be installed without backboard, which is more effective if the nearby vehicle signal heads are equipped with backboards;
- positioning one of the bicycle heads near-side;
- using a smaller signal lens diameter;
- wherever possible, the bicycle signal head should be positioned lower and out of the typical line of sight of the motor vehicle driver while being placed in line of sight of the cyclist.

The above can usually be achieved without reducing the effectiveness or value of the bicycle signal head to cyclists.

4.3 Bicycle Signal Head Size and Type

For far-side bicycle symbol signal heads, it is preferred to use the 300/300/300mm lens size, especially for bicycle-only phasing or if the signal head is to be seen at a distance. This is to ensure that the bicycle symbol is clear to both cyclists and motorists. The 200/200/200mm lens size is generally sufficient for near-side mounting or auxiliary signal head uses. If standard circular ball indication traffic signal heads are being used (with signs), given the slower speeds that cyclists are typically approaching specialized traffic signals, the use of the 200/200/200mm size is generally acceptable, especially if no bicycle arrow signal indications are being used. In general, based on good engineering judgment, the practitioner may select the use of either of a 300/300/300mm or 200/200/200mm as the standard signal head for bicycle use. If a near-side auxiliary head is deployed, it may be smaller than 200mm and could be mounted at a height less than 2.5m as determined by the road authority. In the case of auxiliary signal heads using a lens size less than 200/200/200mm, the bicycle symbol shall be legible and proportioned to fit within the signal lens.

4.4 Bicycle Signal Head Placement

As of January 1, 2017, the revised Regulation 626 under the Highway Traffic Act comes into force, requiring bicycle signals to be not less than 2.5m above the level of the roadway when adjacent to the travelled portion of the roadway and not less than 4.5m above the level of the roadway when suspended over the travelled portion of the roadway, keeping in mind that service and emergency vehicles will travel on the multi-use paths.

Bicycle signals should be aligned to serve cyclists, with the understanding that a cyclist's field of vision may be quite low to the ground due to the cyclists' positioning on the bicycle.

It is preferred that the bicycle signals are placed in line or close to the cyclists' line of sight and generally in line with the cycling facility. It is preferable to place them off of the travelled roadway, so that they can be installed close to the 2.5m minimum height requirement. However, a priority is to place bicycle signal heads where they will not impede or potentially injure a passing cyclist or pedestrian, or be hit by vehicles.

The Highway Traffic Act requires a minimum of two vehicle signal heads on the far side of the intersection. Where bicycles are operating with the exact same signal phasing as the parallel vehicular movements, signal heads provided for bicycles are considered auxiliary only, and if appropriate, a single additional signal head for bicycles may be provided. The bicycle auxiliary signal head should be located as centrally as possible in the cyclists' cone of vision, and should operate in agreement at all times with the motor vehicle signal indications.

Where bicycles are operating on a separate, bicycle specific phase, while not required by the HTA regulation, a minimum of two bicycle specific signal heads should be installed, to ensure redundancy and safety. One of the bicycle signal heads may be installed on the near side of the intersection.

If far-side and near-side bicycle signal heads are used, the near-side signal head should be located so that it can be seen by a cyclist stopped for the signal.

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5. Bicycle Signal Phasing

At the vast majority of signalized intersections, bicycles are able to traverse the intersection without the assistance of bicycle phasing to specifically control bicycle movements. There are, however, circumstances which will provide increased safety, throughput or convenience to cyclists at acceptable impact to conflicting or adjacent motorized traffic or pedestrians. In these cases, special signal phasing using bicycle specific signal heads may be employed. In the case of any discrepancies between the schematic drawings "design figures" and the illustration photos "images" in Chapter 5, the design drawing takes precedents over the image.

5.1 Common Applications of Bicycle-Specific Phasing

Following are some examples of situations in which bicycle specific phasing might be advantageous:

- Where, at a mid-block or intersection crossing (often connecting to a mixed-use trail facility), the bicycle flows are mixed with pedestrian flows. This is particularly true in Ontario with the requirement that cyclists must dismount and walk to use the pedestrian crosswalk.
- Where large volumes of traffic travelling straight ahead on a designated bike lane or bike track conflict with heavy movements of turning traffic, it may be advantageous to both streams to provide temporal separation using separate signalization.
- At locations where no signal indication would otherwise be provided to bicycle traffic. An example of this would be a contraflow bike lane on a one-way street.
- At locations where bicycles are permitted to make movements which are otherwise prohibited for the rest of the vehicle stream. An example would be the restricted entrance to a residential neighbourhood for which vehicular traffic is required to turn but bicycle traffic is permitted to travel straight ahead to enter the neighbourhood.
- At complex intersections where cyclists may be assisted by the provision of separately defined right of way.
- At otherwise traditional locations with high bicycle collision rates that may be mitigated by separating various movements.

Decision criteria are presented formally in Chapter 6.

5.2 Operational Considerations for Bicycle Phasing

Since bicycle phasing is not commonplace, it is incumbent on the practitioner to use engineering judgement as to the appropriateness of installing bicycle phasing and the best way to implement it. Some factors to be considered are as follows:

- Conformity and Consistency.
    - o Driver and cyclist performance improves with familiarity and confidence. Therefore, if special bicycle phasing is used at a location, consideration should be given to using it at all locations similar in nature or at least similar locations along a cycling corridor.
    - o Conversely, if bicycle phasing is only intended to be used at an individual intersection which is unique, very careful consideration must be given to the implementation to ensure clarity to both motorized and non-motorized users.

- Cyclist Behaviour.
  - o Because of the energy necessary to accelerate a bicycle from a stop position to travel speed, momentum is valuable to cyclists. Cycling facility designs have to recognize that cyclists tend to be reluctant to stop unless absolutely necessary.
- Overall Benefits.
  - o In the course of designing bicycle specific phasing, consideration must be given not only to the improvements in safety and efficiency for non-motorized users but to the potential decrease in safety and or efficiency for motorized users. It is understood that in order to promote healthy lifestyles and to promote a move away from the use of single occupant motor vehicles, special promotion of cycling will occur. However, the practitioner must consider the negative consequences, especially on motorist or pedestrian safety, as well as the advantages.
- Pedestrian Conflicts.
  - o Where a bicycle trail or multi-use path crosses a sidewalk, consideration should be given to the right-of-way of pedestrians over bicycles. The RB-73 (Ontario Traffic Manual, Book 18[6]) Cyclist Yield To Pedestrian sign is recommended to communicate the requirement for cyclists to be aware of, and give way to, pedestrians.
- Introductory Period.
  - o The most difficult time of any new traffic control device or operational condition is immediately after implementation. The unfamiliarity of users can lead to erratic driving or riding and the risk of collisions is highest directly after any change.
  - o To maximize the success and safety of any new installation, a combination of the classic 3 E's should be employed:
    - Educational campaigns utilising both traditional and non-traditional techniques are important.
    - Law enforcement should be involved and should provide the necessary level of enforcement and encouragement.
    - Engineering: Advance information signing or other techniques should be employed on a temporary basis to heighten user awareness. This would be similar to the use of the "NEW" warning sign which accompanies new Stop signs, Yield signs or traffic signals.

5.3 Parallel Bicycle and Pedestrian Crossings (Without Bicycle-Specific Phasing)

This section explores the options for locations where the bicycles and the pedestrians cross together or immediately beside each other. The options are presented in increasing complexity, and it is expected that the more complex solutions would only be required where large numbers of bicycles and/or pedestrians and/or motor vehicles interact.

5.3.1 Pedestrian and Bicycle Crossing Configuration

Where a multi-use trail (combination of bicycles, pedestrians and other non-motorized users) crosses a roadway, either in close proximity to a signalized intersection or mid-block, there are two choices. Either the cyclists and pedestrians may be combined in the pedestrian crosswalk (as described in 5.3.2) or a separate crossing denoted by the "elephants feet" pavement marking (called a "crossride") is provided for bicycles.

The use of the crossride means that the interaction of bicycles and pedestrians in the crossing is in theory greatly reduced or eliminated.

There are four possible crosswalk/crossride configurations. These are shown in Figure 4.

The simplest design, Configuration A (termed Separate Pedestrian and Cyclist Crossride in OTM, Book 18[6]), places the pedestrian crossing on one side, which would be next to the sidewalk at a signalized intersection, to serve both the sidewalk and the multi-use trail. This places all bicycles on one side, while a typical multi-use trail operates with the pedestrians on the outside and the faster-moving bicycles closer to the centre, leading to some exchange of positions at the ends of the crossing. The positions of the crossride and the crosswalk in Configuration A may be reversed to reduce conflicts between cyclists and pedestrians. This configuration should operate satisfactorily where the trail users typically have to stop before crossing. Due to space limitations, this is the configuration most typically used for the situation where a multi-use trail parallel to a roadway crosses near a signalized intersection. For a cycle track next to a sidewalk, the cycle track layout is shown as Configuration A (for cycle tracks only) in Figure 4.

Configuration B is an alternative from OTM, Book 18[6] (termed Combined Pedestrian and Cyclist Crossride). Configuration C reverses the cyclist and pedestrian positions compared to Configuration B, which may be a better match to the user configuration on the path (pedestrians being the slower moving users, are typically on the outside of the path and cyclists are usually closer to the centre), but Configuration C is quite wide, and is therefore typically limited to use at mid-block crossings.

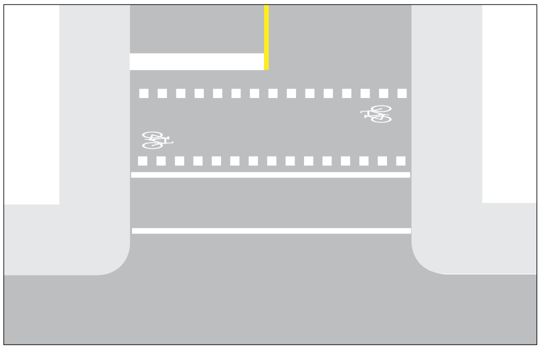
5.3.2 Use of the Same Crosswalk – Cyclists to Walk Across

The most basic method of managing the situation at locations where multi-use trails cross the road or where bike paths merge with sidewalks at intersections, is to require cyclists to default to the basic HTA requirement to dismount and walk across a signalized intersection crosswalk. The TAC Dismount and Walk Sign MUTCDC RB-79 should be used. As well, a stop sign and stop line may be considered on the path or trail to further encourage cyclists to comply.

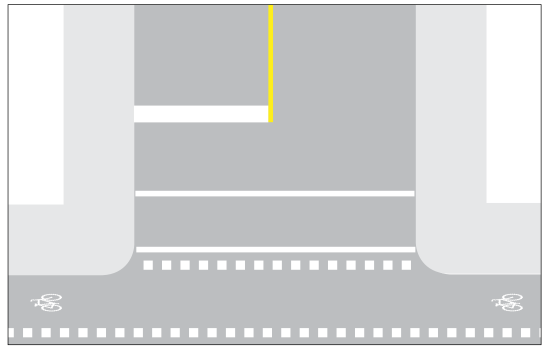
This configuration would be an option where the addition of a crossride is not possible, but the large volume of pedestrians in a crosswalk and/or the width of the crosswalk suggest that the best configuration is to require cyclists to walk. While this is feasible, in many cases cyclists find the requirement onerous or unreasonable and disobey the regulation; therefore the implementation of a crossride should be considered wherever possible.

5.3.3 Signs and Pavement Markings

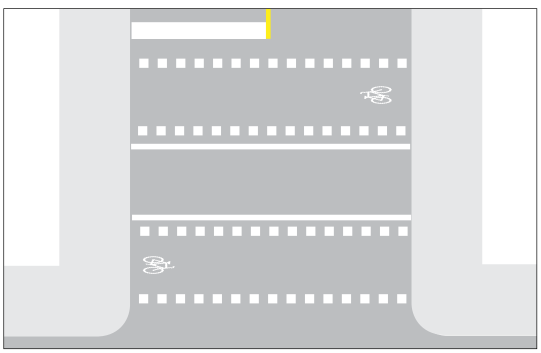
In determining the size of signs used for bicycle facilities shown in this guide, it should first be defined whether the signing is for cyclists only, or for cyclists and motorists. Signing for both cyclists and motorists should conform to the requirements in the OTM, Book series. Signs for cyclists only may be smaller and should conform to the TAC Bikeway Traffic Control Guidelines for Canada – 2nd Edition (January 2012). If there are situations in which cyclist-specific signing might be observed by motorists and thereby cause confusion, the use of a smaller than standard sign might assist. However, for strict legal enforcement purposes, signs such as Stop or Yield signs which are smaller than the minimum under the Highway Traffic Act, or the OTM, Book series, may not be sufficient.



