OPERATIONAL GUIDANCE FOR BICYCLE-SPECIFIC TRAFFIC SIGNALS IN THE UNITED STATES: A REVIEW

Interim Report #1

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by

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1 INTRODUCTION

The purpose of this report is to summarize the relevant design and related guidance for bicycle-specific traffic signals, the existing published literature, and the results of a survey of installed bicycle-specific traffic signals in North America. This interim report contains the following four chapters:

- Background – A summary of relevant design manuals, legislation, and policy.
- Literature Review – A synthesis of published literature related to bicycle-specific traffic signals.
- State of the Practice – A summary of our survey of known installations of bicycle-specific traffic signals, mostly in the U.S. but with a handful of Canadian jurisdictions.
- Research Needs – Based on the results of the above reviews, a discussion of the identified research needs.

2 BACKGROUND

This chapter briefly reviews the relevant design manuals, engineering documents, and enabling legislations. These are provided as context for the subsequent chapters. The review includes both versions of the AASHTO *Guide for the Development of Bicycle Facilities*.

2.1 DESIGN MANUALS

2.1.1 Guide for the Development of Bicycle Facilities (AASHTO, 1999)

The American Association of State Highway and Transportation Officials' [AASHTO] 1999 *Guide for the Development of Bicycle Facilities* recognizes that the greatest risk for cyclists at an intersection is when crossing. This is especially so during periods of low traffic flow at actuated signals where the minimum clearance interval for waiting cars may be inadequate for cyclists entering during the yellow phase. From the *Guide*, equations for the minimum clearance interval are as follows:

For Metric Units:

$$y + r_{clear} \geq t_r + \frac{v}{2b} + \frac{w + l}{v}$$

where:

- y = yellow interval(s)
- r_{clear} = red clearance interval(s)
- t_r = reaction time (1.0 s)
- v = bicyclist speed (m/s)
- b = bicyclist braking deceleration (1.2 to 2.5 m/s^2)
- w = width of crossing (m)
- l = bicycle length (1.8 m)

For English Units:

$$y + r_{clear} \geq t_r + \frac{v}{2b} + \frac{w + l}{v}$$

- y = yellow interval(s)
- r_{clear} = red clearance interval(s)
- t_r = reaction time (1.0 s)
- v = bicyclist speed (mph)
- b = bicyclist braking deceleration (4 to 8 ft/s^2)
- w = width of crossing (ft)
- l = bicycle length (6 ft)

Figure 2-1 Total Clearance Interval Equations (AASHTO, 1999)

It should be noted that for many intersection widths, this formula produces very long yellow and red clearance intervals. Cyclists starting from a stopped position require a minimum total phase time in order to perform a complete crossing maneuver including reacting to the new green signal and accelerating from stop. After establishing minimum yellow and all-red intervals, a minimum green time is needed to ensure most cyclists can safely cross an intersection from a stopped position. Equations for the minimum green time from the *Guide* are as follows:

For Metric Units:

$$g + y + r_{clear} \geq t_{cross} = t_r + \frac{v}{2a} + \frac{w+l}{v}$$

where;

- g = minimum green
- y, r_{clear} = yellow and red clearance intervals actually used
- t_{cross} = Time to cross the intersection
- t_r = Reaction time (2.5 s)
- v = Bicycle speed (m/s)
- a = Bicycle acceleration (0.5 – 1.0 m/s^2)
- w = Width of crossing (m)
- l = Bicycle length (1.8 m)

For English Units:

$$g + y + r_{clear} \geq t_{cross} = t_r + \frac{v}{2a} + \frac{w+l}{v}$$

- g = minimum green
- y, r_{clear} = yellow and red clearance intervals actually used
- t_{cross} = Time to cross the intersection
- t_r = Reaction time (2.5 s)
- v = Bicycle speed (ft/s)
- a = Bicycle acceleration (1.5 - 3 ft/s^2)
- w = Width of crossing (ft)
- l = Bicycle length (6 ft)

Figure 2-2 Minimum Green Time Equations (AASHTO, 1999)

In lieu of field data from actual cyclists at the intersection to be timed, the AASHTO's *Guide* uses three classes of cyclist to estimate cyclist speed for use in the above equations. The three categories of "design" cyclists were originally established in a Federal Highway Administration [FHWA] report on accommodating bicycles on roadways (1994). The FHWA and AASHTO define the classes A, B, and C as follows:

- Class A – Advanced Cyclists: This type of cyclist feels comfortable using the current roadway infrastructure alongside motor vehicles and treats their bicycle similarly to a motor vehicle. Class A cyclists want direct, convenient access to destinations with minimal delay or detour.

- Class B – Basic Cyclists: This type of cyclist is less confident than Class A cyclists and generally avoids interacting with motor vehicle traffic. Class B cyclists are more comfortable on low-volume streets or on roadways with bicycle-specific facilities.

- Class C – Children: Children are not as fast or agile as adult riders. This type of cyclist, whether accompanied by parents or alone, needs well-defined bicycle facilities on busier roads or streets with low motor vehicle speeds and volumes.

The Guide states that, if field observation data is unavailable, the following speeds should be used to accommodate 98 percent of cyclists in Group A, B, and C, respectively: 12 mph (17.6 ft/s), 8 mph (11.7 ft/s), and 6 mph (8.8 ft/s). It is unclear as to the source of these values.

The document contains no other guidance related to bicycle-specific signals.

2.1.2 Urban Bikeway Design Guide (NACTO, 2011)

The National Association of City Transportation Officials [NACTO] Urban Bikeway Design guide contains a chapter on bicycle signal heads. The guide identifies required, recommended and optional features as they relate to bicycle signal heads (including operations and timing parameters). The NACTO guide requires that an "adequate clearance interval (i.e., the movement's combined time for the yellow and all-red phases) shall be provided to ensure that bicyclists entering the intersection during the green phase have sufficient time to safely clear the intersection before conflicting movements receive a green indication." In determining this minimum interval, field investigation of bicyclists' speeds is recommended. The guide suggests intervals sufficient for 15th percentile speeds should be used. Absent field data, the guide suggests that "14 feet per second (9.5 miles per hour) may be used as a default speed." The total clearance interval is specified with the following equation:

$$C_i = 3 + \frac{W}{V}$$

where intersection width (*W*) should be calculated from the intersection entry (i.e., stop-line or crosswalk in the absence of a stop-line) to half-way across the last lane carrying through traffic and *V* is the rolling speed of the cyclist (this differs from AASHTO and Caltrans guidance). The guide notes that there are currently no national standards on determining an appropriate clearance interval.

The NACTO guide mentions that the bicycle minimum green time is determined using the bicycle crossing time for standing cyclists. A clear definition of standing is not provided, though Rubins and Handy define a standing start cyclist as a cyclist with at least 1 foot on the ground.

2.1.3 Guide for the Development of Bicycle Facilities (AASHTO, 2012)

The recently released AASHTO *Guide for the Development of Bicycle Facilities* provides revised treatment of the information as it relates to the types of cyclists and guidance about minimum crossing times. The three classes of cyclists (A, B, and C) have been replaced by two new classes named "*Experienced and Confident*" and "*Casual and Less Confident*". Descriptive characteristics of each class are presented, with a few ranges of operating performance described. These are shown in Table 2-1.

Table 2-1 Rider Characteristics (AASHTO, 2012)

Experienced/Confident Riders	Casual/Less Confident Riders
Most are comfortable riding with vehicles on streets, and are able to navigate streets like a motor vehicle, including using the full width of a narrow travel lane when appropriate and using left-turn lanes.	Prefer shared use paths, bicycle boulevards, or bike lanes along low-volume, low-speed streets.
While comfortable on most streets, some prefer on-street bike lanes, paved shoulders, or shared use paths when available.	May have difficulty gauging traffic and may be unfamiliar with rules of the road as they pertain to bicyclists; may walk bike across intersections.
Prefer a more direct route.	May use less direct route to avoid arterials with heavy traffic volumes.
Avoid riding on sidewalks. Ride with the flow of traffic on streets.	If no on-street facility is available, may ride on sidewalks.
May ride at speeds up to 25 mph on level grades, up to 45 mph on steep descents.	May ride at speeds around 8 to 12 mph.
May cycle longer distances.	Cycle shorter distances: 1 to 5 miles is a typical trip distance.

Information about the design vehicle and key performance characteristics are presented in ranges without the distinction by type or class. The new AASHTO performance assumptions are shown in the table below:

Table 2-2 Key Performance Criteria (AASHTO, 2012)

Bicyclist Type	Feature	Value	
		U.S. Customary	Metric
Typical upright adult bicyclist	Speed, pave level terrain	8-15 mph	13-24 km/h
	Speed, downhill	20-30 plus mph	32-50 plus km/h
	Speed, uphill	5-12 mph	8-19 mph
	Perception reaction time	1.0-2.5s	1.0-2.5s
	Acceleration rate	1.5-5.0 ft/s^2	0.5-1.5 m/s^2
	Coefficient of friction for braking, dry level pavement	0.32	0.32
	Deceleration rate (dry level pavement)	16.0 ft/s^2	4.8 m/s^2
	Deceleration rate for wet conditions (50-80% reduction in efficiency)	8.0-10.0 ft/s^2	2.4-3.0 m/s^2
Recumbent bicyclist	Speed, level terrain	11-18 mph	18-29 km/h
	Acceleration rate	3.0-6.0 ft/s^2	1.0-1.8 m/s^2
	Deceleration rate	10.0-13.0 ft/s^2	3.0-4.0 m/s^2

Note: The speeds reported are for bicyclists on shared use paths. Experience suggest that maximum speeds on roadways can be considerably higher

The new guide presents timing issues separately for standing and rolling bicyclists. For stopped bicyclists, the guide presents the equations to determine the minimum green required for a cyclists to start from stop and clear the intersection width (this width is not specifically defined). These equations are presented in

Table 2-3. Note that the presentation of the calculation of minimum green recommends a change in the reaction time from 2.5 secs to 1.0 secs for standing crossing time (i.e. a bicycle starting from a stopped position).

Table 2-3 Bicycle Minimum Green Time Using Standing Bicycle Crossing Time (AASHTO, 2012)

U.S. Customary		
$\mathbf{BMG} = \mathbf{BCT_{standing}} - \mathbf{Y} - \mathbf{R_{clear}}$ $\mathbf{BMG} = \mathbf{PRT} + \frac{\mathbf{V}}{\mathbf{2a}} + \frac{(\mathbf{W}+\mathbf{L})}{\mathbf{V}} + \mathbf{Y} + \mathbf{R_{clear}}$		
where:		
BMG	=	bicycle minimum green time (s)
$\mathrm{BCT_{standing}}$	=	bicycle crossing time (s)
Y	=	yellow change interval (s)
$\mathrm{R_{clear}}$	=	all-red (s)
W	=	intersection width (ft)
L	=	typical bicycle length = 6 ft (see Chapter 3 for other design users)
V	=	bicycle crossing speed at inter-section (ft/s)
PRT	=	perception reaction time = 1s
a	=	bicycle acceleration (1.5 ft/s2)

Metric		
$BMG = BCT_{standing} - Y - R_{clear}$ $BMG = PRT + \frac{V}{2a} + \frac{(W+L)}{V} + Y + R_{clear}$		
where:		
BMG	=	bicycle minimum green time (s)
$BCT_{standing}$	=	bicycle crossing time (s)
Y	=	yellow change interval (s)
R_{clear}	=	all-red (s)
W	=	intersection width (m)
L	=	typical bicycle length = 1.8 m (see Chapter 3 for other design users)
V	=	bicycle crossing speed at inter-section (ft/s)
PRT	=	perception reaction time = 1s
a	=	bicycle acceleration (0.5 m/s^2)

For rolling cyclists, the guide presents equations for determining the braking distance and rolling crossing time. A cyclist who enters the intersection just at the end of green should have sufficient time to clear the intersection during the yellow change and red clearance intervals. The rolling time is presented as the sum of the braking distance, intersection width, and length of bicycle divided by the assumed rolling speed (suggested as 10 mph or 14.7 ft/s). These equations are presented in Table 2-4. The presentation of these equations in the previous guidance as a means to determine the length of yellow change interval and red clearance for bicyclists has been removed. Instead, the new AASHTO guide states that "the yellow interval is based on the approach speeds of automobiles, and therefore, should not be adjusted to accommodate bicycles" (pp 4-46). The guide suggests modifying the red time, or if that is insufficient, to provide for extension time using a dedicated bicycle detector and controller settings to add sufficient time to clear the intersection.