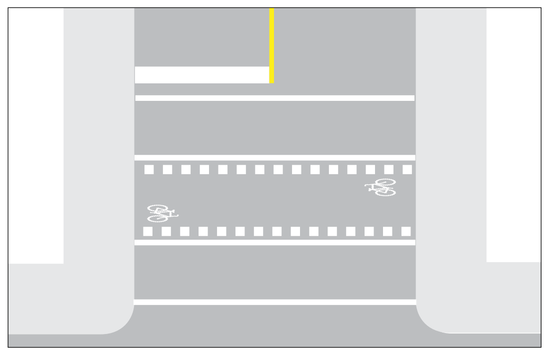
Configuration A*



Configuration A (for cycle tracks only)



Configuration B



Configuration C

Figure 4 – Crosswalk/Crossride Configurations

Notes:

– Crosswalks and crossrides not to scale.

** The positions of the crossride and the crosswalk may be reversed.*

Figure 5 – Image: Multi-Use Trail Beside Traffic Signal, Stop Control, Crossing

Crosswalk and crossride pavement markings should generally comply with OTM, Books 11 and 18[6] for line types and spacing. In addition, this guide shows bicycle stencils in the crossrides in specific positions. Only the stencils that are considered required at signalized intersections are shown. If the flow of path users at a particular site suggests the need, the practitioner may add additional stencils to guide cyclists and provide information to pedestrians.

5.3.4 Parallel Pedestrian and Bicycle Crossings, Signalized Intersection – No Bicycle Signal Traffic Control

If a cross ride is implemented at a "signalized" intersection, bike signals should be implemented so all modes (walking, cycling and motor vehicles) have the same form of control. At stop-controlled intersection, all users (including cyclists crossing through a cross ride) must follow the same rules for a stop controlled intersection.

If for some reason the road authority does not want to install bike signals to connect an in-boulevard multi-use path or bikeway, then a cross ride should not be installed at a "signalized" intersection. Cyclists would therefore be required to cross as a pedestrian using the crosswalk from boulevard to boulevard. Shown in Figure 5.

5.3.5 Parallel Multi-Use Trail Pedestrian and Bicycle Crossings – No Separate Bicycle Phasing

Figures 6 through 13 show various situations, with the common theme that bicycles are given signal indications. In Figures 6, 7, 8 and 9 there are the two alternative configurations of multi-use trail crossing parallel to a signalized intersection with no separate signalization of the bicycle movements. The wider crosswalk/crossride system in Figure 8 places the roadway stop line further from the intersection, which may impact signal timing or operations. Bicycle movements are governed by the regular vehicle signal patterns. This configuration may be used if the practitioner is satisfied that the cyclists will consistently obey the standard vehicle signals.

An auxiliary signal specific to cyclists may also be added, if showing the same displays as the main vehicle signals, to improve cyclist compliance. While only one auxiliary signal for bicycles is required under the HTA regulations, if the practitioner feels that the vehicle signals are not satisfactory as "back-up" in the event of an indication failure in the bicycle signal, a second bicycle signal may be added for further redundancy.

To best organize the crossing, the TAC Pathway Organization Sign MUTCDC RB-94 or RB-95 may be used. The ID-20 pushbutton sign is used when the signal operation is actuated.

If there is an observed conflict between path users and turning motor vehicles, a combination of reduced speed warning for the bicycles in the vicinity of the crossing through the use of the "Slow Watch for Turning Traffic" sign and the Bicycle Trail Crossing Side Street sign MUTCDC WC-44 for both directions of parallel traffic will serve to minimize conflicts between bicycles and turning traffic. The "Cyclists Stop Here on Red" sign may be used if lack of signal compliance is noted.

In order to manage the conflict between cyclists on the multi-use path and pedestrians on the perpendicular sidewalk, the Rb-73 Cyclists Yield To Pedestrians sign should be used whenever cyclist and pedestrian volumes or conflicts suggest the need.

The pedestrians on the sidewalks walking in a direction perpendicular to the multi-use path are not provided with specific information about the right-of-way status of bicycle traffic on the path.

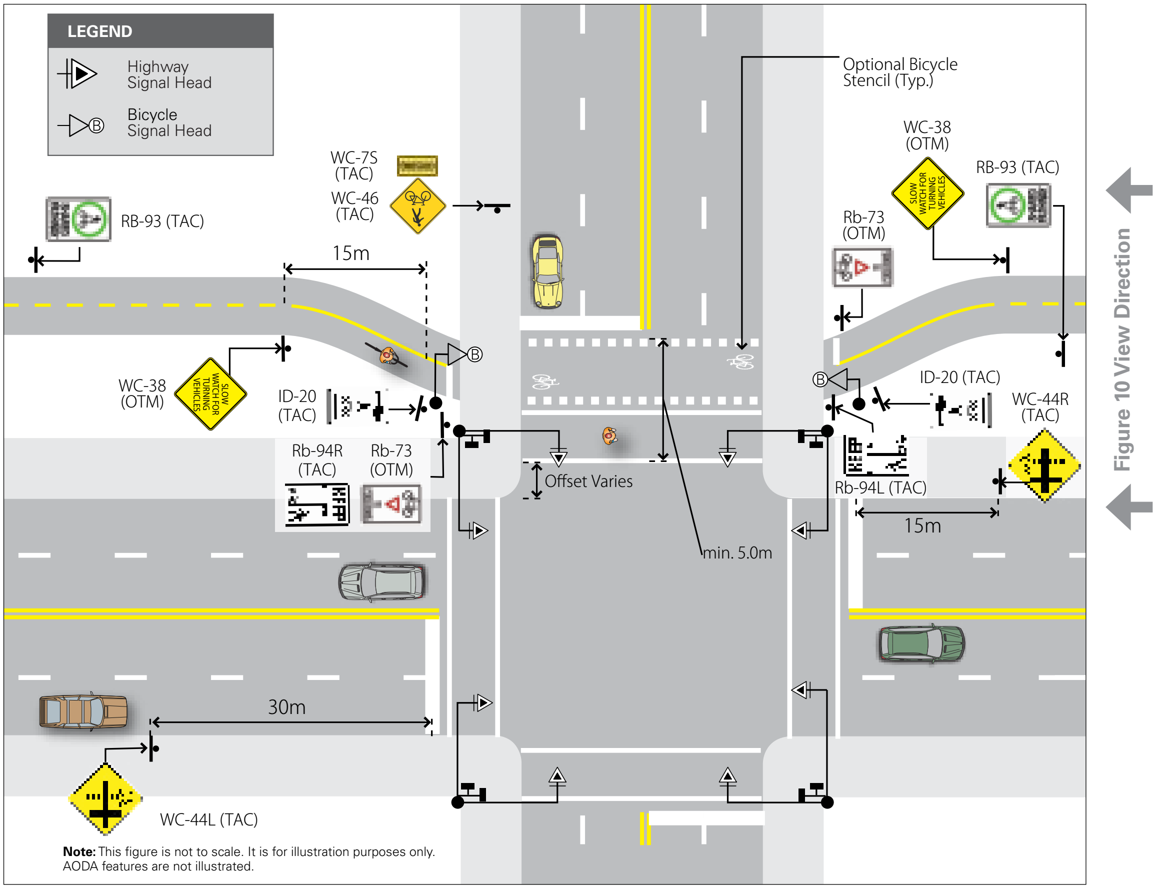


Figure 6 – Design: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration A, Auxiliary Signal Head

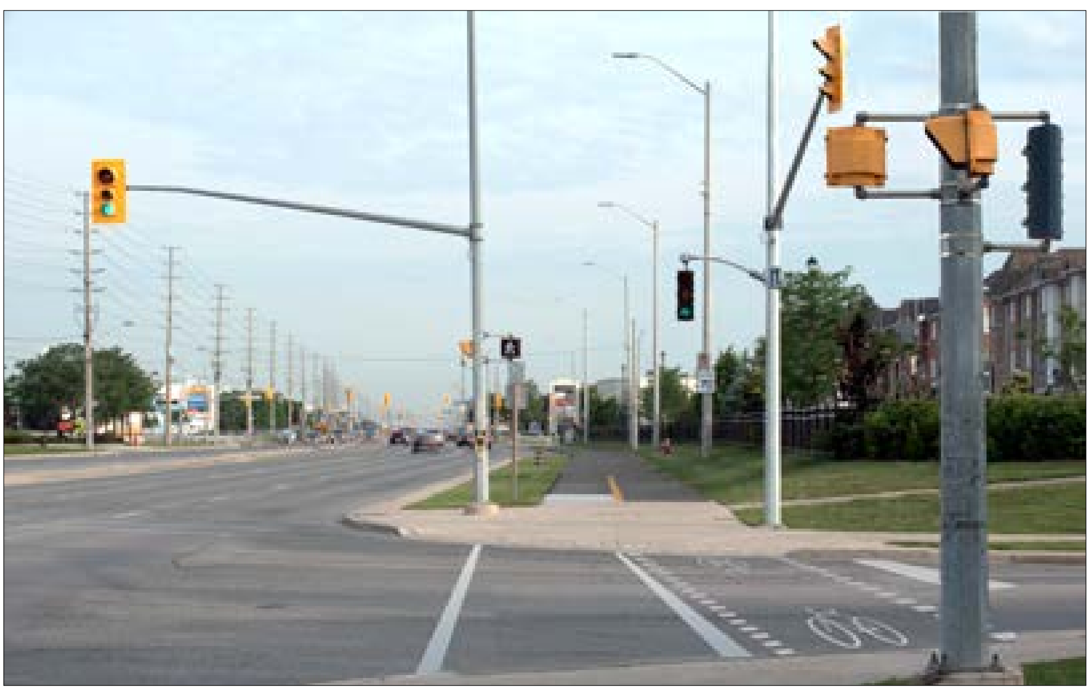


Figure 7 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration A, Auxiliary Signal Head

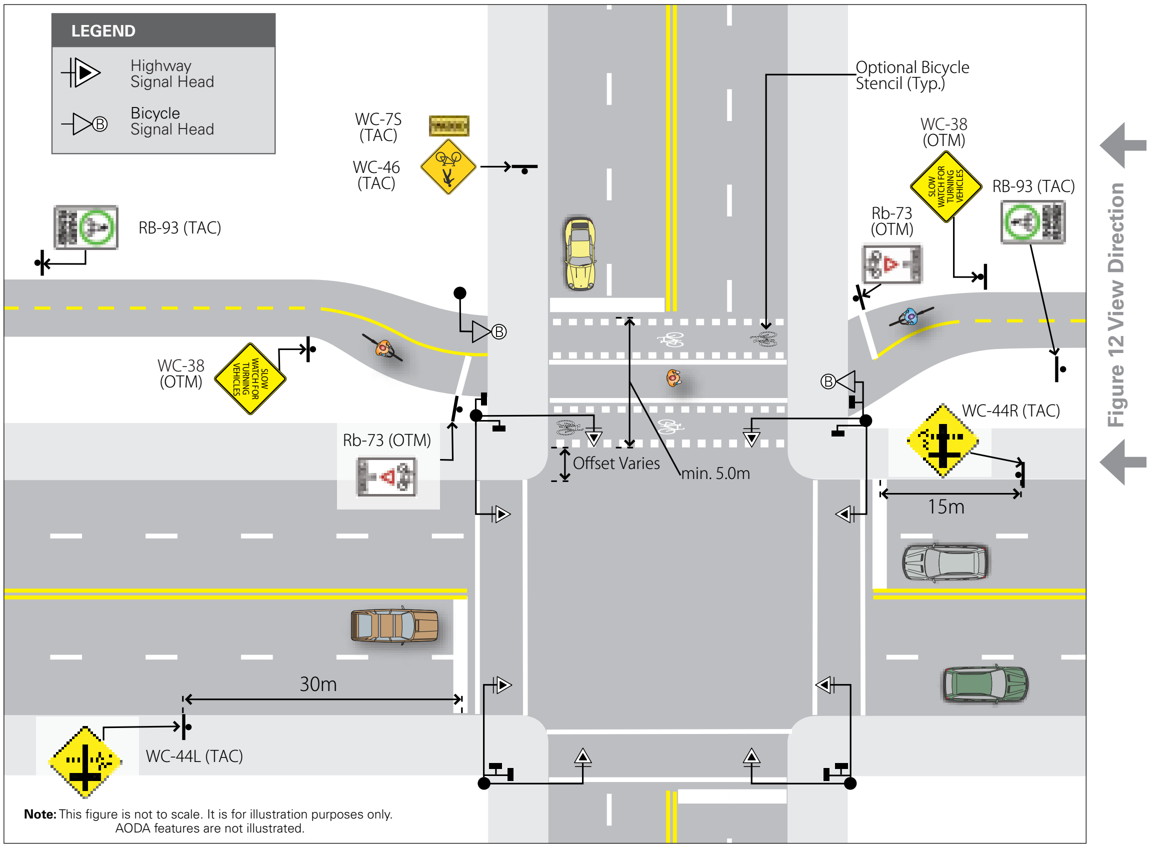


Figure 8 – Design: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration B, Auxiliary Signal Head