Table 2-4 Rolling Bicycle Crossing Time Considering Braking Distance (AASHTO, 2012)

U.S. Customary		
$BCT_{standing} = \frac{BD + W + L}{V}$ $BD = PRT \times V + \frac{V^2}{2a}$		
where:		
$BCT_{standing}$	=	bicycle crossing time (s)
W	=	intersection width (ft)
L	=	typical bicycle length = 6 ft (see Chapter 3 for other design users)
V	=	bicycle crossing speed at inter-section (ft/s)
BD	=	breaking distance (ft)
PRT	=	perception reaction time = 1s
a	=	deceleration rate for wet pavement = 5 ft/s^2

Metric		
$BCT_{standing} = \frac{BD + W + L}{V}$ $BD = PRT \times V + \frac{V^2}{2a}$		
where:		
$BCT_{standing}$	=	bicycle crossing time (s)
W	=	intersection width (m)
L	=	typical bicycle length = 1.8 m (see Chapter 3 for other design users)
V	=	bicycle crossing speed at inter-section (ft/s)
BD	=	breaking distance (m)
PRT	=	perception reaction time = 1s
a	=	deceleration rate for wet pavement = 1.5 m/s^2

The document also contains some information on detectors and placements. There is no other guidance related to bicycle-specific signals.

It must be noted that AASHTO 2012 recommendations for minimum stopping sight distance are slightly different than the previous 1998 Guide with a smaller deceleration rate; the minimum stopping sight distance S is calculated using this formula:

$$S = PRT\ V \ + \frac{V^2}{30(f \pm G)}$$

where the recommended PRT is 2.5 seconds and f is 0.16; hence, in all cases $BD < S$.

There is no discussion of potential dilemma zones.

Regarding bicycle detection the new AASHTO guide states that “Actuated traffic signals should detect bicycles”. The guide also indicates that “It may be desirable to install advance detection bicycle detection, similar to advance vehicle detection. Where it is installed, advance detection makes it possible to minimize delay to cyclists and provide green extension time by installing one small area detection zone about 100ft (30 m) from the stop bar, with a second, perhaps larger, detection zone located at the stop bar".

The new AASHTO guide does not discuss the impact of stopping sight distance (close to 100 ft at 15 mph) on detection location, green extension timing for bicycles, or the impacts of green extensions on total intersection delay or maximum green times.

2.1.4 MUTCD (FHWA, 2009)

There are two references to bicycle signals in the current MUTCD. First, in *Section 4D.07 Size of Vehicular Signal Indications* the manual permits the use of an 8 inch circular indication for the "sole purpose of controlling a bikeway or a bicycle movement." The use of the RYG bicycle stencil in lenses is not provided.

In *Section 9D.02 Signal Operations for Bicycles* standards are provided for the installation of visibility-limited signal faces. The MUTCD requires that when these are used, "signal faces shall be adjusted so bicyclists for whom the indications are intended can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces shall be provided for the bicyclist". In addition, the manual states that on bikeways[1], "signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists."

2.1.5 California MUTCD (Caltrans, 2012)

The California MUTCD includes significant guidance for bicycle-specific signals. Section 4C.102 provides a *Bicycle Signal Warrant* which states that "a bicycle signal should be considered for use only when the volume and collision or volume and geometric warrants have been met". These are identified as:

- volume (based on the number of bicycles per peak hour (at least 50) and the number of vehicles at the peak hour entering the intersection)
- collision (when 2 or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions) and
- geometric (a path connection or to allow a movement not allowed for vehicles).

The manual states that a bicycle signal should be used only after other alternatives have been used.

The California MUTCD allows 8 inch lens for the circular indications in a signal face installed for the sole purpose of controlling a bikeway or a bicycle movement. The manual specifies the use of the bicycle insignia by stating that "only green, yellow and red lighted bicycle symbols, shall be used to implement bicycle movement at a signalized intersection". Figure 4D-112 (CA) in the manual shows the RYG arrangement (with bicycle stencil facing left):

[1] "a generic term for any road, street, path, or way that in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes" MUTCD, pg 11

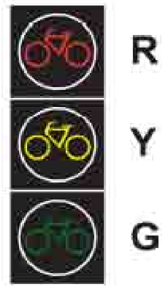


Figure 2-3 Figure 4D-112 (CA) Example of Bicycle Signal Face

The manual provides detection guidance (including drawings of detector placement). It also provides provisions on the minimum timing parameters. The manual states that "for all phases, the sum of the minimum green, plus the yellow change interval, plus any red clearance interval should be sufficient to allow a bicyclist riding a bicycle 6 feet long to clear the last conflicting lane at a speed of 10 mph (14.7 ft/s) plus an additional effective start-up time of 6 seconds, according to the formula:

$$G_{min} + Y + R_{clear} > 6\,\text{sec} + \frac{(W + 6\,ft)}{14.7\,ft/sec}$$

where:

G_{min} = Length of minimum green interval (sec)
Y = Length of yellow interval (sec)
R_{clear} = Length of red clearance interval (sec)
W = Distance from limit line to far side of last conflicting lane (feet)

The minimum time, based on the distance, is provided in a table, shown following:

Table 2-5 Signal Operations - Minimum Bicycle Timing (Caltrans)

Table 4D-109 (CA). Signal Operations - Minimum Bicycle Timing

$G_{min} + Y + R_{clear} \geq 6$ sec + (w+6 ft)/14.7 ft/sec, where
G_{min} = Length of minimum green interval (sec)
Y = Length of yellow interval (sec)
R_{clear} = Length of red clearance interval (sec)
W = distance from limit line to far side of last conflicting lane (ft)

Distance from limit line to far side of last conflicting lane	Minimum phase length (minimum green plus yellow plus red clearance)
Feet	Seconds
40	9.1
50	9.8
60	10.5
70	11.2
80	11.9
90	12.5
100	13.2
110	13.9
120	14.6
130	15.3
140	15.9
150	16.6
160	17.3
170	18.0
180	18.7

The AASHTO and California formulas estimate similar numbers; with the default AASHTO values of perception-reaction (1 second), speed (14.7 ft/sec), and acceleration (1.5 ft/sec^2), the first two terms of the AASHTO equation are approximately 6 seconds.

$$PRT + \frac{V}{2a} \approx 6\ sec.$$

2.1.6 Traffic Signal Timing Manual (FHWA, 2008)

The FHWA Traffic Signal Timing Manual (2008) contains many references to accommodating bicycles at intersection signals but no specific guidance in terms of timing parameters or clearance intervals. The manual is currently being updated and will likely include additional guidance.

2.1.7 Traffic Signal Guidelines for Bicycles (Transportation Association of Canada (TAC), 2004)

This report compiled to provide a list of best practices for the application of bicycle-specific traffic signals in Canada, this report is comprehensive in its recommendations regarding bicycles at traffic signals. Section 4.1.2 of *Traffic Signal Guidelines* recommends that bicycle signals comply with the bicycle standards of Quebec province which requires signals to consist of three 200 mm (8 in.) circular lenses stacked vertically with bicycle insignia as shown in Figure 2-4. Inclusion of a lens insignia is expressly recommended to eliminate motorist confusion.

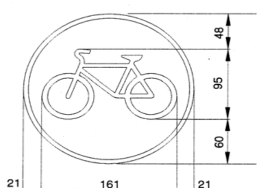


Figure 2-4 Quebec Standard Signal Head (TAC)

Another aesthetic recommendation is that the housing color of bicycle signals be black (opposite the usually-yellow housings for motorist signals) to further distinguish their special use. It is noted that bicycle signals are intended to signal permissive movements only with all bicycle movements being permitted unless there is signage to indicate otherwise.

Sections 4.1.3 and 4.1.4 discuss timing and phasing for bicycle signals, respectively. The average typical cruising speed of a cyclist is given to be 20 km/h (12.4 mph), and it is suggested that cyclists in mixed traffic are adequately served by existing green times for the majority of cases. Recognizing the extra steps for cyclists to begin pedaling from start (e.g. lock into toe clips, engage lower gear) the document recommends an absolute minimum green time of 5 seconds. It is also suggested that minimum vehicular greens at very wide crossings or on uphill gradients be extended to accommodate cyclists. Recommendations for clearance intervals are that yellow times should remain unchanged, since cyclists can more easily stop than motor vehicles, and that, if needed, red clearance displays can be extended to accommodate slower cyclists. For exclusive bicycle phasing, the recommended minimum green time is 10 seconds for most intersection widths. For very wide intersections where cyclists must accelerate from a stop, an additional 5 s can be allocated to the minimum green time for a total of 15 seconds. Yellow and red times should be shorter and longer than motorist times, respectively, although values for these times were not given.

Section 4.1.5 states procedures for installation of bicycle signals. Recommendations applicable to newly installed signals are as follows:

- One signal head should be installed in the field of vision of cyclists or within 30 meters of the stop bar for easy perception and identification of the signal
- 300 mm lenses are appropriate for signal heads more than 30 meters away from stopped cyclists. Alternatively, bicycle signals may be placed in both the road median and at the far edge of very wide intersection.

- Signal indications should contain LED's
- Mounting heights for bicycle signals should be the same as pedestrian signals heads on the opposite side of an intersection. Bicycle signals placed over the travelled part of the roadway should be mounted at the standard signal height above the roadway. Suggested mounting heights and positions can be seen in Figure 2-5.
- Supplemental near-side displays are suggested for very wide intersections or those with complex geometry

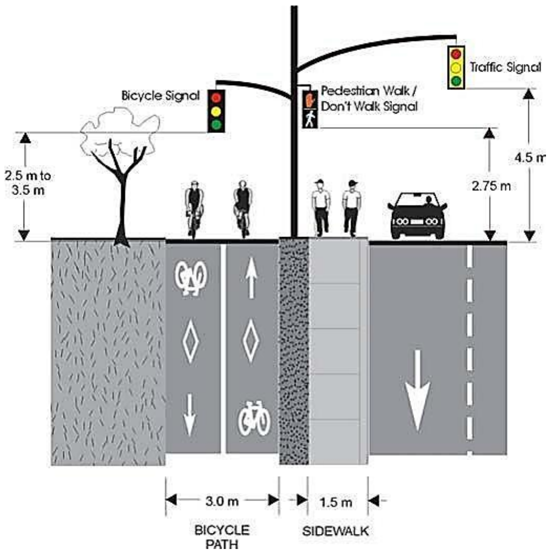


Figure 2-5 Typical Mounting Heights for Bicycle Traffic Signals -- Figure 4.2 (TAC)

Section 4.1.6 discusses justifications for the installation of a bicycle signal. Although several key factors to consider are detailed in the report, no thresholds or minimum numbers of cyclists are given to warrant a bicycle signal. The view of the authors is that appropriate implementation is dependent on many factors and justification for one intersection is not necessarily appropriate for another intersection, even one with similar geometry. There is a strong emphasis on the use of engineering judgment in conjunction with the key factors: safety, traffic/cycling volumes, conflicting movements, and public input. Engineering judgment is also important when deciding whether or not to incorporate an exclusive bicycle phase into the timing plan at an intersection. Only rare circumstances should be considered for a "fully actuated" bicycle signal as exclusive phases can increase delay for other modes.

2.1.8 Manual of Uniform Traffic Control Devices for Canada, 2008 update (TAC, 2008)

The Canadian MUTCD has similar guidance to *Guidelines* for the design aspects of bicycle signals. The Canadian MUTCD states that standard bicycle signal lenses are 200 mm (8 in.) circular lenses but that when the lens is more than 30 meters (98.4 ft) away from stopped cyclists, 300 mm (12 in.) lenses may be considered. It also states that a bicycle signal head should be "mounted within the cone of vision of cyclists and preferably within 30 m upstream of the stop bar" with vertical mounting preferred. The guidance on this characteristic is that the minimum height for a bicycle signal over a roadway is 4.5 meters (14.8 ft). No guidance on cyclist performance values is given in the Canadian MUTCD.

2.1.9 Design Manual for Bicycle Traffic (CROW, 2007)

The CROW Design Manual for Bicycle Traffic (2007) takes a more qualitative approach to guidance for bicycle infrastructure than the US and Canadian guidance documents. All discussion of traffic measures are centered around five main requirements for bicycle-friendly infrastructure: attractiveness, comfort, directness, safety, and cohesion. For traffic signals, two of the main requirements are applicable – directness and comfort. At intersections, both directness and comfort deal with cyclist delay which is broken down into the probability of stopping and the wait time once stopped. The chance of stopping/possibility of proceeding and the wait time are considered highly significant when assessing the quality of a bicycle crossing. A basic premise of the guide is that bicycles should have to stop as little as possible. An average wait time of less than 15 s is considered good with an absolute maximum wait time (in built-up areas) of 90 seconds.

To aide in the appropriate timing of signals to meet these optimal conditions, the CROW manual provides suggested design values for speed (20 km/h)(12.4 mph), acceleration (0.8 to 1.2 m/s2), deceleration (1.5 m/s2), and perception-reaction time (1s). Variety in speed and acceleration because of cyclist characteristics and road conditions is acknowledged.

Although warrants for bicycle signals are not explicitly discussed, safety for cyclists is cited as an important consideration for the installation of any type of traffic signal – specifically where motorist cross-traffic speed and/or volume is high enough to hinder cyclists' crossing of an intersection. Maintaining the flow of bicycle traffic is another reason for the installation of a signal, particularly when the right of way of the cyclists needs to be emphasized.

2.2 RELEVANT LEGISLATION

This search was not exhaustive but identified related legislation that allows the use of bicycle signal indications.

2.2.1 Oregon

Oregon Senate Bill 130 amended ORS 811.260 to describe the requirements of a bicyclist when facing a green, yellow, or red bicycle signals. The definitions are (quoted directly):

- Green bicycle signal. A bicyclist facing a green bicycle signal may proceed straight through or turn right or left unless a sign at that place prohibits either turn. The bicyclist shall yield the right of way to other vehicles within the intersection at the time the green bicycle signal is shown.
- Steady yellow bicycle signal. A bicyclist facing a steady yellow bicycle signal is thereby warned that the related right of way is being terminated and that a red bicycle signal will be shown immediately. A bicyclist facing a steady yellow bicycle signal shall stop at a clearly marked stop line, but if none, shall stop before entering the marked crosswalk on the near side of the intersection, or if there is no marked crosswalk, then before entering

the intersection. If a bicyclist cannot stop in safety, the bicyclist may proceed cautiously through the intersection.

- Steady red bicycle signal. A bicyclist facing a steady red bicycle signal shall stop at a clearly marked stop line, but if none, before entering the marked crosswalk on the near side of the intersection, or if there is no marked crosswalk, then before entering the intersection. The bicyclist shall remain stopped until a green bicycle signal is shown except when the bicyclist is permitted to make a turn under ORS 811.360.

The requirements for the steady yellow bicycle signal can lead to a bicyclist's dilemma zone. Though, as later discussed there is no discussion of dilemma zones for bicyclists in the current guidelines.

2.2.1 California

California similarly defines the requirements of a bicyclist when facing a bicycle signal indication in Section 21456.3 Transportation Bicycle Signals as (quoted directly):

- An operator of a bicycle facing a green bicycle signal shall proceed straight through or turn right or left or make a U-turn unless a sign prohibits a U-turn. An operator of a bicycle, including one turning, shall yield the right-of-way to other traffic and to pedestrians lawfully within the intersection or an adjacent crosswalk.
- An operator of a bicycle facing a steady yellow bicycle signal is, by that signal, warned that the related green movement is ending or that a red indication will be shown immediately thereafter.
- Except as provided in subdivision (d), an operator of a bicycle facing a steady red bicycle signal shall stop at a marked limit line, but if none, before entering the crosswalk on the near side of the intersection, or, if none, then before entering the intersection, and shall remain stopped until an indication to proceed is shown.
- Except when a sign is in place prohibiting a turn, an operator of a bicycle, after stopping as required by subdivision (c), facing a steady red bicycle signal, may turn right, or turn left from a one-way street onto a one-way street. An operator of a bicycle making a turn shall yield the right-of-way to pedestrians lawfully within an adjacent crosswalk and to traffic lawfully using the intersection.
- A bicycle signal may be used only at those locations that meet geometric standards or traffic volume standards, or both, as adopted by the Department of Transportation.

2.3 ODOT DESIGN POLICY

ODOT has established an addendum to the Traffic Signal Policy and Guidelines. The policy is included in the Appendix A

3 LITERATURE REVIEW

Increasing cycling as a regular mode of transportation has many personal and environmental benefits that have been noted in recent literature (Pucher, Dill, & Handy, 2010). These benefits, paired with growing concerns about pollution and traffic congestion from personal car use, have motivated many municipalities to attempt to elevate the use of bicycles among their populations. Subsequently, the amount of funding for bicycle-specific infrastructure has increased in recent years (Dill & Carr, 2003).

Although some individuals and interest groups advocate for a complete lack of bike-specific facilities or "vehicular cycling" (Pucher & Buehler, 2009), it has been shown that people are encouraged to bike with increased choices in infrastructure/bike-specific facilities, especially new or less confident riders (Dill, 2009; Koorey, 2010; Pucher et al., 2010). Meanwhile, there is some evidence that that safety (measured as an individual's risk) improves with increased ridership (Jacobsen, 2003; Robinson, 2005) (i.e. the safety in numbers theory). Additionally, research suggests that the connectivity of the bicycle network plays into people's choices to bike (Dill, 2009; Mekuria, Furth, & Nixon, 2012). Difficult connections not only create discontinuities in the bicycle network but also pose a threat to perceived cyclist safety and comfort (Krizek & Roland, 2005). Safety, or the perceptions thereof, has been cited as a significant factor in people's decision to cycle (Pucher & Dijkstra, 2000). Indeed, it has been shown that more than half of Portland residents are concerned about their safety when cycling and thus limit their time on a bicycle (City of Portland Bureau of Transportation [PBOT], 2004). In a classification now copied by many, a (2009) report by Roger Geller of PBOT revealed that 60% of the surveyed population self-classified as "Interested but Concerned" 'cyclists,' citing fear for their safety as a primary deterrent to cycling. Insecurities about safety and gaps in connectivity at intersections pose barriers to cycling that could be alleviated by new technologies like bike signals.

Bicycle-specific traffic signals are a common element of the bike network in European countries where cycling is popular (Fischer et al., 2010) and have been implemented in several U.S. cities (see state of the practice results), with formal experimentation as proscribed in the MUTCD in additional cities pending. Presently, despite their increasing usage in the U.S., no official guidance exists in *The Manual on Uniform Traffic Control Devices* on the placement, design, phasing, timing, or warrants for the use of bike signals (FHWA, 2009). This lack of standards or regulatory guidance creates liability and limits the installation of these signals to those wishing to participate in an experiment. In addition, inconsistent infrastructure could lead to a consequent lack of understanding and compliance by cyclists riding in unfamiliar cities.

A couple studies have indicated intersection types and characteristics for which bike-friendly signal timing or a bike phase would be beneficial for improving level of service (LOS) for both cyclists and motorists (i.e. intersections with bicycle clearance-time accidents, very wide widths, or those on major bicycle routes with high cyclist volumes (Wachtel, Forester, & Pelz, 1995) and those on collector streets or with steep grades (Taylor & Mahmassani, 2000)). When combined with concerns about safety of riders, liability for controlling jurisdiction, and efforts to increase rates of cycling, there is a clear need to explore variables needed to operate bicycle-specific traffic signals for use in the United States.

Descriptive data on cyclist performance characteristics like speed, acceleration, and offset time that affect intersection clearance time are important for effective timing of bike phases. Timing not conducive to cyclists can result in car-bike accidents. Wachtel et al. (1995) noted the connection between signal timing and a common type of car-bike collision: that which occurs when a cyclist is hit by a motorist after lawfully entering an intersection during the yellow phase. Due to an insufficient amount time allotted to the cyclist by the yellow and red phases, the cyclist remains in the intersection when cross traffic is given a green indication.

An FHWA (1994) report classified bicycle user types into three categories: A) "Advanced cyclists", B) "Basic cyclists", and C) "Children". A limited amount of research on cyclist performance has been carried out in an attempt to create empirically-derived values to confirm or reject these assumptions. Some of the published values associated with these user types are assumptions that lack empirical evidence. Further studies have addressed the potential effects of empirically-derived signal timing on the capacity at signalized intersections (note capacity-related work is discussed later).

To gather sources for this review, electronic searches were conducted using Google, Google Scholar, and TRIS Online (National Transportation Library) using "bike" or "bicycle" in conjunction with other keywords: "signal," "operation," "safety," "performance," "timing," "intersection," "compliance," and "clearance." Relevant studies published at any date were considered for inclusion though the earliest utilized study dated from 1980. Sources were limited to those in English and included material found on the Fietsberaad (a partner of the Dutch Cycling Embassy) website that was originally published in Dutch and translated to English. In order to analyze results of already-implemented bike signal projects, it was necessary to include non-peer reviewed research found in government documents.

This chapter aims to synthesize the important literature in three areas: (1) cyclist performance characteristics, (2) traffic operations and signal issues associated with bicycle traffic, and (3) safety and compliance. The objective of this paper is to illuminate gaps and discrepancies in the current research that must be addressed in order to recommend parameters for the timing and operation of bicycle-specific traffic signals.

3.1 PERFORMANCE CHARACTERISTICS

Fundamental definitions of cyclist performance are critical for engineering design of bicycle-specific traffic signals, specifically their signal timing. Because humans are not uniform in their performance capabilities or equipment, there is a range of values for many performance characteristics. Studies compiled on cyclist performance explored one or more of four specific performance characteristics: crossing time, acceleration, perception-reaction time, and speed. Data were gathered from individuals on working road infrastructure at traffic signals originally timed for automobile traffic – not bicycle-specific signals. This would presumably not have an effect on basic performance characteristics of cyclists. Furthermore, intersections for all studies were selected based on their high volume of bicycle traffic in order to obtain statistically significant sample sizes.

Before delving into a discussion of the findings, it is important to define working variables used in performance studies. Wachtel et al. (1995) defined two start types for cyclists crossing an intersection: rolling and standing. Cyclists "who enter at full speed late in the green or during the yellow phase" were defined as crossing with a "rolling" start while those "who have stopped on red and start from a new green" were defined as crossing with a "standing" start (p. 38). Subsequent studies adopted these start type definitions.

Crossing distance or intersection width was defined by Rubins and Handy (2005) as "the distance from the first crosswalk line on the near side of the intersection to the first line on the other side of the intersection (the third line encountered rather than the limit line on the far side)" (p. 23). They also noted that this definition was chosen because of convenience and practicality since "most bicyclists stop at the first crosswalk line at red lights and because bicyclists are safely out of the path of cross traffic when they cross the third line" (p. 23). This definition of intersection width appears to be used by all following studies with the exception of two, which defined intersection width similarly to Rubins and Handy but with an additional six feet to account for complete clearance of a bicycle through an intersection (Shladover et al., 2011; Shladover, Kim, Cao, Sharafsaleh, & Li, 2009).