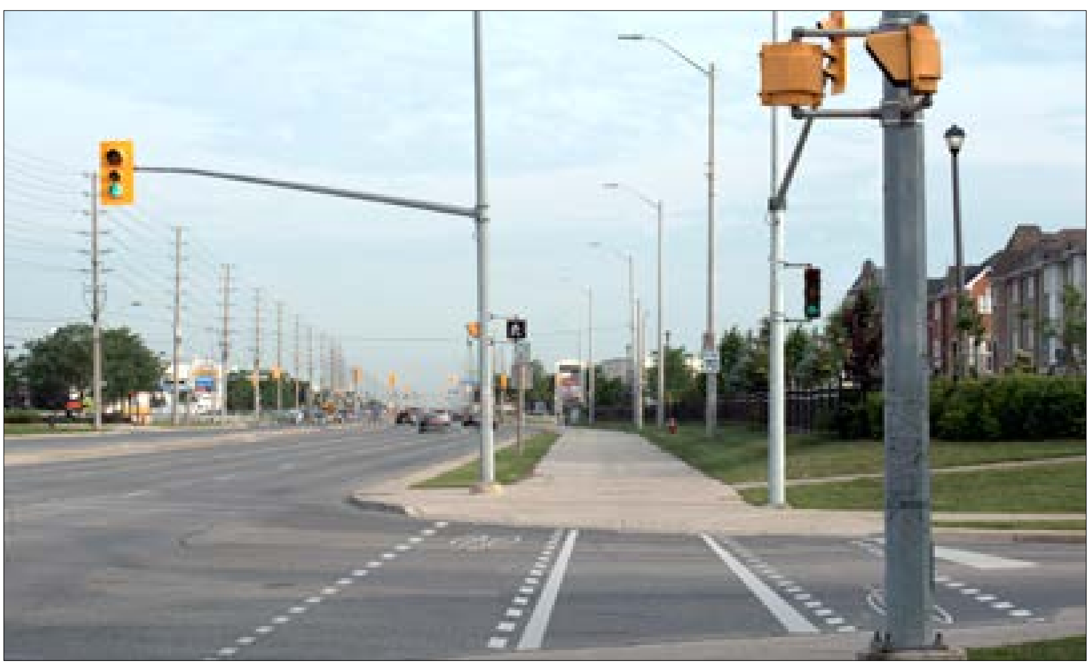


Figure 9 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration B, Auxiliary Signal Head

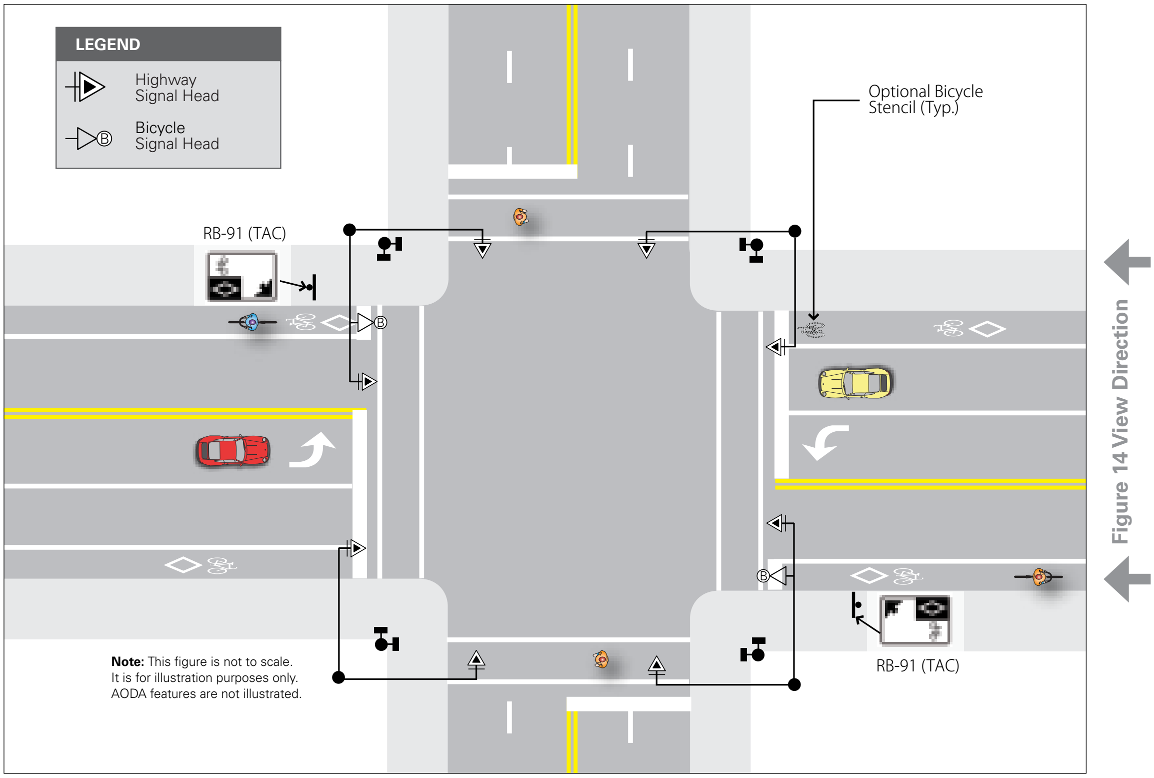


Figure 10 – Design: Bike Lane at Signalized Intersection

Figure 11 – Image: Bike Lane at Signalized Intersection

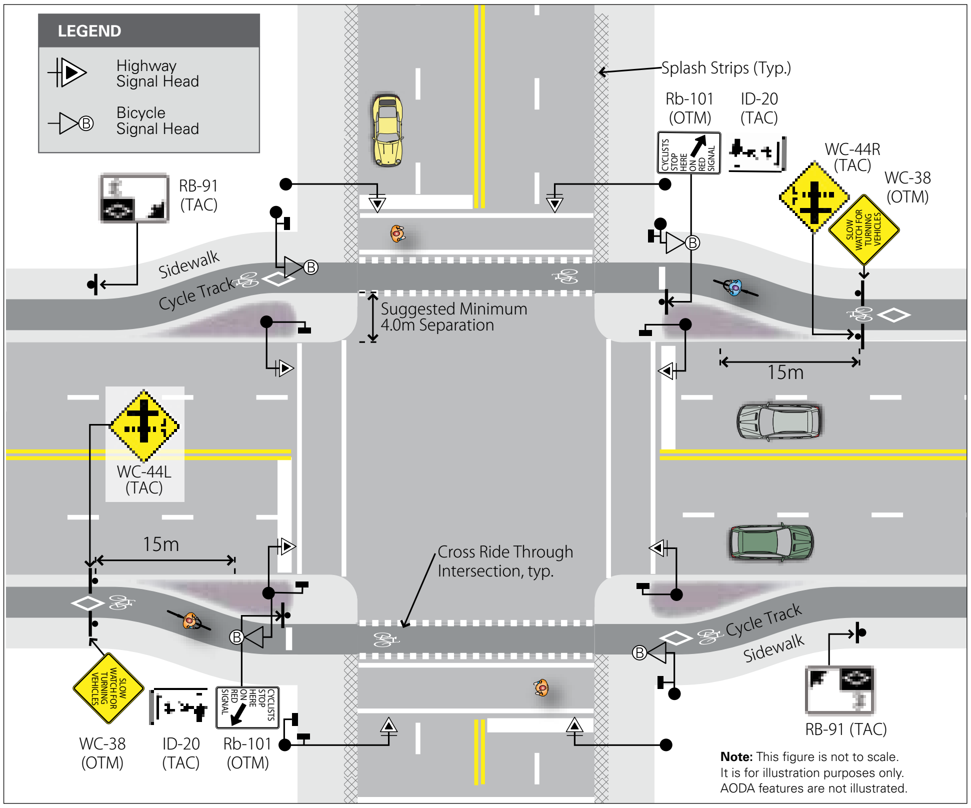


Figure 12 – Design: Bike Track at Signalized Intersection

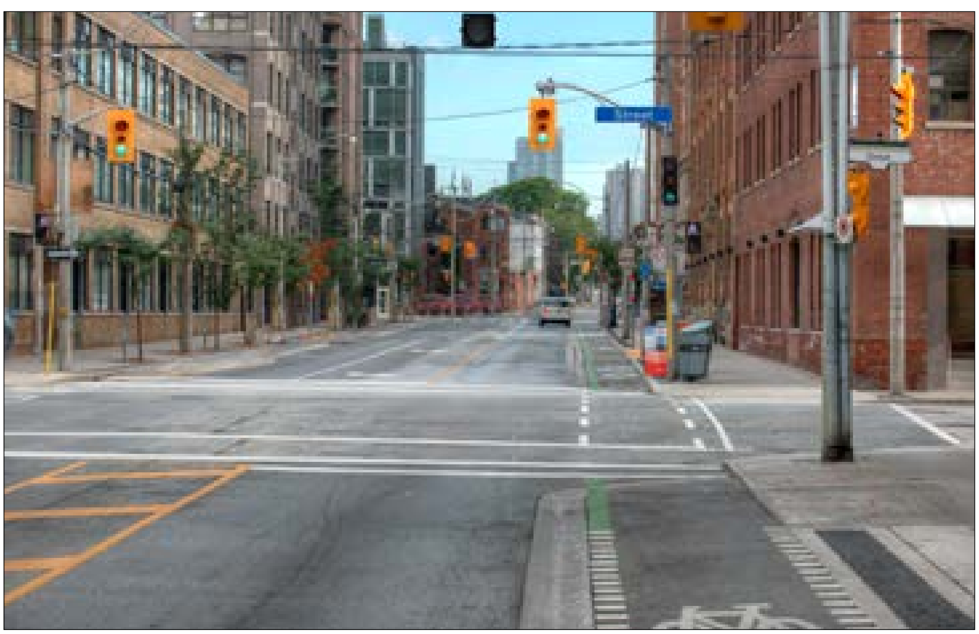


Figure 13 – Image: Bike Track at Signalized Intersection

In the rare extreme case where the painted stop line and the Rb-73 sign are not effective in separating pedestrian and cyclist flows, the pedestrian signal heads could be relocated to extend the pedestrian crosswalk across the arterial roadway to include the multi-use trail as well, although this causes inconvenience to the pedestrians on the sidewalk and could have a significant effect on the signal timing and operational efficiency of the intersection.

5.3.6 Bicycle Path and Track Crossings - No Separate Bicycle Phasing

Figures 10 through 13 show two common on-street bicycle facility types, a bicycle lane and a cycle track. As with the parallel multi-use trail crossings, these facilities will typically operate using the same signal patterns as for parallel general purpose traffic. The designs shown have an additional signal head for bicycle traffic, to make it easier for cyclists to determine the signal status.