3.1.1 Crossing Time

While other performance characteristics have been examined because of their influence on crossing time, the time a cyclist needs to cross an intersection is the most basic parameter needed for bicycle-specific signal timing. Crossing times for the two start types are used for different purposes in signal timing. The length of the minimum green indication (green time) in a signal phase is governed by the time it would take standing start cyclists to cross the intersection since, presumably, this cyclist would need the greater amount of time to cross compared to a rolling start cyclist. In many states, it is legal for cyclists to cross into an intersection during the yellow clearance, rolling start crossing times are used to determine minimum yellow indication length so as to ensure that cyclists entering an intersection have enough time to make it safely across.

Although most of the performance studies reviewed did measure crossing time, it was generally used to determine other performance characteristics. Only two studies made explicit comparisons of their crossing time data (Rubins & Handy, 2005; Wheeler, Conrad, & Figliozzi, 2010). In these studies, crossing time was determined by review of video footage. Rubins and Handy (2005) examined crossing time at ten signalized intersections and reported significant variation in crossing times for seemingly homogeneous populations of cyclists. The findings revealed a weak linear relationship (linear regression R^2 value of 0.27) between crossing time and width for both start types. Clearly, other factors besides intersection width have influence on crossing time.

Wheeler et al. (2010) inspected the differences in crossing time between men and women at two intersections – one with a level grade and one that had a slight uphill grade–during winter and summer seasons. It was determined that minimum clearance times accommodating the average cyclist would be insufficient to accommodate a large portion of female riders. It was concluded that at wide and graded intersections especially, females need more time to cross safely and comfortably.

As evidenced by these two studies, crossing time is not governed by a single variable like intersection width. In order to discern the reason for crossing time variability, it is prudent to individually consider the fluctuations of other performance measures from which it is comprised. This has been carried out in a few studies whose particulars are discussed below.

3.1.2 Acceleration

Crossing time for standing starts is comprised of the time to recognize the signal change and accelerate to a constant speed in addition to the time it would take to cross the remaining portion of the intersection at that constant speed. Values for cyclist acceleration are therefore important to determining minimum green times.

A 1997 study by Pein analyzed riders on a trail at roadway crossings. Crossing time and distance were collected and fit by linear regression. Accelerations were then estimated from this model. He found the 15^{th} percentile and mean accelerations of standing start riders to be 2.4 ft/s^2 and 3.5 ft/s^2, respectively. These values are reasonable when compared to suggested design values in AASHTO's *Guide for the Development of Bicycle Facilities* (2012) and (2012) and the Netherland's *CROW Design manual for Bicycle Traffic* (2007). As noted by Pein, it is not made clear by either design aid if suggested accelerations were mean, 15^{th} percentile, or other percentile values. The age distribution of users on the trail may have affected how closely his values matched those in existing design aids. Pein states that in a previous study of the trail, the majority of cyclists were adults between the ages of 26 and 65 with very few people over the age of 66 or under the age of ten.

Wheeler et al.'s discussion of acceleration points to gender differences in acceleration. No explicit values for acceleration were reported but the findings suggested that males continue accelerating past the midpoint of an intersection while females reach their top speed somewhere near the midpoint of the crossing. This was true at both the level and graded intersection during winter and summer and would partially account for the differences in crossing times discussed previously.

Findings for acceleration allude to the adequacy of existing design values for an average cyclist population. However, lower accelerations might be reasonable for populations with higher numbers of older people, very young children, and women. It is unclear what adjustments should be made for intersections with grades. More data is needed to elucidate the effects of cyclist demographics (like age and gender) and intersection grade on acceleration.

3.1.3 Perception Reaction / Start-up Lost Time

As previously noted, the minimum green time is based on the crossing time needed by standing-start cyclists. Thus, the time used to recognize the indication change and begin acceleration, the start-up time, is a relevant aspect of cyclist performance.

Three studies explored start-up time. It should be noted that perception reaction time [PRT] and start-up lost time are not the same in these studies. The start-up lost time [SLT] is equal to the PRT plus the time needed to accelerate to the crossing speed. Raksuntorn and Khan (2003) took the most general approach to exploring start-up time and noted that the first five bicyclists in a queue experienced a significant start-up lost time but that of following bicyclists was marginal. This could be due to cyclists behind them being "tipped off" to the signal change and therefore able to ready themselves to depart before space is made by leading cyclists. The total start-up lost time for this study (the sum of individual headways per phase) was found to be 2.5 seconds. The reaction times of the first bicycles can be seen in Figure 3-1. Assuming the researchers followed standard procedures for measuring saturation flow, it can be seen that the reaction and travel time to the common measuring point are in the range of 0.25-5 seconds. Reaction times would be less than these since it would not include the time to travel to the reference position.

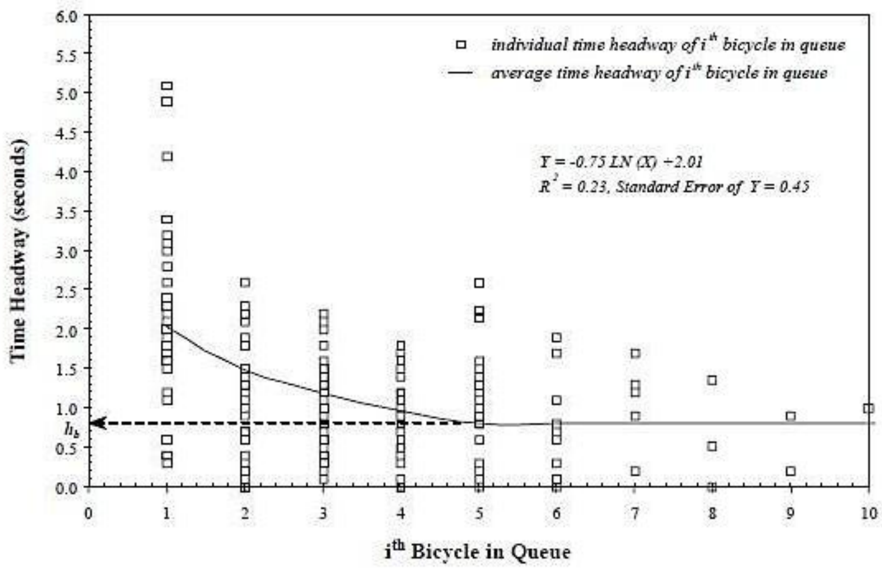


Figure 3-1 Headways of ith bicycle in queue (Raksuntorn and Khan, (2003)

Another study found start-up lost times for each of the three start types discussed previously. Noting that finding start-up lost times was important in determining minimum green time, Rubins and Handy (2005) took the intercepts from linear regression equations fitted to plots of crossing time versus crossing distance as the start-up time for each start type; 3.1, 0.5, and 2.1 seconds for standing, quasi-rolling, and rolling starts, respectively. However, it is not particularly clear how SLT would be used to determine minimum green time (i.e. no formula was given) as the study only states that minimum green should account "for the time required for the bicyclist to accelerate." Presumably, if you had an average cyclist speed, you could add the SLT to that to determine an appropriate crossing time and therefore signal timing. Furthermore, since crossing time and distance were not heavily correlated in this study – the average R^2 value for the regression lines was 0.354 – these values are rough estimates and lack corroboration from further studies.

The most comprehensive study exploring start-up lost time (referred to in their paper as "offset" time) was done by Shladover et al. (2011) and expanded upon data from an existing study from 2009. Offset times were determined graphically by plotting cyclists trajectories (position vs. time) and extracting the time difference where the line tangent to the trajectory curve (indicating cruising speed) crossed the line of the starting position. This offset time is the time required for a cyclist to react, start, and accelerate to cruising speed. The study found 80th and 90th percentile offset times to be, four and five seconds, respectively (though there were outlier times of up to 8 seconds for 90th percentiles at one intersection). One study intersection was a noticeable outlier in terms of its distribution of longer offset times. Exploration of this outlier led to the discovery that cyclists at that particular intersection were more slowly moving into the intersection due to three factors – the limited visibility and high speeds of cross traffic and the steeply crowned intersection. It was determined that cyclists were more cautiously moving out into the intersection because of visibility concerns about dangerous cross traffic and, additionally, were physically slowed by the steep crown at the crossing. It therefore took a longer amount of time to accelerate to a final speed. These findings suggest that intersection characteristics besides grade can have an effect on cyclist performance and thus have important implications for minimum green time that should be considered when adjusting signal timing for bicycles. More research and data are needed to generalize these findings and provide realistic startup-lost time design values.

3.1.4 Speed

Of the sources that explored performance characteristics of cyclists, seven reported values for cyclist speed. The results of two studies by Shladover et al. (2011 & 2009) were combined, however, so this section of the review will deal with six studies. The performance measure "speed" can be further dissected into three speed types that were reported: approach, mean crossing, and final crossing speed. Definitions for speed parameters are found in Table 3-1.

Table 3-1 Definitions of Reported Speed Types

Reported Speed Definitions			
Approach	**Final Crossing**	**Cruising**	**Mean crossing**
Speed of cyclist nearing the intersection but far enough away to be unaffected by traffic control.	Speed of cyclist as they crossed far edge of intersection after beginning from a standing start.	Speed of rolling start cyclists as they cross the far edge of the intersection.	The crossing time divided by the total intersection width. This measure does not account for acceleration from stop at the start of the crossing maneuver.

Approach speeds were observed for one study and reported as ranges by facility type with the fastest speeds for cyclists in bike lanes as opposed to those on multi-use paths or sidewalks (Opiela, Khasnabis, & Datta, 1980) (see Table 3-2).

Table 3-2 Reported Speeds (km/h) from Opiela et al , 1980

	Sampling	Observed Speeds (km/h)		
Facility	**Periods**	**Mean**	**Maximum**	**Minimum**
Bike path	14	20.26	39.18	4.38
Bicycle lane	4	24.99	40.88	4.07
Sidewalk	5	18.51	30.15	3.39
No facility	5	19.07	36.91	8.06
Overall	28	20.71		

This potentially points to faster allowable design speeds for more confident users riding next to traffic in a bike lane. Another source reported average speed of crossing cyclists using a simple calculation of crossing distance over crossing time (Wachtel et al., 1995). Speeds from these first two studies are reasonably close to speeds listed in AASHTO's *Guide*, which are meant to accommodate 98 percent of class A and B riders.

Remaining sources reported final crossing speeds of standing start cyclists and cruising speeds of rolling start cyclists. While video recording was utilized by all studies to collect raw data, analysis and subsequent calculations and reporting of speed were varied and made comparisons between study results difficult.

Pein used crossing distance vs. crossing time for individual riders to develop a 15th percentile crossing speed equation and a linear regression equation for estimating average crossing speed. The fit of the line of the 15th percentile equation (R^2 value of 0.99) was much better than that of the linear regression for mean speed estimates (R^2 value of 0.75) implying that the reported 15th percentile speeds are more representative of the study population. While the mean speed, 7.9 mph, compared favorably to the AASHTO value for speed of basic adult cyclists, the 15th percentile speed, 6.7 mph, was much closer to the design value for children (AASHTO 1999 class C, 6 mph). This leads to the inference that speed assumptions in AASHTO 1999 guide do not in fact accommodate 98% of adult cyclists. The 2012 guide only provides a range for paved level terrain (8-15 mph). One possibility for the low 15th percentile speeds found in the study is discussed by Pein and has to do with the study location: a trail. These speeds were low when compared to actual rolling speeds of cyclists riding on the roadway adjacent to the trail crossings. The lower speeds could potentially be explained by a difference in trip purpose with recreational riders on the trail traveling at a more leisurely pace than presumably utilitarian riders on the roadway. As this was the only study that used data from a trail, more research is needed to determine if trip purpose significantly affects crossing and cruising speeds.

Shladover et al. (2011) combined the cumulative distributions of crossing speeds at each study intersection and analyzed their differences with respect to variables associated with each crossing (including both cyclist and intersection characteristics). While most average speeds per intersection were within the range of AASHTO design values for adult cyclists, it was shown that final crossing speed for both standing and rolling starts was noticeably influenced by intersection geometry; speed, visibility, and density of opposing cross-traffic; age and ability of the cyclist population; trip purpose (i.e. recreational vs. utilitarian trips); and time of day. It isn't clear how trip purpose was determined, though it is implied that knowledge of the land uses and the likelihood that there were tourists biking in the area were decision factors. The researchers also found that offset times and final crossing speeds were not correlated, further emphasizing the dependency of crossing speed on a variety of factors.

A study by Wheeler et al. (2010) sought to determine correlations of gender, intersection grade, and season with crossing speed. It was determined that intersection grade and gender of the cyclists significantly affected crossing speeds. Results differed from those of Shladover with observed average speeds significantly lower than the 11.7ft/s (8 mph) suggested by the 1999 AASHTO guideline for basic adult cyclists (class B). Similarly to acceleration results from this study, females experienced statistically significant slower crossing speeds than males leading to longer required crossing times.

A study of cyclists in Davis, CA found the mean and median crossing and cruising speeds of the study population to be comparable to AASHTO values (Rubins & Handy, 2005) but, since AASHTO values are meant to accommodate 98% of cyclists for their respective cyclist type, it makes more sense to compare these assumptions with the 2nd percentile values from the study. The study found that speeds for 98% of cyclists from both standing and rolling starts were well under design values in AASHTO even though it was noted by the researchers that the majority of the study population was made of college-aged adults. A histogram of the speeds observed by type (standing, rolling, and quasi-rolling are presented in Figure 3-2. Quasi-rolling starts are defined as those of cyclists stopped (with at least 1 foot on the ground) several bicycle lengths from the stop line which allows them to speed up before entering the intersection.

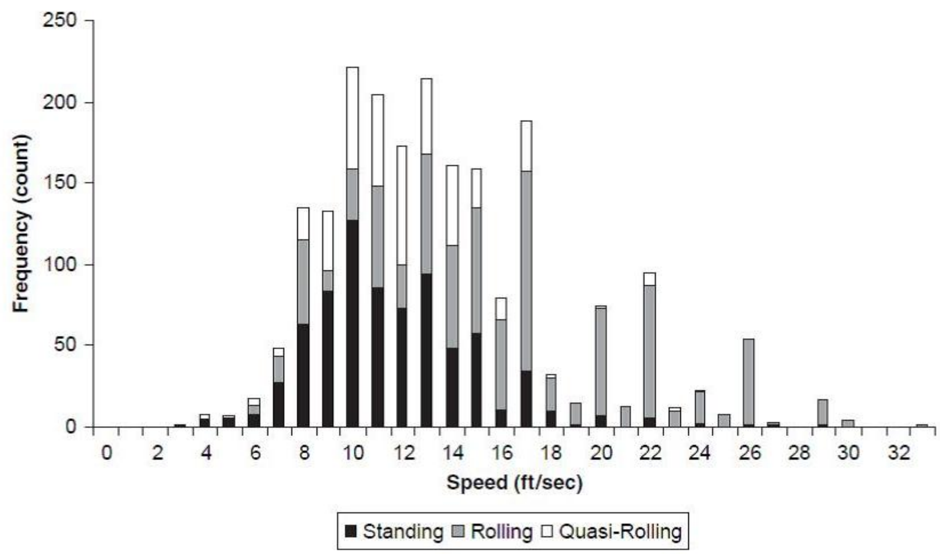


Figure 3-2 Histogram of Speed Frequency of All Observations (Rubins and Handy, 2005)

Comparing speed values across studies was difficult because the assortment of speeds reported, i.e. mean, median, 15th percentile, etc. This is telling of an uncertainty among researchers about which speeds are most representative of cyclist populations and/or what percentage of the population is reasonable to accommodate. Researchers from one study expressed concern about the use of speed values higher than the 2nd percentile value since signal timing would not accommodate particularly vulnerable groups, such as children (Wachtel et al., 1995). Also problematic was the incongruous analysis of factors influencing crossing speed. Table 3-3 and Table 3-4 summarize the differences in study scope and reporting methods, respectively.

As demonstrated by the findings for crossing and cruising speed in the six previously discussed studies, crossing speed is highly dependent on a wide range of variables including, but not limited to cyclist age, gender, and ability; trip purpose; and intersection geometry and grade. Other performance measures that affect overall crossing time were found to be similarly variable over a range of parameters. Therefore, crossing time is dependent on a large number of environmental and demographic factors. Additional research is needed to quantify these relationships.

Table 3-3 Comparisons of Study Scope with Respect to Speed

	Speed Type			Start Types Examined		Influencing factors compared or discussed						
Study	**Approach**	**Cruising**	**Crossing**	**Standing**	**Rolling**	**Grade**	**Trip purpose**	**Visibility**	**Season**	**Cyclist age and ability**	**Gender**	**Facility type**
Opiela et al.	x			n/a	n/a							x
Pein		x	x	x	x		x					x
Rubins & Handy		x	x	x	x					x		
Shladover et al.		x	x	x	x	x	x	x		x		
Wachtel et al.		x	x	x	x							
Wheeler et al.			x	x		x			x		x	

Table 3-4 Comparisons of Speed Reporting

	Reported as							
Study	**2nd %-ile**	**10th %-ile**	**15th %-ile**	**20th %-ile**	**50th %-ile**	**Mean**	**Median**	**Range**
Opiela et al.						x		x
Pein			x			x		
Rubins & Handy	x		x			x	x	x
Shladover et al.		x		x	x			
Wachtel et al.								x
Wheeler et al.			x			x		

3.2 Traffic Operations and Signal Issues

Signalized intersections have traditionally been designed to accommodate motor vehicle traffic. Introduction of bike-specific phasing has the potential to lower the capacity and flow for other modes of travel at intersections because of the possibility for exclusive phasing Conversely, if cycling is to grow as a utilitarian means of transport, the quality of service for cyclists must be considered. This would require that signal timing provide adequate time for users to clear the intersection safely and comfortably without enduring unnecessarily long wait times. In the CROW manual, it is noted that "Waiting for traffic lights appears to be the most significant source of delay" for cyclists and that "waiting time is a significant measure for bicycle-friendliness" (2007, p. 204). Moreover, shorter wait times for cyclists are not only a matter of the quality of service but also of compliance. Since shorter wait times are preferred, cyclists are more likely to cross at noncompliant times if faced with unnecessarily long waits (Fietsberaad, 2003). Measures to alleviate long wait times for cyclists while providing adequate clearance times for all users are currently in place in the Netherlands and include special measures for left-turning bicycles and twice green for cyclists in the same cycle phase (de Haan, Zeegers, & van der Linden, 2003).

Flow rate of cyclists through intersections has implications for appropriate signal timing to accommodate cyclists. Raksuntorn and Khan (2003) measured saturation headway and flow rate of cyclists at two signalized intersections. This study looked at cyclists' distances from each other and the adjacent motorist lane. From these, they determined the unspecified width of a "sublane", 3 of which fit into an 8 ft-wide bike lane. The saturation headway for all cyclists was found to be 0.80 seconds with a corresponding saturation flow rate of 1,500 bicycles per hour of green time *per sublane*. So, the 0.80s headway relates to 3 sublanes within an 8 ft-wide bike lane for a total flow of 4,500 per hour of green per 8ft bike lane. The latter value is in contrast to the recommended bicycle saturation flow rate in the Highway Capacity Manual [HCM] (Transportation Research Board, 2010) of 2000 bicycles per hour of green time. The study also revealed a positive relationship between bike lane width and capacity. As the HCM value is not based on empirical evidence and does not account for varying lane widths, there is a need for more bicycle saturation flow studies that can confirm the results of Raksuntorn and Khan and/or further examine factors that influence bicycle saturation flow rate at signalized intersections.

A 1995 study, *Signal Clearance Timing for Bicyclists*, cursorily explored whether or not minimum yellow and red intervals for automobiles were appropriate for accommodating bicycles (Wachtel et al., 1995). Using equations for minimum yellow and red intervals found in combined form in the 1999 AASHTO's *Guide*, researchers determined that cyclists needed a maximum of 2.8 seconds of yellow time – below the minimum recommended in the MUTCD for vehicles – and nearly 12 seconds of all-red time (red interval as the clearance interval and when using a cyclist speed of 8mph, they get a clearance time of 11.6 seconds). It was found that timing already in use for cars should be adequate for bicycles since the yellow interval yielded cyclists an extra 0.2-0.5 seconds and, since an red clearance interval of more than 6 seconds would be against guidance in the MUTCD, locally permitted red maximums would have to suffice (Wachtel et al., 1995). It should be noted that the low and high velocities used were 8-20 mph and 8-25 mph for yellow and red interval equations, respectively, though it is unclear how researchers arrived at these speeds or why they differ between the two equations. A check of yellow and red intervals using transparent, empirical data would be an apropos follow-up to the signal timing portion of this study.

Two studies by Shladover et al. (2009 & 2011) used experimentally-derived performance measures from both studies to come up with bicycle-friendly green times. These green times were input into traffic simulation software to examine the effects of bike-friendly timing on motorist delay during congested and uncongested scenarios at actuated traffic signals. It was demonstrated that minimum green times for cyclists had no significantly negative impacts on delay. It was noted that during congested travel periods, vehicle actuation would automatically increase the minimum green time to an adequate length for cyclists. Work to investigate the effects of more innovative signal phasing options, like "twice green" – giving cyclists two green phases within a cycle, is needed in addition to research to corroborate the findings of Shladover et al. (2009 & 2011). It must be emphasized that the finding regarding the lack of significantly negative impacts on delay was reached using simulation (SYNCHRO) in a very small set of traffic scenarios and major and minor traffic flows.

Shladover et al. (2011) also plotted the total time available to cross the intersection based on the observed values of offset and crossing speeds as a function of crossing width. The figure also shows the guidance for minimum green from the Caltrans MUTCD. In the figure the 80th percentile crossing times are indicated by dashed lines and the 90th percentile crossing times are solid lines. The orange lines represent an outlier intersection. The Caltrans timing appears to represent the 85th percentile cyclist performance.