5.4 Bicycle and Pedestrian Crossings – with Bicycle-Specific Phasing

For some situations, bicycle specific signal heads and warning signs may not provide the bicycle crossing with a sufficient level of safety. This may occur due to poor visibility, where the boulevard trail is set back a large distance from the parallel roadway, where cyclists are travelling at high speeds or where there are high volumes of bicycles and/or turning traffic, resulting in conflicts. Options are to partially or completely separate the parallel right and left motor vehicle turning movements from the bicycle phase. For either of the phasing patterns that follow, consideration should be given to adding Rb-79 No Right Turn On Red signs if bicycle/vehicle conflicts occur during the bicycle-specific phase operation. Bicycle-specific detection is required for either form of bicycle phasing, unless the bicycle phasing is operated on fixed-time plans, with time-of-day operation as an option.

5.4.1 Advanced Protected Bicycle Phase

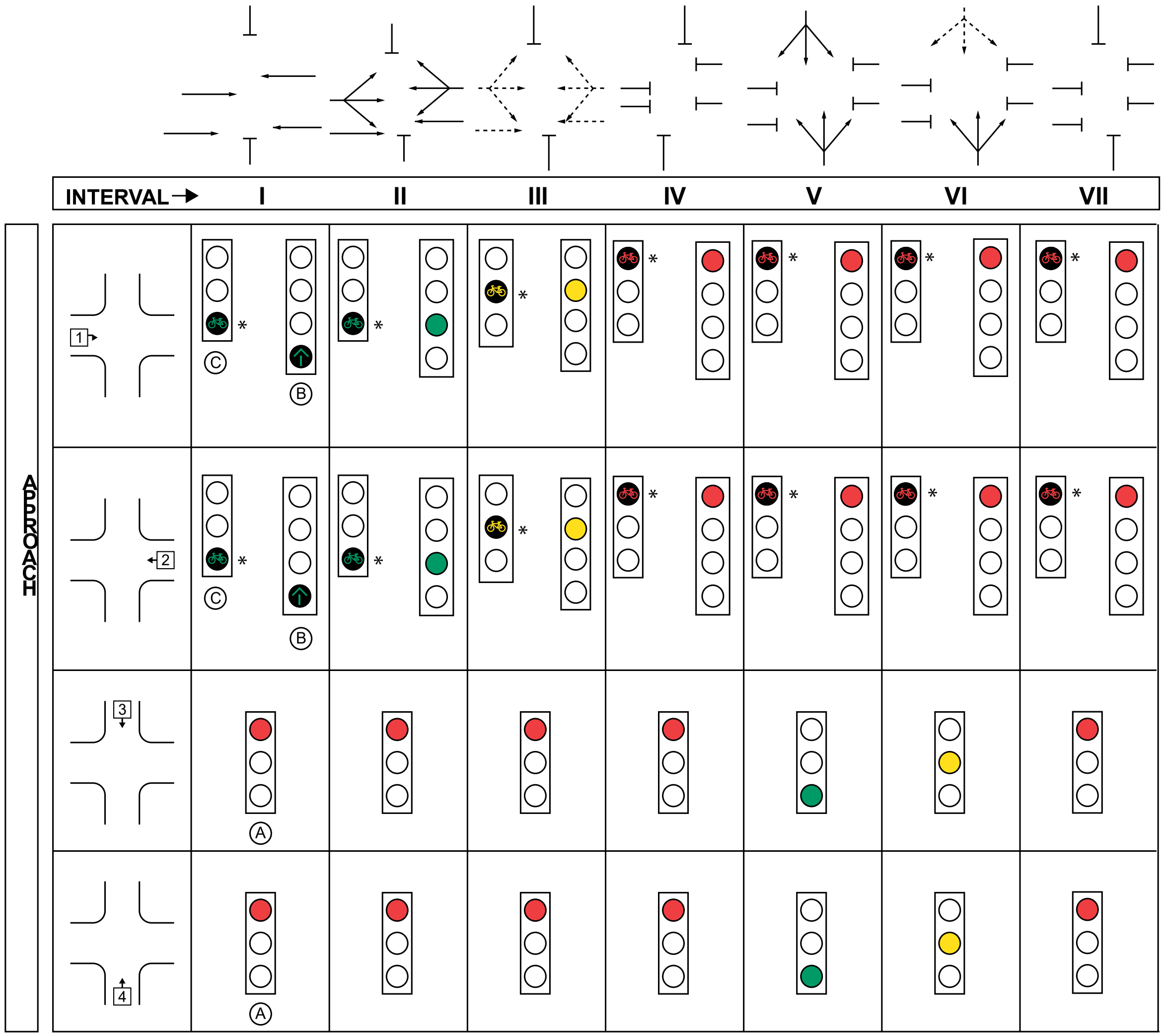
5.4.1.1. Advanced with Vehicle Through Movement

At locations with a designated bike lane or cycle track and heavy through bicycle traffic conflicting with heavy turning traffic, particularly right turning traffic, a leading bicycle phase may be helpful. Vehicular traffic is controlled by a four section head with the straight through green arrow and a green ball. Vehicular traffic is initially shown the straight up green arrow at the same time that the bike signal displays green. After a short green bicycle interval, which allows the group of standing bicycles an opportunity to proceed into the intersection and take possession of the conflict space, the vehicle indication changes from straight up green arrow to green ball. The bicycle green remains on for the full phase, changing to amber and red only at the end of the vehicle phase. Figure 14 shows the phasing diagram. The drawback is the somewhat increased delay for motorists.

Pedestrian movements may also receive advanced movement status under this phasing configuration. This phasing is applicable to the crosswalk/crossride combination of crossing, for intersections with bicycle boxes or for reserved bicycle lanes or cycle tracks.

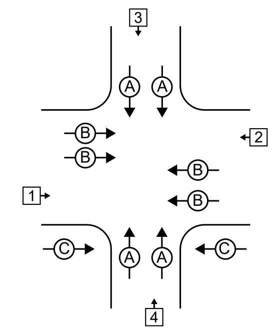
5.4.1.2 Advanced without Vehicle Through Movement

At locations with a designated bike lane or cycle track with heavy turning traffic, a leading bicycle phase may be used similar to a pedestrian only leading phase. Cyclists are provided with an advanced green signal while motor vehicles face a red ball. After a short green period, which allows the group of standing bicycles an opportunity to



SIGNAL HEAD PLACEMENT

As well as one primary and one secondary vehicle signal head for each approach, bicycle-specific signals are installed for the crossride on the south side.



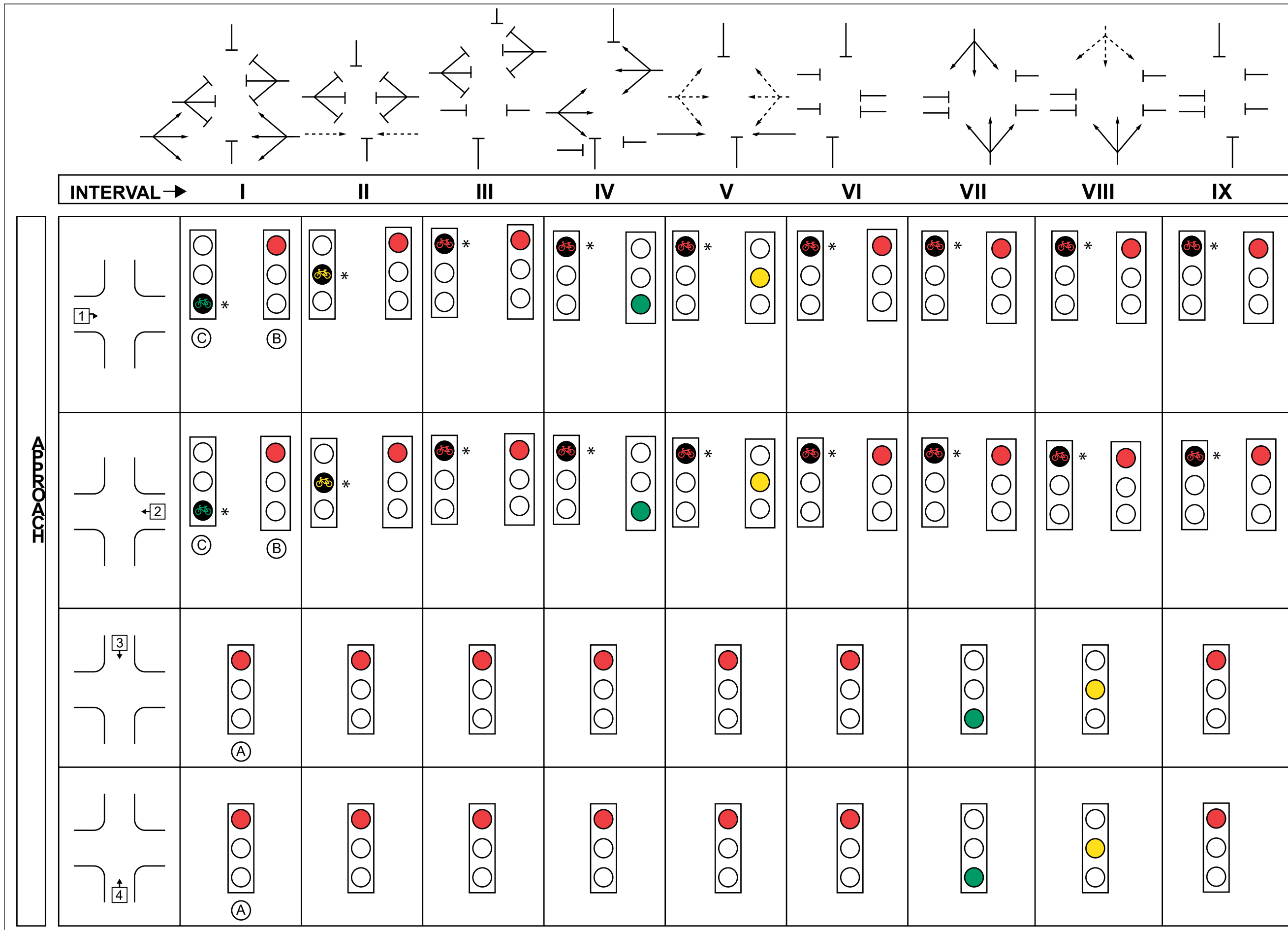
NOTE: The phasing shown has bicycle clearance concurrent with vehicle clearance intervals. That is generally preferred to eliminate confusion. However, if required, the bicycle amber and all-red intervals may be different, as long as the bicycle signal heads are carefully oriented to minimize viewing by motorists.

OPERATION:

Motor vehicle traffic is shown "Through-Only" arrows while bicycles start into the intersection. This then changes to green ball indications and the remaning phasing is the same as a basic two-way phase operation.

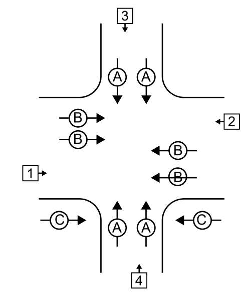
* Bicycle symbol signal heads are to be used after January 1, 2017.

Figure 14 – Signal Phasing: Bicycle-Advanced Through Only Phase



SIGNAL HEAD PLACEMENT

As well as one primary and one secondary vehicle signal head for each approach, bicycle-specific signals are installed for the crossride on the south side.



NOTE: The bicycle signal heads should be carefully oriented to minimize viewing by motorists.

OPERATION:
Motor vehicle traffic is held while bicycles start into the intersection. The bicycle phase is completed before the motor vehicle are released.

* Bicycle signal heads are to be used after January 1, 2017.

Figure 15 – Signal Phasing: Bicycle-Only Separate Phase

proceed into the intersection and take possession of the conflict space, the motor vehicle signal display changes from red ball to green ball. The bicycle green remains on for the full phase, changing to amber and red at the end of the vehicle phase. Pedestrians may be provided with coincidental walk signal to provide a simultaneous advanced pedestrian interval.