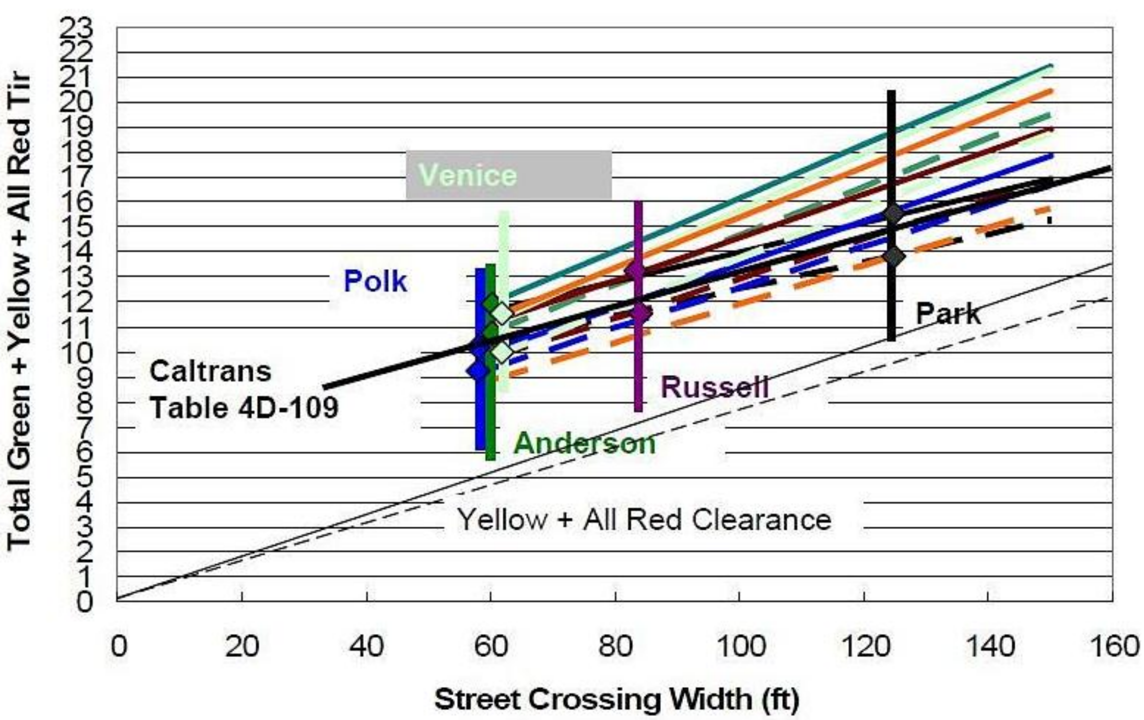


Figure 3-3 Crossing Times as a Function of Street Width (Shaldover et al)

There is a marked need for further examination of bicycle flow and the effects of bike-friendly signal timing, using reliable performance data, on traffic flow in order to effectively time signals for bicycles while minimizing delay for other users

3.3 SAFETY AND COMPLIANCE

In order to create guidance for bicycle-specific traffic signals, information is needed on their safety effects and whether or not cyclists comply with these special indications. In fact, compliance may affect safety of cyclists using bicycle infrastructure. One study on drivers' attitudes of cyclists found that drivers increased risky behavior around bike-specific facilities, possibly because there was less perceived risk of a cyclist making unpredictable maneuvers into the way of the motorist (Basford, Reid, Lester, Thomson, & Tolmie, n.d.).

Although there are a number of bike signals in place, few studies have attempted to illuminate their effectiveness at increasing safety and compliance. One case study of a bike signal at a trail crossing of a roadway in Denver, CO attempted to look at compliance of cyclists before and after the installation (Denver, CO, 2009). Previous to installation, only a pedestrian signal head existed and cyclists were considered "compliant" only if crossing during the "WALK" phase. As might be expected, cyclists continued to cross during the flashing hand phase of the pedestrian signal since it allowed ample time for them to cross. It was shown that with the installation of a bike signal, cyclists were more likely to cross during the bicycle interval time. However, comparison of cycle phase time and signal displays of the bike and pedestrian signals revealed that, while cyclists were more likely to cross at compliant times, compliant times provided by the bike signal matched the existing behavior of cyclists. The study also sought to examine potential motorist confusion regarding the bike signal. None was found but more studies are needed to corroborate this result.

Compliance of cyclists at bike-specific signals is likely related to overall cyclist compliance with all traffic indications, especially signalization at intersections. Two studies done abroad analyzed the rate of red-light running at signalized intersections and factors that affect the likelihood of this type of non-compliance. The first study looked at red-light running of users on both bicycles and electric bikes. It was found that, for cyclists only, 50% of riders violated the red indication. The likelihood of red-light running increased significantly with youth, decreasing group and queue size, low cross-traffic volume and witness of other users running the red light. The study identified three types of cyclists: law-obeying, risk-taking, and opportunistic. Risk-takers and opportunists violated a red interval differently with risk-takers riding through the signal without yielding and with opportunists growing impatient with the red indication and crossing during an available gap (Wu, Yao, & Zhang, 2011). The behavior of the opportunists validates the assertion that increased wait time increases non-compliance of cyclists (Fietsberaad, 2003). Lastly, it was found that the majority (70%) of non-compliant cyclists crossed during the very beginning or end of the red phase suggesting two scenarios: (1) cyclists speeding through the intersection to avoid stopping and (2) cyclists "jumping the gun" and beginning their crossing maneuver before the green phase (Wu et al., 2011).

The second study done on cyclist compliance analyzed cyclist behavior at signalized intersections in Melbourne, Australia. Researchers found the rate of red light non-compliance to be only 7% -- much lower than that for cyclists in the previously-mentioned study. Researchers also found that left-hand turn violations (similar to right-hand turns in the United States) were 28.3 times as likely, indicating that non-compliant actions with few conflict points are more attractive to cyclists. Results also showed that the presence of other users deterred the infringement of traffic indications as did gender, with females being more compliant (Johnson, Newstead, Charlton, & Oxley, 2011).

Parks, Monsere, McNeil and Dill (2012) studied compliance with signals in the Washington D.C. area as part of a wider evaluation of the cycling infrastructure. They found compliance at signals strongly related to crossing traffic and somewhat related to delay or progression for cyclists. Each of these intersections are unique so while it is difficult to state definitively, a trend is apparent. The results of this analysis is shown graphically in Figure 3-4 which shows the rate of compliance and a function of the conflicting vehicle flow rate (expressed as 15 minute flow rate).

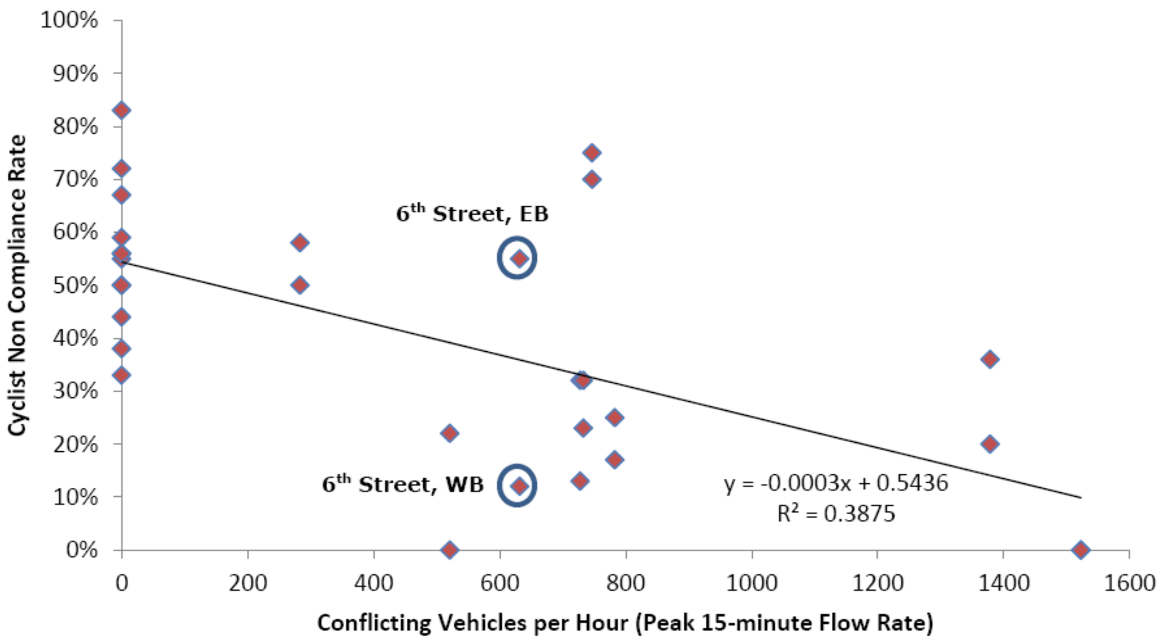


Figure 3-4 Observations of Bicyclist Non-Compliance, Pennsylvania Ave, Washington D.C. (Parks et al, 2012)

Cooper et al (2012) recently presented an analysis of user behaviors at 12 intersections in San Francisco metropolitan area. The study observed 557 cyclists in the 4-6PM hours and categorized red light running behaviors. Figure 3-5 shows a horizontal bar chart reflecting these data. The non-compliance ranged from 36 to 4%. The higher non-compliance intersections "generally had more gaps in traffic" while the higher compliance locations had "steady opposing traffic."

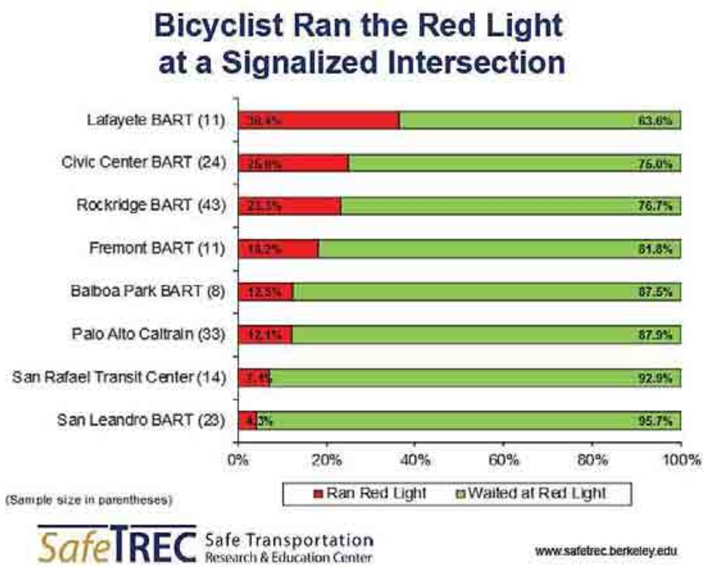


Figure 3-5 Observations of Bicyclist Behavior at SF Intersections (Cooper et al, 2012)

In terms of safety, no studies quantitatively evaluated installed bike signals for their effects on safety, though, as noted in previous sections of this review, cyclist safety increases with increased availability of infrastructure. Theoretically, bike signals could increase cyclist safety by separating user modes. This would mitigate collisions such as the “right hook” where a motorist turning right collides with a cyclist crossing through an intersection.

One criticism of bicycle-specific signals is that the possibility that motorists will confuse the indication with ones meant for motor vehicles. No published studies were found that examined this empirically or in a simulator.

In the realms of safety and compliance at bike signals, there is much room for growth in research. Further study is needed to investigate how bike signals affect cyclist behavior by encouraging compliance since compliance is an important factor in the potential effectiveness of bike signals that seek to reduce auto-bike conflicts by separation of users. Extensive study is also needed on the actual safety effects of installed bike signals.

3.4 DISCUSSION

This review summarizes the available research on bicycle performance as it relates to signal timing, the effects of bike-friendly signal phasing on motorist delay, and the safety and compliance of cyclists at bike signals. The review reveals a number of inconsistencies in the literature on bicycle performance, notably for cyclist speed. While some studies observed cyclist accelerations and speeds consistent with those suggested by AASHTO, others found that representative speeds were well under those values. Furthermore, there seems to be disagreement among professionals on which representative speeds should be considered when adjusting signal timing for bikes. Recommended adjustments for geometric factors such as grade or intersection skew were not identified.

The greatest variability in performance-related literature stems from the examination of influences on performance characteristics. Findings show that a wide variety of cyclist traits and intersection qualities contribute to the performance of cyclists. Further investigation of these correlations is needed in order to customize signal phasing at intersections with particular demographics and geometries. More detailed, quantitative knowledge of variables affecting performance will enable further study of signal timing and contribute to a greater understanding of changes in motorist delay and traffic flow due to bike phasing. Research on the safety of currently implemented bike signals is lacking. This is a crucial gap in the knowledge needed to create standards for the operation of bike signals since safety is a priority concern for cyclists and municipalities alike. A summary of the research topics addressed in the studies of this review is included in Table 3-5 below and further illuminates the research gaps in the areas of signal timing, safety, and compliance.