5.4.2 Bicycle Only Phase

The most restrictive manner of separating bicycles and turning traffic is to allow the bicycles a minimum green to start, and then transition to bicycle amber and red. All parallel traffic, including pedestrians, is held until the bicycle red is displayed. This provides limited signal time for bicycles but provides complete separation of the conflicting traffic streams. This phasing is shown in Figure 15. This configuration would operate well with bike boxes, which would permit the bicycles to be positioned to take advantage of the unrestricted left and right turns. The chief drawback is the short time interval available for bicycles, which may increase delay for motorists.

5.4.3 Signalization for Bicycle-Specific Phasing

Figures 16 through 19 show two bicycle signal heads placement each for crosswalk/crossride configurations A and B, which have two bicycle signal heads for each movement. Two bicycle-specific signals for each bicycle movement should be used to provide for display redundancy where separate phasing is employed for bicycle movements that is separate and distinct from the phasing for parallel general purpose traffic. Either near-side/far-side or double far-side signal head placements are acceptable. The same basic signal head placements should also be applied to bicycle lanes or tracks, where separate phasing is required.

5.5 Mid-block Crossing Configurations

Mid-block crossings are not as restricted for space and crosswalk/crossride configurations A, B or C can be used. Configuration C may be more compatible with paths where the bicycles, as faster travellers, are in the centre of the path. As noted previously, the final choice of layout will often be a function of the path operating characteristics and width and the practitioner should make an engineering decision based on typical layouts nearby (for consistency) and other factors.

Figures 20 through 23 show Configuration C with either near-side/far-side signals or double far-side signals. Figures 24 through 27 show Configurations A and B with near-side/far-side signals, although double far-side signals may be used for these configurations as well.

The median island shown in Figures 20, 22, 24 and 26 is optional. The design works equally well with or without it.

Typically, bicycle-specific detection is recommended. The pedestrian pushbuttons may be used if they are accessible and available to cyclists. If the location of pushbuttons for pedestrians to comply with AODA requirements places them in a position that is not easily accessed by cyclists, then cyclist detection or cyclist specific pushbuttons and signs should be used.

5.6 Intersection Pedestrian Signal (IPS) Crossings

The situation will occur where a neighbourhood bike route or a designated bike lane crosses a major roadway at a location equipped with an intersection pedestrian signal. The cyclist is expected to use the IPS as a vehicle, regulated by the stop sign. An alternative is to equip the IPS to be activated either by detection in the bicycle lane or by a bicycle

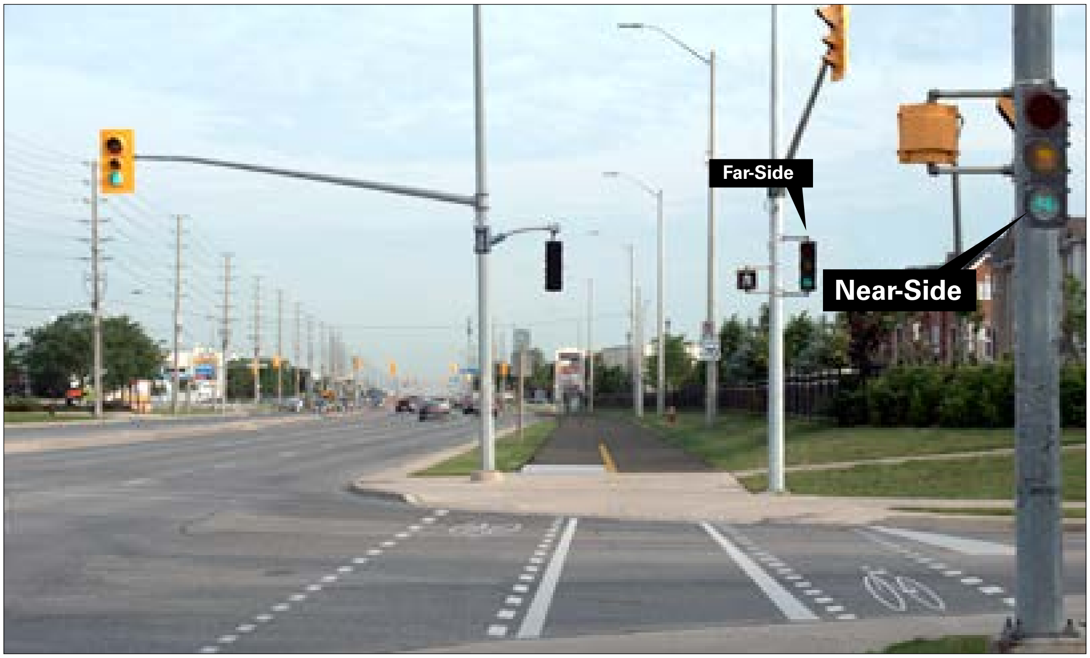


Figure 16 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration B, Near-Side/Far-Side

Figure 17 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration B, Double Far-Side

Figure 18 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration A, Near-Side/Far-Side

Figure 19 – Image: Multi-Use Trail Beside Traffic Signal, Signal Control, Crossing Configuration A, Double Far-Side

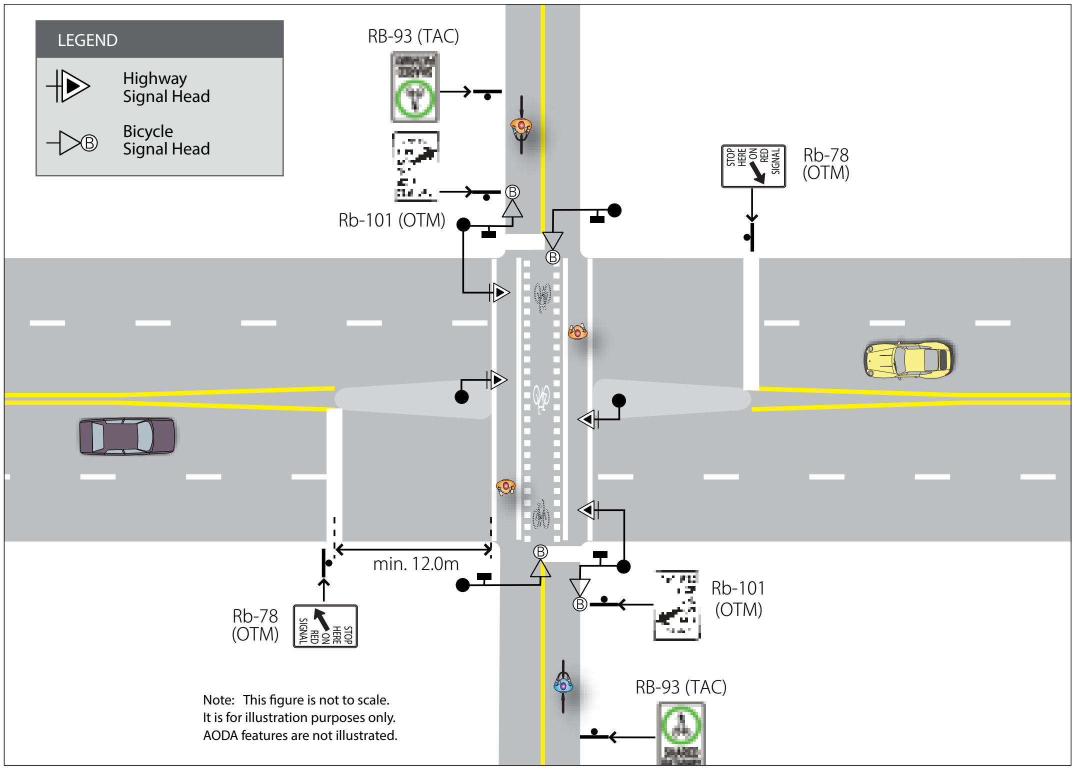


Figure 20 – Design: Mid-block Signalized Trail Crossing, Configuration C, Near-Side/Far-Side

Figure 21 – Image: Mid-block Signalized Trail Crossing, Configuration C, Near-Side/Far-Side

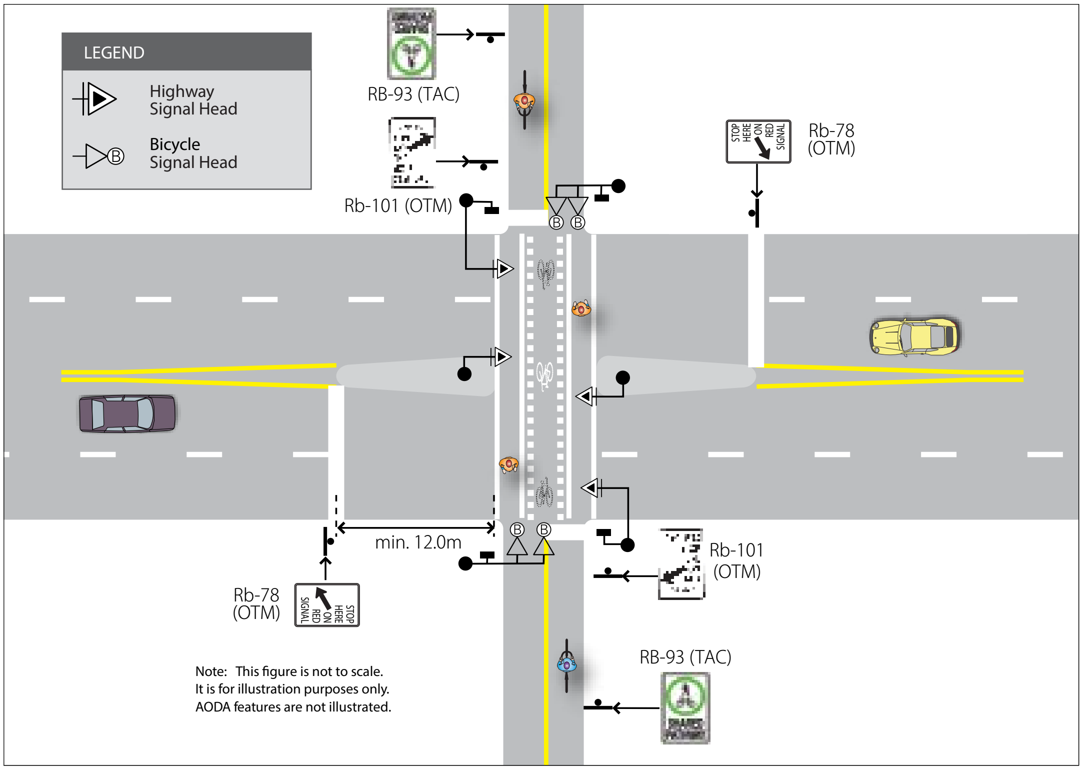


Figure 22 – Design: Mid-block Signalized Trail Crossing, Configuration C, Double Far-Side

Figure 23 – Image: Mid-block Signalized Trail Crossing, Configuration C, Double Far-Side

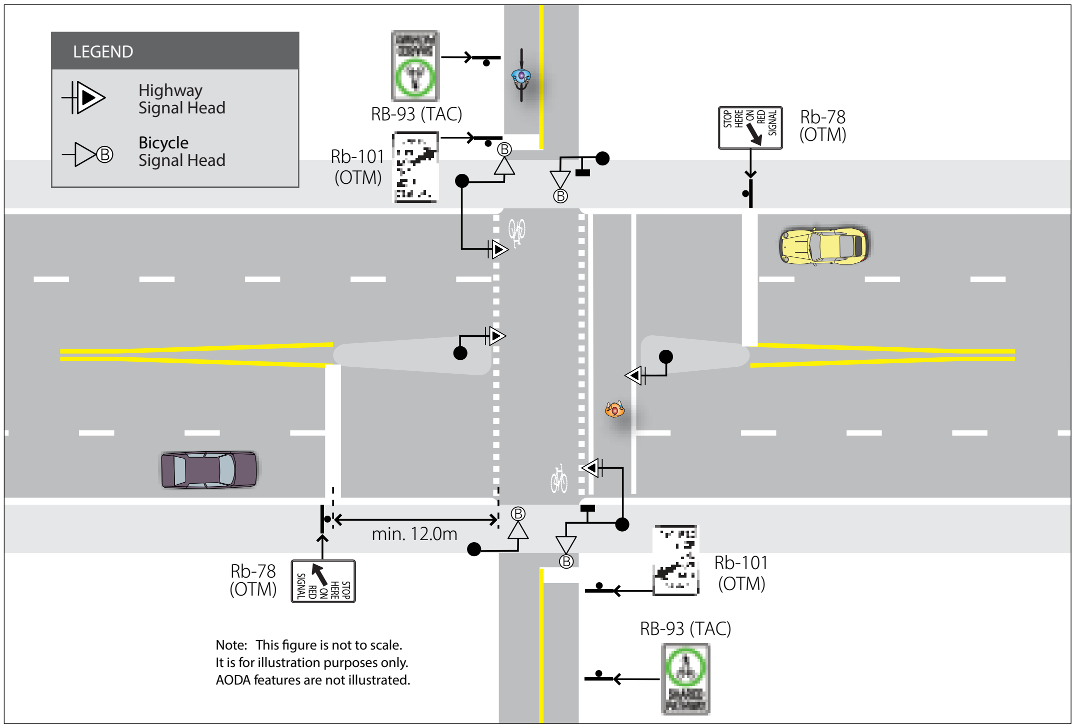


Figure 24 – Design: Mid-block Signalized Trail Crossing, Configuration A, Near-Side/Far-Side

Figure 25 – Image: Mid-block Signalized Trail Crossing, Configuration A, Near-Side/Far-Side

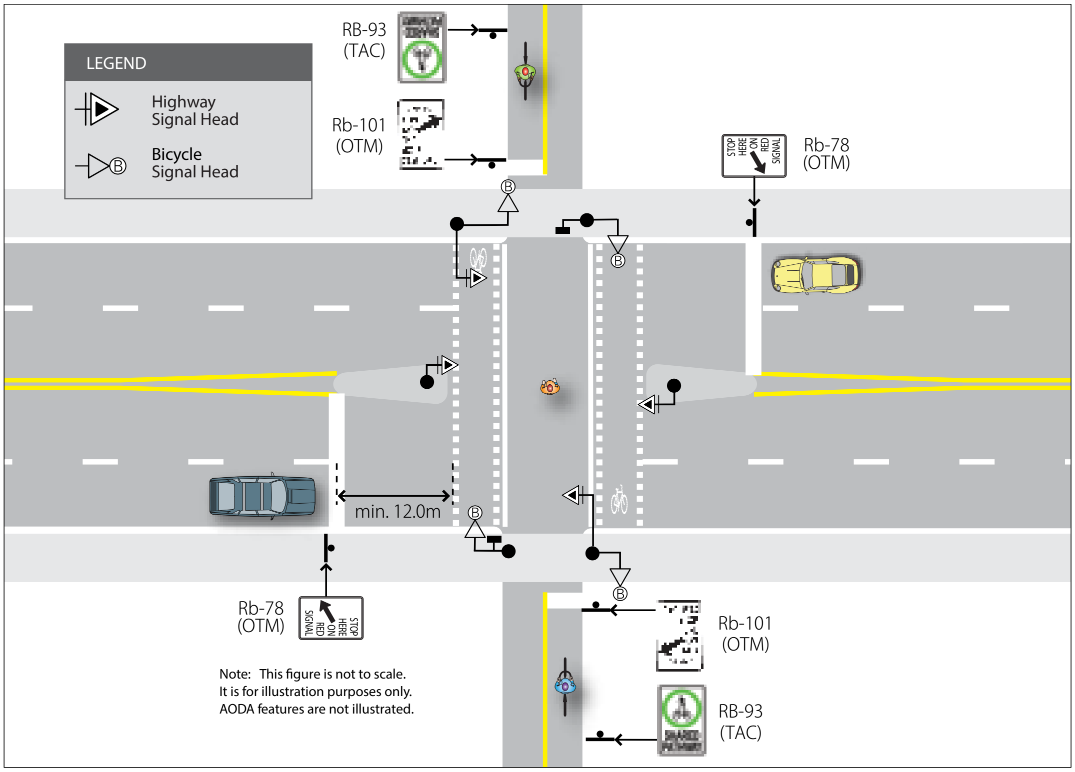


Figure 26 – Design: Mid-block Signalized Trail Crossing, Configuration B, Near-Side/Far-Side

Figure 27 – Image: Mid-block Signalized Trail Crossing, Configuration B, Near-Side/Far-Side

specific detection. The option of bicycle signals for the sidestreet is not permitted as it would conflict with the stop signs (which govern cyclist movements).

5.7 Contraflow Bicycle System

In order to provide continuity in the bike network, it is sometimes necessary to operate bicycles in a direction opposite to the vehicular flow on a one-way street. The lanes may be separated simply by pavement markings or by physical barriers such as curbs. Where the contraflow bicycle lane intersects with a signalized intersection, the only indication that is available would be pedestrian signals.

To provide throughput and safety benefits, bicycle traffic signals are preferable for the contraflow direction, as they are less likely to create confusion for motorists entering the road from nearby driveways.

The bicycle signal phasing generally parallels the vehicular signal phasing for the opposite direction (considering turn phases), but may utilize bicycle-specific signal timings and/or movements.

Figures 28 and 29 show signal configurations for a one-way street with the bicycle lanes split.

Figures 30 and 31 show signal configurations for a bi-directional bicycle lane system, all on one side of a one-way street.

5.8 Rural Applications

Bicycle facilities in rural situations tend to differ from the more common urban facilities. Typically rural bicycle facilities, if present, are limited to bicycle shoulders. Pedestrian actuation, if available, may be poorly located for bicycle riders to access. Motor vehicle detection is typically by induction loops. Where significant bicycle volumes are present at a rural signalized intersection, especially one on a defined bicycle route, attention should be paid to signal timing, especially clearance time, and to pavement markings and signing that would ensure the cyclist positions him or herself over the preferred location on the detection loop. Detection loop sensitivity should be optimized to pick up bicycle calls.