Table 3-5 Study Scope Summary

Study	Research Topic(s) Addressed									
	Performance Measures				Signal Timing				Safety & Compliance	
	Crossing Time	Acceleration	Start-up Time	Speed	Saturation Flow Rate	Minimum Green	Minimum Yellow	Minimum Red	Safety	Compliance
Johnson et al.										x
Opiela et al.				x						
Pein		x		x						
Rubins & Handy	x		x	x						
Raksuntorn & Khan			x		x					
Shladover et al.			x	x		x				
Wachtel et al.				x			x	x		
Wheeler et al.	x	x		x						
Wu et al.										x

3.5 CONCLUSION

Studies have explored three topics crucial to advising guidance on the implementation of bicycle-specific traffic signals: performance, traffic operations, and safety & compliance. Currently, data on performance characteristics is lacking consistency in reporting methods and exploration of variables affecting performance. There is no consistent methodology to determine field or real world crossing speeds, accelerations, and start-up time losses. Furthermore, the literature suggests that intersection characteristics besides grade (e.g. limited visibility, high speed of cross traffic) do have an effect on cyclists' performance. In addition, the literature suggests that cyclists' demographics (e.g., gender, age) can significantly affect performance. The potential existence of dilemma zones has not been discussed in the literature.

Preliminary research using traffic simulation in a very restricted set of scenarios has shown no negative effects on intersection capacity or delays with the introduction of bike-friendly signal timing. However, this work was limited in scope and treatment. Clearly, more studies are needed to corroborate these findings and consider a meaningful array of green extensions, bicycle volumes, and traffic volumes at major and minor crossing streets as well as the impacts on arterial progression.

Safety and compliance literature are another major gap in research to date with very few documented analyses of quantitative comprehension, safety, and compliance impacts of bike signals. These missing pieces of research are crucial for determining design and operational standards for the implementation of bicycle-specific traffic control.

4 STATE OF THE PRACTICE – BICYCLE-SPECIFIC TRAFFIC SIGNALS

This chapter reports on the practices that operating agencies currently use to employ bicycle-specific traffic signals. The purpose of this synthesis is to illuminate the similarities and differences between installed signals in terms of their physical and operational properties. These include mounting height, signal housing color, and signal timing. Additionally, information was gathered on the motivations and guidance used to design the bike signals. Discussion of the findings of the synthesis is organized via these three categories. Individual data sheets on each signal head can be found in Appendix C.

Data for all reported jurisdictions was gathered via an online survey[2] disseminated through e-mail with the exception of data from Portland, OR, which was gathered via site visits and correspondence with agency contacts. Surveys were sent out to agencies in twenty-one jurisdictions, nineteen in the United States and two in Canada. A copy of the survey instrument can be found in Appendix B. The per-city response rate for the survey, including data gathered for Portland, was 71%. A breakdown of responding jurisdictions can be found in Figure 4-1.

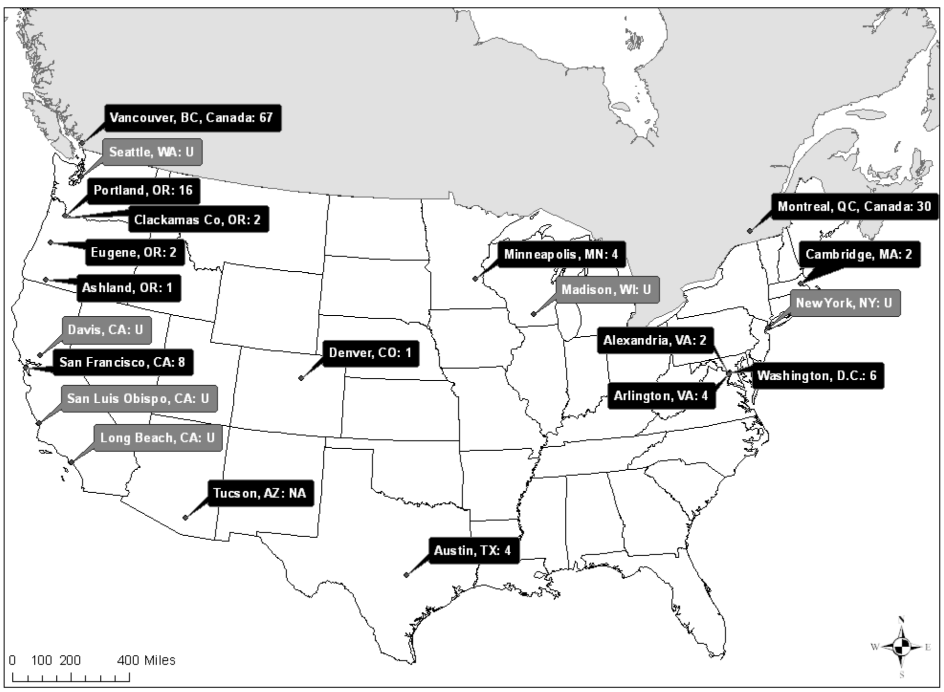


Figure 4-1 Jurisdictions identified with bicycle-specific signals and survey respondents.

Note: numbers following the ":" denote the number of reported signal heads at that location. "U" denotes a non-response for that location. "NA" denotes a response from Tucson on their TOUCAN signals which is shown for completeness.

Using the per-city response rate and knowledge of signals in non-responding jurisdictions, it is estimated that the survey attempted to document a total of 241 signal heads. This equates to 62% per-signal head response rate for the survey.

In all, a total of 63 intersections and 149 separate signal heads were analyzed for this chapter. It should be noted that although a response from a Tucson, AZ contact was collected, information about the signals in that jurisdiction was not used statistically for the Synthesis of Practice. Tucson has designed special signalized intersections called "TOUCAN"s that only serve bicycle and pedestrian traffic on the side street approaches. With no potential for confusion among motorists or bicyclists, these types of signals were not the focus of this survey.

All statistics reported in this synthesis are based on received responses and site visits only. The columns labeled "unknown" contain the percentage of respondents who took the survey but did not respond to a particular question.

4.1 PHYSICAL PROPERTIES

Physical representation of a signal relates to its visibility and recognition. This section analyzes the physical aspects of the signals themselves as well as their placement in relation to other traffic control devices.

4.1.1 Characteristics of the Signal Head

Five characteristics of the bicycle signal heads were described in this synthesis: backplate presence and color, signal housing color, lens size, traits of the insignia, and the presence of louvers or a visibility limited indication. A summary of the survey results for these characteristics is found in Table 4-1.

Standard signal housing colors, yellow and black, made up the majority of housing colors for reviewed signals. Eight signal heads from San Francisco were reported as being "Dark Green" and appear in the "Other" column of Table 4-1. The reported color of backplates, when present, varied between black and yellow, although the vast majority of bicycle signals have no backplates. Of those that do, yellow and black were almost equally reported. Pictures of the various housing and backplate combinations are shown in
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
f.

It should be noted that these elements reflect local design practice. For example, the housing color of Vancouver, BC bicycle signals head housing (yellow) matched the motorist signals. In the survey, it was more common for U.S. jurisdictions to use different color housing than motor vehicle signals. The majority of U.S. signal lenses were 12"; Canadian signals were more likely 8". This corresponds to guidance in Canadian MUTCD and the fact that signal heads are often placed on both sides of the intersection.

As one way to differentiate the bike signal from motorist signals, many bicycle signal heads display an insignia (or stencil) of a bicycle in the lens. The majority of installed bicycle signals have some sort of insignia on the lenses. Interestingly, there is variation on the direction of the insignia faces. Canadian signals were more uniform in their use of a left-facing lens insignia (in Montreal and Vancouver). Within and between the U.S. cities, there is variation with the

application of lens insignia. Also, two basic forms of the insignia were found: a realistic outline of a bicycle and a more abstract one. Pictures of these are shown in
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
c.

Most of the surveyed signals heads did not use louvers or other modifiers to restrict the visibility of the bicycle signal to be viewed by cyclists only. Generally, when louvers were employed, it was at intersections with major safety concerns and/or where the bicycle signal aligned with the motorist signal and might be easily confused. Louvers were not heavily utilized in either of the surveyed Canadian jurisdictions.

Table 4-1 Elements of the Signal Head

Characteristic		Number of Signal Heads			Percent of Signal Heads		
		US	CN	Total	US	CN	Total
Backplate Color	Black	18	0	18	35%	-	12%
	Yellow	10	0	10	19%	-	7%
	No backplate	24	97	121	46%	100%	81%
	Unknown	0	0	0	-	-	-
Housing Color	Black	32	37	69	62%	38%	46%
	Yellow	12	60	72	23%	62%	48%
	Other	8	0	8	15%	-	5%
	Unknown	0	0	0	-	-	-
Lens Size	12"	35	7	42	67%	7%	28%
	10"	0	0	0	-	-	-
	8"	9	90	99	17%	93%	66%
	Other	2	0	2	4%	-	1%
	Unknown	6	0	6	12%	-	4%
Bicycle Insignia	Faces Left	19	79	98	37%	81%	66%
	Faces Right	20	0	20	38%	-	13%
	No Insignia	12	18	30	23%	19%	20%
	Unknown	1	0	1	2%	-	1%
Utilization of Louvers	Yes	38	17	55	73%	18%	37%
	No	13	80	93	25%	82%	62%
	Unknown	1	0	1	2%	-	1%

US = United States, CN = Canada

Note: All percentages are rounded to the nearest integer.

Note: Percentages based on total number of surveyed signal heads, 149.

4.1.2 Placement and Mounting

In the U.S. motor vehicle traffic signals are located on the far side of the intersection unless there are sight distance issues. This practice has been followed with installations of bicycle signal heads. About 19% of the US sample and 64% of the Canadian intersections had signal heads placed on both the near and far side of the intersection. Near side-only bicycle signals are

commonly found in Europe but no near side-only signals were found in our North American survey. Note that these near-side heads are typically smaller and lower in Europe. Pictures of some typical mounting locations are shown in
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
a and b.

The reported mounting heights of bicycle signals varied widely, from 7 to 19 feet (measured from pavement elevation at the bicycle stop bar). The mounting height partially correlated with the intersection placement of the signals – intersections with signals on both near and far sides tended to have lower mounting heights. Lower mounting heights were also common when the bicycle signal was mounted on the same pole as the pedestrian indication. The mounting heights are summarized in Table 4-2 Placement and Mounting using height bins to simplify the display.

Table 4-2 Placement and Mounting

Characteristic		**Number of Intersections**			**Percent**		
		US	**CN**	**Total**	**US**	**CN**	**Total**
Intersection Placement*	Near side-only	0	0	0	-	-	-
	Far side-only	22	13	35	81%	36%	56%
	Both	5	23	28	19%	64%	44%
	Unknown	0	0	0	-	5%	-
Mounting Height	< 10 ft	13	0	13	25%	-	9%
	10-14.9 ft	19	93	112	37%	96%	75%
	15+ ft	8	4	12	15%	4%	8%
	Unknown	12	0	12	23%	-	8%

* *Percentages based on total number of surveyed intersections, 63.*

4.2 OPERATIONAL PROPERTIES

4.2.1 Detection, Phasing, Restricted Movements, Accompanying Signage

All of the signalized intersections from Vancouver BC and Montreal, QC were reported to not include detection. Forty-four percent of U.S. signals were on recall with no detection. For the remaining intersections with some form of detection, loop detection was the most common. For intersections with loop detection, most used the bicycle detector pavement marking found in the MUTCD to inform cyclists of where they could be detected. Some U.S. locations also included push button actuations. Close-up pictures of these are shown in
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
d. The pavement marking from the MUTCD "to request green" was commonly used (see Figure 4-2). Two jurisdictions (Austin, TX and Portland, OR) reported experimenting with a detection feedback indication which illuminates when the controller detects the presence of cyclists. A close-up of Portland's installation is shown in
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
d. There was no information included in the survey questions about advance detector placement.

Based on submitted timing plans, commentary from the survey, and internet research, the phasing for the majority of the signals could be determined. In the U.S., 59% of the intersections provided for an exclusive phase for the bicycle movement. It was very common to restrict and conflicting motor vehicle movement as part of the design and operation (70% of the U.S. and 56% of the Canadian intersections). Although the geometry of a few intersections mitigated the need to restrict conflicting movements, overall, motorists were restricted from making some sort of movement while at an intersection with a bicycle signal. The restricted movements were almost entirely turns against the bikeway with a few intersections restricting all movement by vehicles while bicyclists were crossing. The majority (64%) of intersections with motorist restrictions had an exclusive phase for cyclists at the bicycle signal.