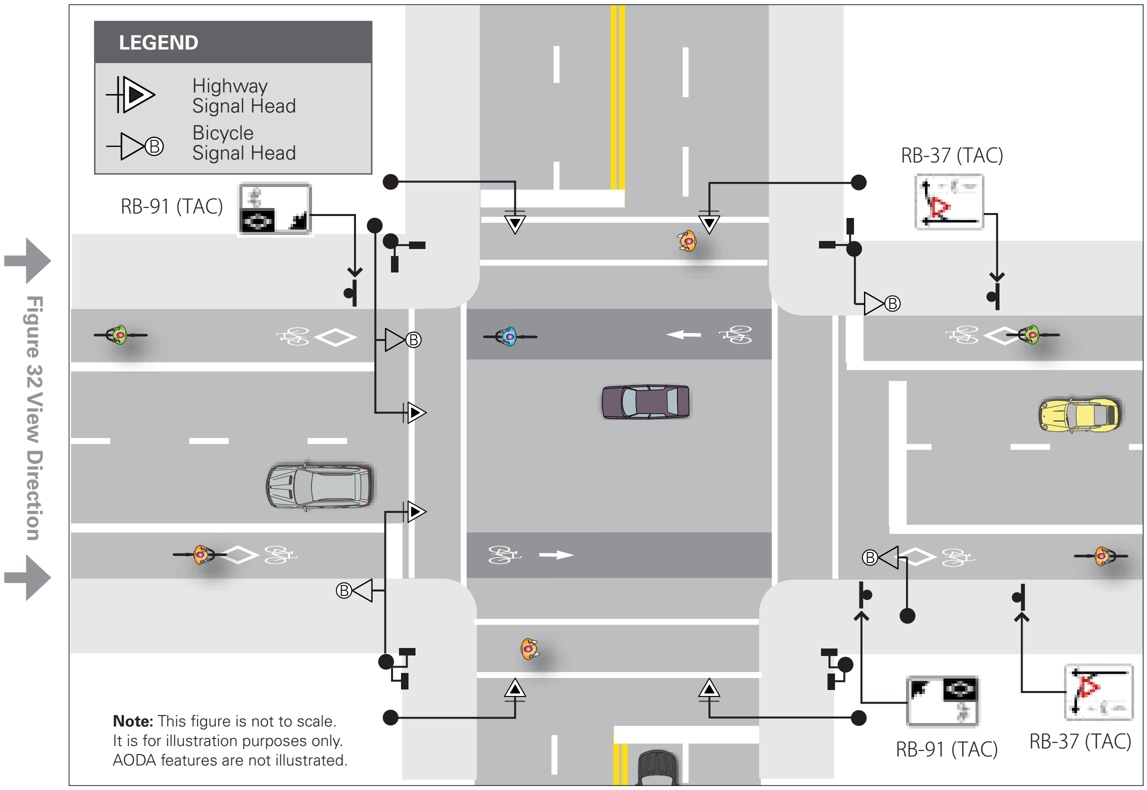


Figure 28 – Design: One-Way Street with Contraflow Bike Lane

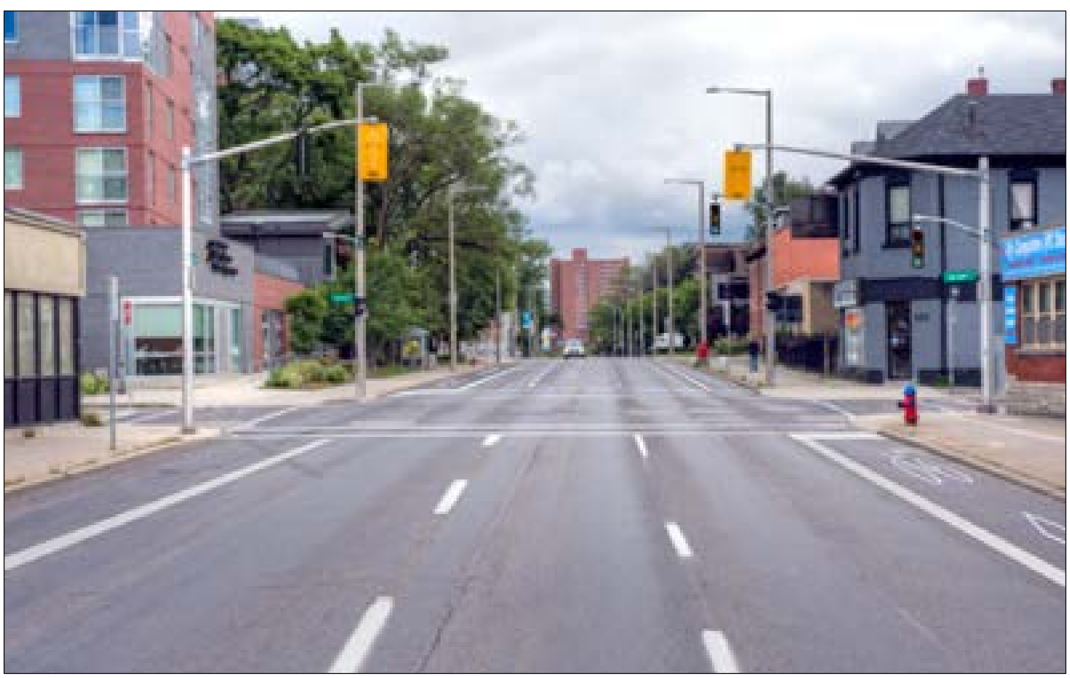


Figure 29 – Image: One-Way Street with Contraflow Bike Lane

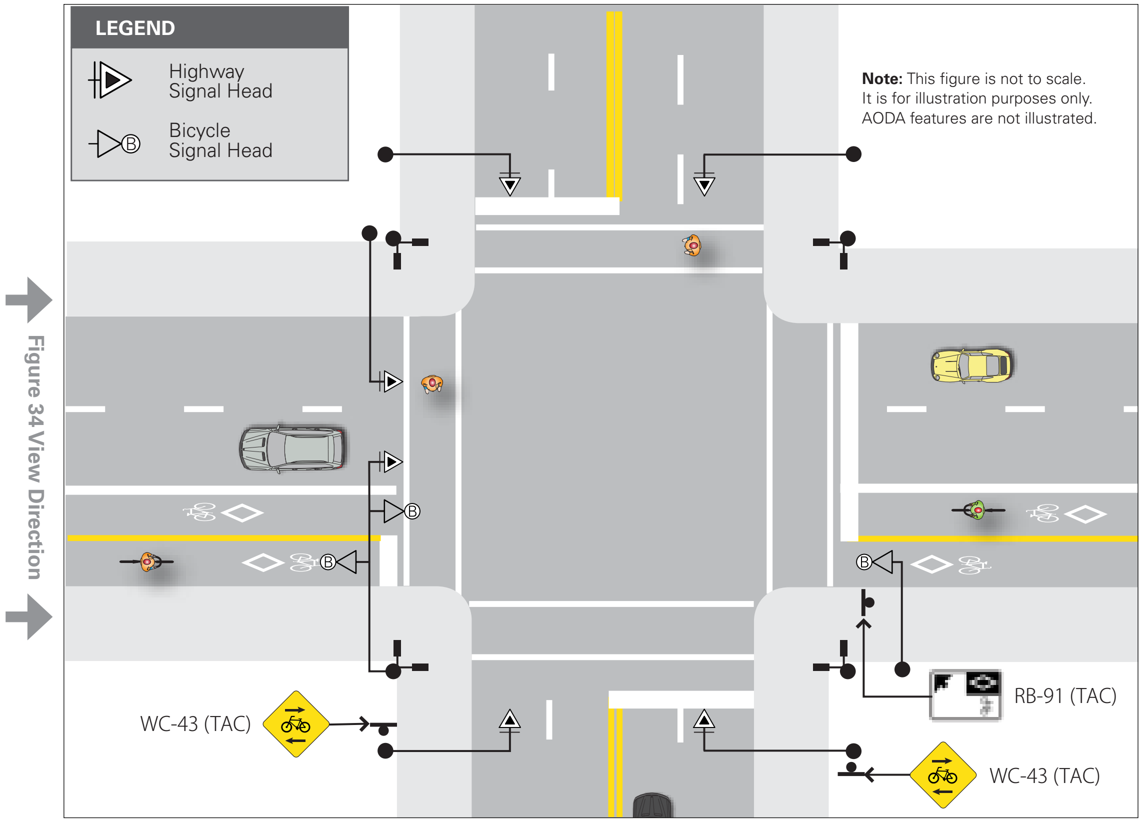


Figure 30 – Design: One-Way Street with Bi-Directional Bike Lane

Figure 31 – Image: One-Way Street with Bi-Directional Bike Lane

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6. Decision Criteria

There are two types of decision or input criteria which are applicable to bicycle signal/bicycle phasing installation. Bicycle signal heads and bicycle signal phasing may be installed where circumstances suggest benefit to cyclists, motorists, pedestrians or all three. Bicycle demand may also be used as a factor in the decision to install a full or partial traffic signal. This section will discuss the two types of justification.

6.1 Criteria Which May Be Used When Considering Separate Bicycle Phases

The term "bicycle-specific phases" includes separate movements, leading or separate phases and contraflow bicycle movements. The decision to provide a separate bicycle phase should be based on a need to reduce delays and eliminate conflicts between bicycles and turning vehicles. The following is a summary of the factors which may be considered when assessing the need for a separate bicycle phasing. An engineering study may be required to determine the impact between bicycles and other modes of traffic.

Volume/Delay Criteria

The following scenarios could be good candidates for providing a separate bicycle phase:

- At locations with high volume of bicycle movements where the overall delay is of concern.
- At locations with high volumes of turning vehicles where the safety of cyclists is of concern.
- At locations with a contraflow bicycle movements.

Collision/Conflict Criteria

- a bicycle signal phase should only be considered for use when an engineering study finds that a significant number of bicycle/motor vehicle conflicts occur or may be expected to occur at the intersection and that other less restrictive measures would not be effective
- collisions (when two or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12 month period and it is determined by the road authority that a bicycle signal will reduce the number of collisions)
- when there is a need to provide a leading interval for cyclists in order to increase their visibility and safety
- geometric factors – to control the separation of conflicting movements between cyclists and motorists

Planning Criteria

- Where the addition of a special bicycle phase would complete the continuity of a bicycle system and where the movement protected or encouraged would otherwise be challenging

Geometric Criteria

- geometric (a path connection or to allow movement not allowed by vehicles)
- geometric factors: an intersection that impedes cyclist crossings that could be mitigated with the bicycle phase
- an approach to a signalized intersection is intended for bicycles only and it is desirable to signalize that approach

- examples of geometric configurations that might benefit from the use of a bicycle signal phase include:
  - o a bike lane to the right of a high volume right turn; and,
  - o a multi-use path that comes into the intersection in such a way that motorists may not see or yield to cyclists approaching the intersection

Timing/Phasing Criteria

- where paths cross roadways – to provide a shorter green time for cyclists when no pedestrians are present
- if there is a bicycle movement that is not accommodated by typical traffic signals

Demographic/Geographic Criteria

- proximity to schools, parks, and popular bike routes should be considered

Impacts to Consider

- bicycle signals should be considered in the context of the benefits and impacts to all road users, both vulnerable and motorized
- additional delay to all roadway users should be considered

Costs

- cost of implementing revised signal operation

6.2 Input to Existing Traffic Signal Warrants

6.2.1 Full Traffic Signal Justification

Bicycles which are part of the general traffic stream or are on designated bike lanes or cycle tracks within the roadway should be included along with motor vehicles when performing traffic counts for the purpose of considering whether a new full traffic signal is justified.

6.2.2 IPS or Mid-Block Pedestrian Signal Justification

While intersection pedestrian signals and mid-block pedestrian signals are primarily devices to aid pedestrians in crossing the roadway, they can serve that purpose for bicycles equally well, as long as provision is made to ensure bicycles can cross the intersection legally and reasonably efficiently. IPS are particularly useful in providing continuity for neighbourhood bike routes when crossing an arterial, while mid-block signals fit well with multi-use or bicycle trail crossings. In the case of a new IPS or mid-block signal to be equipped with bicycle detection or a retrofit to serve bicycles, it is appropriate to add the bicycle traffic to the pedestrian volumes when considering the justification for installation of the signal.

7. Bicycle Detection

7.1 General

Bicycle detection is achieved through the use of inductive loops, or a variety of other detection technologies including video, radar, microwave, infrared, and ultrasonic. Bicycles may be detected using the equipment already in place for general motor vehicle traffic. Alternately, detection specific to bicycles may be installed. A bicycle detector is a vehicle or pedestrian detector that has been assigned to indicate the presence or passage of bicycles in a designated area of the roadway at a signalized intersection.

Things to consider for bicycle detection:

- use of existing versus bicycle-specific detection;
- active or passive detection, requiring various levels of involvement by the cyclist;
- technologies with differing requirements and impacts on the infrastructure, most specifically the roadway pavement; and
- differing sensitivities to bicycles constructed of different materials, specifically the difference between ferrous (steel) and non-ferrous frame and wheel materials.

Bicycle detection is typically installed to measure the presence of bicycles:

- on actuated approaches at semi- or fully-actuated intersections;
- travelling in the general purpose lanes at intersection approaches without bicycle lanes;
- travelling in a bicycle lane;
- at intersections with bicycle signals and/or bicycle specific timings and phasing that are actuated; or
- in left-turn lanes where bicycles may turn left.

While it should be a basic requirement to provide bicycle specific detection wherever bicycles are present, the provision of reliable bicycle detection can assist in establishing bicycling as a legitimate mode of transport. The benefits of providing for bicycle detection at signalized intersections include improved efficiency and reduced delay for bicycles, increased safety and convenience, the discouraging of red light running and the provision of adequate green and/or clearance times for bicycles.

It is important to note that bicycles are more difficult to detect with some common types of vehicle detection technologies than a motor vehicle. Therefore, attention should be paid at both the design and installation stages to ensure that bicycle detectors are appropriate to the environment and will operate reliably.

7.2 Criteria Which May be Used When Considering the Need for Bicycle-Specific Detection

Bicycle-specific detection is required for circumstances in which bicycles move on their own separate phase(s). At actuated signals, either bicycle-specific detection or detection tuned to recognize bicycles reliably should be considered, based on policy, actual demand and bicycle system structure. In other instances, bicycle-specific detection is optional but may be considered highly desirable.

Factors which can be considered in determining whether bicycle detection is installed may include:

- bicycle demand or volume;

- bicycle network considerations, such as signed bike routes or bike lanes and consistency with similar locations throughout the network;
- actuated sidestreets with low sidestreet motor vehicle volume and/or short minimum and vehicle extension timing;
- unusual geometry, such as wide intersections; or
- loops which have low probability of detecting bicycles, such as large rectangular loops.

7.3 Common Types of Bicycle Detectors

7.3.1 Induction Loops

General Vehicle Loops

The most common type of detector in many jurisdictions is the in-pavement induction loop. When the existing vehicle detection is to be used, specific attention must be paid to the sensitivity settings of the detection amplifier. The goal is to set the sensitivity as high as possible without having the detection system "lock up" and place a steady call instead of detecting the arrival of vehicles. Testing and site visits to ensure reliable operation may be required. In some cases, such as when there are long lead lengths from the loop to the controller, it may simply not be possible to use existing loops.

Given the lower sensitivity to bicycles of regular general purpose loops, the use of pavement markings and signing, as discussed later in this chapter, indicating to cyclists where to position their bicycles to have the best chance of being detected, is very important.

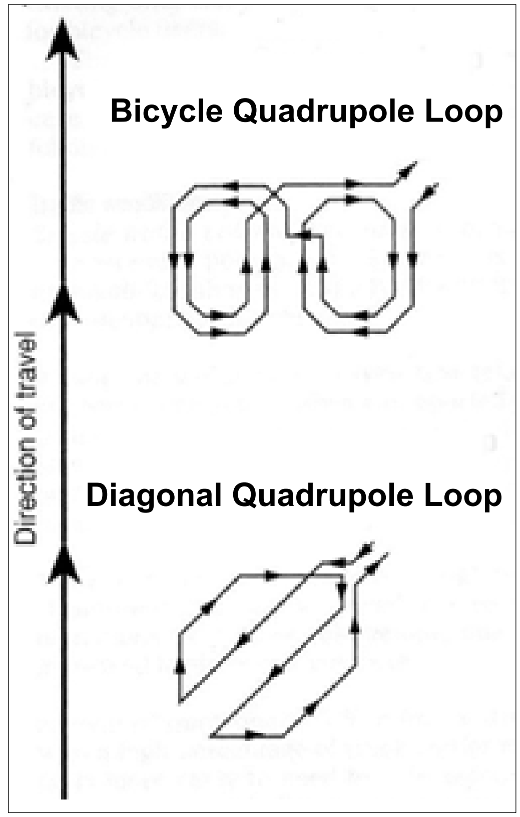

Figure 32 – Quadrupole Detectors

Bicycle Specific Loops

Introducing loops designed specifically to detect bicycles will improve overall intersection operation for both general purpose traffic and cyclists. For bicycles, the loops have greater sensitivity and will be more reliable over the long run. Generally, these loops are capable of detecting ferrous and non-ferrous metal bicycles with reasonable accuracy. The regular vehicle loops can be adjusted with lower sensitivity, meaning higher reliability (less likelihood of lock-up.) It is relatively easy (and not overly expensive) to design in bicycle detection when introducing all-new detection to a roadway approach. However, retrofitting bicycle loops often means the destruction of the general purpose loops, and therefore, other types of bicycle detection may be a better choice.

To help ensure that bicycles are detected, quadrupole or diagonal quadrupole loop detectors are recommended because they are bicycle sensitive over their entire area. Figure 32 shows a typical bicycle-specific loop design. Four turns of #16 gauge copper wire is recommended to effectively detect a wide range of bicycle types. Ideally, loops should be placed in locations that are logical and convenient to cyclists, such as close to the edge of the roadway in a through or combined lane, and close to the right side of a left-turn lane. In order to maximize the loop's effectiveness, supplemental bicycle detector pavement markings and informational signs may be utilized. These markings are discussed in more detail later in this section.

Other loop designs can work but may be less effective and may require a cyclist to position themselves within a much smaller detection area. Therefore, the importance of the use of the supplementary bicycle detector pavement marking and informational signage is increased with other loop designs.

Some road authorities have successfully implemented long-distance detection using induction loops placed about 5 to 10 metres upstream of an intersection within a bicycle lane.

7.3.2 Video

Detection methods that utilize image recognition from video detectors are capable of detecting a cyclist at an intersection over a larger area than a loop detector. However, video detectors have been shown to have a reduced effectiveness in the dark, including registering false calls when shadows appear within the detection zone.

A typical video detector is comprised of a camera and an image processor that is programmed to analyze video images and mimic a loop detector. Defined detection zones can be relatively easily modified, which offers increased flexibility in detector layouts. Video detectors present an excellent alternative to loop detectors in a variety of situations, including where the pavement quality is poor and installation of in-pavement loops can be challenging. Costs for video detection are typically higher than for loop installations.

7.3.3 Radar

There are two forms of radar detection. The above-ground is similar to microwave detection. The wireless in-ground detection systems communicate by radio with a backbone paired with the traffic control system and are capable of differentiating between motor vehicles and bicycles in the same lane.

7.3.4 Microwave

Microwave detectors are mounted above the ground similar to video and beam a cone shaped area to an approaching bicycle, which reflects some of the microwave energy back to the detector. This type of detection can be considered in areas where detector pavement installation is not possible.

7.3.5 Optical

Optical detection uses pulsed infrared light-emitting diodes (LEDs) technology to detect the return time of light from the object to the sensor. This technology can detect many types of motor vehicles and bicycles in all weather conditions, any time of the day. The system can also determine the direction of travel of vehicles, thereby preventing false calls to traffic signal controllers.

These non-intrusive detectors are mounted directly to current traffic infrastructure similar to video detection. Some models also include an onboard image processor with the capability to transmit video images back to the jurisdiction.

7.3.6 Pushbuttons

Another form of bicycle detector is a bicycle-specific pushbutton, which has some advantages over other forms of detection:

- Pushbuttons are simple and easy to use compared to other forms of detection that may require the cyclist to position themselves precisely or approach the intersection in a certain prescribed way in order to be detected.
- Pushbuttons allow for feedback to the cyclist that they have been detected (for example by a visual and/or auditory signal produced by the pushbutton when activated), which may increase compliance with the signal indication and ultimately improve safety.
- Pushbuttons avoid missed calls due to technical limitations experienced with other forms of detection (such as induction loops not detecting a bike with insufficient metal content, or other forms of detection affected by weather conditions like heavy snowfall).

However, pushbuttons also have disadvantages:

- As an active, rather than passive, form of detection, they do not automatically detect the cyclist, but rely on the individual cyclist to activate them.
- Pushbuttons are not appropriate for all intersection geometries (for example to detect a cyclist stopped in a left-turn lane at a typical intersection).

Cyclist activated pushbuttons can be used in conjunction with loop detection. While this arrangement increases the cost of detection, it provides the advantages of both active and passive detection.

Pushbuttons are most appropriate where an off-road cycling facility – such as a multi-use trails or a cycle track – meets a signalised intersection or mid-block crossing. They may also be applicable for single lane approaches, for designated bicycle lanes and other forms of operation where the cyclist is naturally riding next to the right side curb.

If a pushbutton is used, the location of the device should not require cyclists to dismount or be rerouted out of the way or onto the sidewalk to reach it. It should be placed on the right side of the intersection approach, positioned in a manner that is relatively convenient for the cyclist and away from the radius of the curve where it could be struck by large vehicles making a turn.

The pushbutton can be used either to call a bicycle specific phase or to call the pedestrian phase.

Depending on cyclists to use pedestrian pushbuttons is not generally recommended, and should preferably be limited to low bicycle volume locations.

7.4 Pavement Markings and Signage

As opposed to motor vehicles which have greater size and mass and are more easily detected, bicycle detection is highly dependent on the position of the bicycle in relation to the position of the loop detector. In order to realize the maximum level of effectiveness from bicycle detectors, it is important that the cyclist position themselves in the area that provides the strongest detection signal from the loop. Cyclists can be aided in improving the likelihood of being detected by in-pavement loops

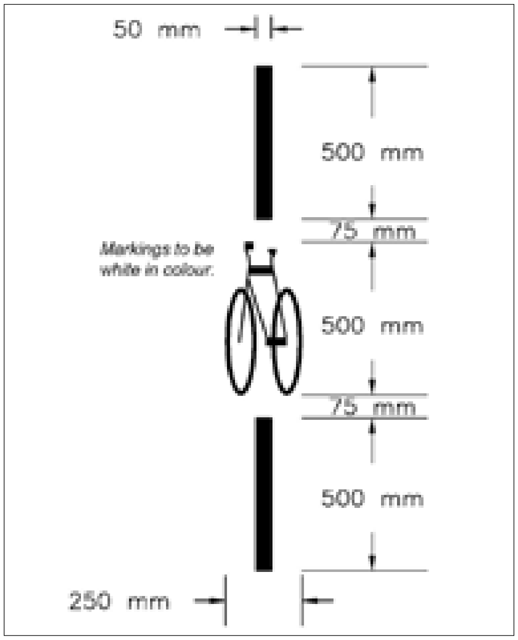

Figure 33 – Bicycle Detector Pavement Marking

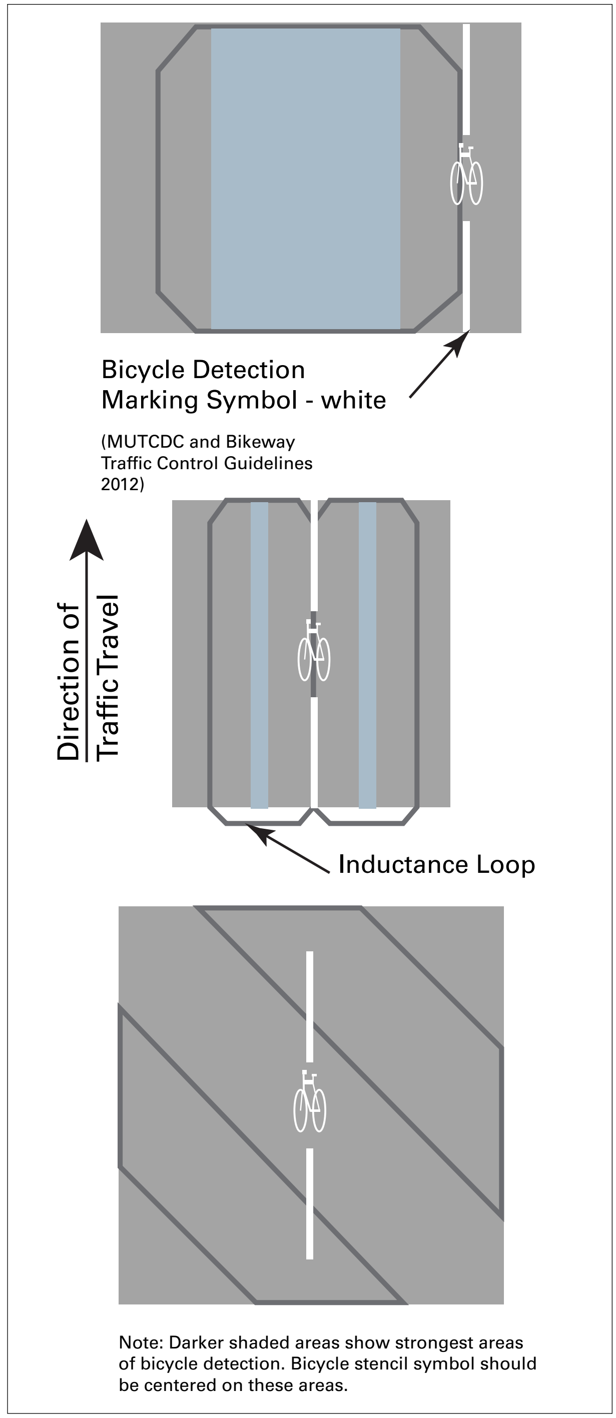

Figure 34 – Signal Detection Areas by Loop Detector Type

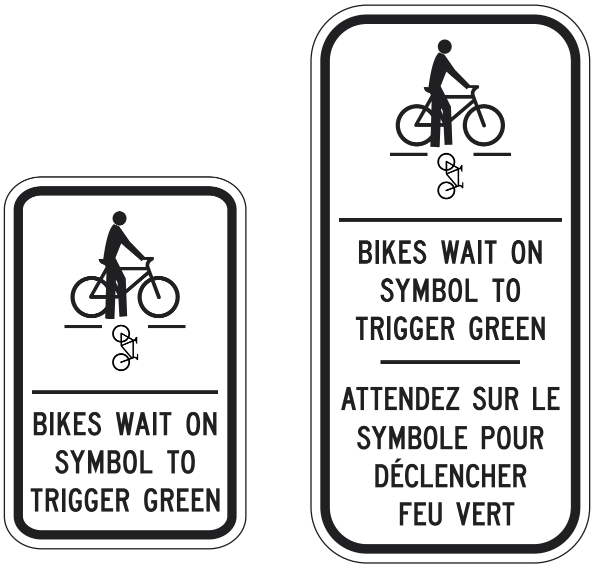

Figure 35 – Bicycle Signal Detection Stencil Sign (OTM Rb-102 & Rb-102 (B))

by careful application of pavement markings, possibly in combination with information signage, which would indicate where to place the bicycle in order to best be detected.

Figure 33 shows the TAC approved symbol which indicates to cyclists where to position the bicycle on the roadway.

Figure 34 shows the typical placement of the pavement marking symbol on various loop configurations.

Figure 35 shows Ontario standard signs OTM Rb-102 & Rb-102 (B) which should accompany this pavement marking stencil, especially for the introductory period.

APPENDIX A
Parameters for Calculating Bicycle Signal Timing

In the absence of empirical information, the following suggested values may be considered:

Starting PRT = 1.0 s minimum

V = 4.0 - 5.6 m/s (14-20 km/h)

a = 1.0 m/s^2

L = 1.8 m

SU = 6 seconds

W = typically measured from stop bar to far crosswalk line or equivalents if marking is not present

PRT for stopping = 2.5 seconds

d = deceleration rate of 3.0 m/sec^2

Suggested Values From Other Sources

TERM	SOURCE	VALUE
V	NACTO[5]	14 f/s (15.4 km/h)
W	NACTO[5]	stop line to mid-point of far lane
V, level	AASHTO (2012)[4]	13-24 km/h
V, level	California	14.7 f/sec (16.1 km/h)
V	TAC	20 km/h
V	CROW	20 km/h
V, downhill	AASHTO (2012)[4]	32-50 km/h
V, uphill	AASHTO (2012)[4]	8-19 km/h
PRT	AASHTO (2012)[4]	1.0 – 2.5 seconds
PRT	CROW	1.0 second
Deceleration, dry	AASHTO (2012)[4]	4.8 m/s^2
Deceleration, wet	AASHTO (2012)[4]	2.4-3.0 m/s^2
Deceleration	CROW	1.5 m/s^2
L	AASHTO (2012)[4]	1.8 m
a	AASHTO (2012)[4]	0.5 – 1.5 m/s^2
A	CROW	0.8 – 1.2 m/s^2
SU	California	6 Seconds
Tmin	TAC	5 – 15 seconds

APPENDIX B
References

1. **Highway Traffic Act (HTA)**, Office Consolidation, Revised Statutes of Ontario,1990, Chapter H.8 and the Regulations thereunder (as amended); Queen's Printer for Ontario.

2. **Accessibility for Ontarians with Disabilities Act (AODA)**, Statutes of Ontario, 2005, Chapter 11 and the Regulations thereunder (as amended); Queen's Printer for Ontario.

3. **Ontario Provincial Standard Drawings**, Volume 4, Electrical Drawings, Division 2000. Ministry of Transportation, Ontario and Municipal Engineering Association.

4. **Guide for the Development of Bicycle Facilities"**, AASHTO, 2012.

5. **Urban Bikeway Design Guide**, NACTO, 2012.

6. **Ontario Traffic Manual, Book 18 "Cycling Facilities", December 2013**.

Ontario

Book 12A

Ontario Traffic Manual

November 2018