Finally, nearly 74% of the U.S. signals included some form of accompanying signage to provide additional information that the signal head controlled bicycle movements. The signs were generally consistent (see
Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals
e) though Long Beach, CA added lettering to the signal backplate.

Table 4-3 Operational Elements

Design Element		**Number of Intersections**			**Percent of Intersections**		
		US	**CN**	**Total**	**US**	**CN**	**Total**
Detection Type	Loop	7	0	7	26%	-	11%
	Video	2	0	2	7%	-	3%
	Loop & push-button	4	0	4	15%	-	6%
	Push-button Only	2	0	2	7%	-	3%
	No Detection/ Recall	12	36	48	44%	100%	76%
	Unknown	0	0	0	-	-	-
Phasing Type	Exclusive	16	13	29	59%	36%	46%
	Concurrent	7	23	30	26%	64%	48%
	Leading interval	1	0	1	4%	-	2%
	Unknown	3	0	3	11%	-	5%
Restricted Movements	Yes	19	20	39	70%	56%	62%
	No	6	16	22	22%	44%	35%
	Unknown	2	0	2	7%	-	3%
Accompanying Signage	Yes	20	9	29	74%	25%	46%
	No	6	27	33	22%	75%	52%
	Unknown	1	0	1	4%	-	2%

*One reviewed signal, from Portland, OR, with a leading interval for cyclists is included.
Note: Percentages based on total number of surveyed intersections, 63.
Note: The definition for "Exclusive" includes those signals that are concurrent with pedestrian traffic but not motorist traffic.

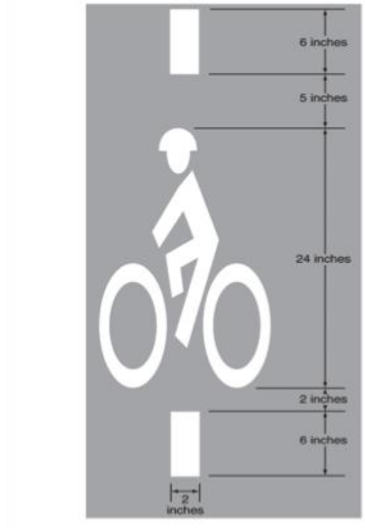


Figure 4-2 Bicycle Detector Pavement Marking

Figure 4-3 Photographs of Various Elements of Bicycle-Specific Traffic Signals

4.2.2 Signal Timing

Survey respondents were asked to report the minimum green, yellow, and red times for the bicycle signals. These statistics are reported in Table 4-4. Because a comparison of minimum times also needs to account for intersection width, these minimum times were normalized based on the "standing start" equation for bicycle minimum green time (BMG) from AASHTO's 2012 Guide. The Guide-suggested values for PRT (1s), L (6ft), and a (1.5ft/s2) were used in these calculations (T). Intersection widths were obtained from Google Earth. These normalized values are presented in Table 4-4. Although timing information could not be determined for all signals, analysis of the data revealed a range of speeds.

Table 4-4 Assumed Cyclist Speeds, Derived from Minimum Green Times and Intersection Widths

Statistic		US	CN	Total Sample
Minimum Green Time (sec)	Mean	10.6	8.2	3.7
	Median	10	7	4
	Low	4	5	3
	High	19	25	5
Intersection width (ft)	Mean	77.6	71.5	78.7
	Median	80	70	75
	Low	30	45	30
	High	110	95	135
Assumed Cyclist Speed (ft/s)	Mean	8.2	8.8	8.5
	Median	6.5	7.2	7.2
	Low	2.1*	4.6	2.1*
	High	18.7	17.4	18.7
% of sample with available timing information		78%	36%	54%

*Extreme low due to one location with a narrow intersection width and lengthened bicycle indication to be concurrent with pedestrian indication. Next lowest value was 3.8 ft/s.

It should be noted that other characteristics of the intersection and cyclist population were beyond the scope of knowledge reasonably available to survey respondents. From the literature review, it is clear that factors beyond intersection width affect crossing time and other cyclist performance characteristics. The calculated assumed speeds, detached from this supplementary information, are difficult to compare across signals as it is impossible to group the signals by meaning intersection or cyclist characteristics.

4.3 MOTIVATIONS AND DECISION CRITERIA

4.3.1 Motivations

Another aspect of signal head installation is the motivations behind it. Survey respondents were asked to cite the reasons for installing signals at particular locations. Reasons for installation could be grouped into five categories:

1. Cyclist non-compliance with previous traffic control
2. Presence of a contra-flow bicycle movement

3. A diagonal (or otherwise unique) cyclist path through the intersection
4. Safety concerns for cyclists
5. Other

From Table 4-5, bicycle signals are most commonly installed when cyclists are moving against motorist traffic or taking a non-standard path through an intersection or when there are safety concerns for cyclists at that intersection. The many contra-flow responses are from installations in Vancouver, BC and Montreal, QC with two-way cycle tracks. Reasons falling into the "Other" category were few. For two signals, infrastructure updates gave the agencies an opportunity to install the signal. Three more signals were installed for experimental reasons – to try out new traffic control and/or signal timing for cyclists.

Table 4-5 Motivations for Installation

Motivations	Number of Intersections			Percent of Sample		
	US	CN	Total	US	CN	Total
Non-compliance	3	0	3	8%	-	3%
Contra-flow	6	36	42	17%	69%	48%
Unique path	13	3	16	36%	6%	18%
Safety	9	12	21	25%	23%	24%
Other	4	1	5	11%	2%	6%

Note: percentages do not add to 100% as more than one motivating reason per intersection could be cited

4.3.2 Decision Criteria

Very few jurisdictions had clear decision criteria for the installation of bicycle signals. Four survey respondents and the Portland Bureau of Transportation (PBOT) indicated that they had some sort of decision criteria for installing the signals. Table 4-6 indicates the jurisdictions with decision criteria and the source/type of the criterion.

Table 4-6 Decision Criteria

Jurisdiction	Source/Type of Decision criteria
Ashland and Clackamas Co., OR	ODOT Traffic Signal Policy and Guidelines, Addendum 2
Eugene, OR	Independently Developed
Portland, OR	Independently Developed
San Francisco, CA	CAMUTCD

4.3.2.1 Ashland and Clackamas County, OR

Traffic control in these two Oregon jurisdictions is governed by the Oregon Department of Transportation and thus uses the decision criteria given in Addendum 2 of Oregon's Traffic Signal Policy and Guidelines, found in Appendix A.

4.3.2.2 Eugene, OR

Eugene has three criteria, of which one should be met, to install a bicycle signal:

1. Two or more bicycle/motor vehicle crashes, which happened for reasons that could've been prevented by the installation of a bicycle signal, occurred in the last three years.
2. Geometric factors at an intersection that impede cyclist crossing that could be mitigated with a bicycle phase.
3. When there is a bicycle-only approach to an intersection.

4.3.2.3 Portland, OR

Portland specifies that one of the following conditions/objective be met in order to warrant a bicycle signal:

1. Geometric factors – to control the separation of conflicting movements between cyclists and motorists
2. When there is a bicycle-only approach to an intersection
3. When there is a need to provide a leading interval for cyclists in order to increase their visibility and safety
4. Where paths cross roadways – to provide a shorter green time for cyclists when no pedestrians are present
5. If there is a bicycle movement that is not accommodated by typical traffic signals
6. If there are high cyclist volumes at an intersection

4.3.2.4 San Francisco, CA

San Francisco uses the warrants given in the California MUTCD that have been previously discussed in this report (See section 2.1.5).

Of the five agencies with decision criteria, all include warrants based on geometric factors that affect cyclists crossing an intersection. The existence of a bicycle-only approach and collision criteria were warrants present in four of the five agencies' documents.

5 RESEARCH NEEDS

The review of the existing literature and synthesis of practice has highlighted several areas in need of additional research. Overall, there is a lack of consistency in terms of bicycle signal design and operations including timing, detection, signal characteristics, and signal location. This might be expected given the "experimental" status of bicycle signals in the US. Adoptions of standard guidance would benefit from focused research in the following areas:

- It is clear that there is a wide range of published cyclist performance data (perception-reaction times, rolling speeds, accelerations) that can be used to guide the selection of basic signal parameters such as minimum green, yellow and red clearance intervals, and extension times. Though 10 mph is now cited in the AASHTO, Caltrans, and NACTO documents as an assumed rolling speed, the empirical evidence indicates that there is a wide range of performance that may need to be accommodated based on individual locations. Specific research needs in this area are:
    - While the guidance documents recommend field-obtained values, there is no consistent methodology to determine field speeds, acceleration, and start-up lost time values. Most published studies have used slightly different measurements.
    - Performance values could possibly be affected by trip purpose or rider type. Some speed data cited in the literature was gathered from trail riders, who may have a significantly different riding behavior than urban bicycle commuters. Similarly, weekend cyclists may exhibit different performances than weekday cyclists.
    - The effects of grade on cyclist speeds are not quantified (i.e. for every percent increase in grade speed assumptions change by some amount).
    - There is little published research about start-up reaction times, possibly as a function of signal head placement (near-side or far-side).
- There is no treatment of potential bicycle dilemma (indecision) zones or minimum stopping sight distances in the guidance documents. Field-based empirical evidence related to the following would be useful:
    - Reaction times to yellow indications, possibly as a function of approach speed and cyclist type.
    - The placement of advance detection for actuated signals for timing extensions.
- There was limited analysis on how bicycle phases (with active extensions) might affect delay for all other users. More detailed delay analysis could be performed in simulation software (such as in VISSIM). This would aid in the establishment of better warrants. Additionally, the interaction between detection distance, green time extension, and traffic delays have not been studied.
- Information on the cyclist compliance at bicycle-specific signals, especially in context to other signals is lacking. Research is need to address:
    - How compliance compares between locations with and without a bicycle-specific signals under similar contexts. Implicit in this analysis would be guidance on suitable delays that cyclists are willing to tolerate to have a separated phase (safety – mobility tradeoff).
- Empirical evidence that document improvements in the safety of cyclists at these signals is still limited. Given the unique locations where these have been installed, a robust safety

analysis may be challenging. Surrogate measures, such as a conflict analysis might be useful.

- There is a clear need for research into the most appropriate design for bicycle specific signal heads. The 2010 FHWA scan tour noted a variety of designs for bicycle signal heads. Parameters such as size, location, and the means to designate that the signal head is for bicyclists could have significant impact on bicyclist and motorist comprehension, as well as the ability to utilize the bicycle signal head in a variety of intersection configurations.

6 REFERENCES

American Association of State Highway and Transportation Officials. (2012). *Guide for the Development of Bicycle Facilities*. American Association of State Highway and Transportation Officials.

Basford, L., Reid, S., Lester, T., Thomson, J., & Tolmie, A. (n.d.). *Drivers' perceptions of cyclists* (No. TRL549). United Kingdom: Department of Transport of the United Kingdom.

City of Portland Bureau of Transportation [PBOT]. (2004). *Pedestrian and Bicycle Enhanced Enforcement Project: Opportunity Analysis*. Portland, OR: PBOT.

CROW ede Rik de Groot, H. (Ed.). (2007). *Design Manual for Bicycle Traffic*. CROW Record. CROW, Ede.

de Haan, D., Zeegers, T., & van der Linden, P. (2003). Bicycle-friendly Traffic Lights. *Verkeerskunde (Traffic Engineering)*, *10*, 32–37.

Denver, CO. (2009). *Traffic Signal Study Behavior*. City and County of Denver, CO.

Dill, J. (2009). Bicycling for Transportation and Health: The Role of Infrastructure. *Journal of Public Health Policy*, (30), S95–S110.

Dill, J., & Carr, T. (2003). Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them. *Transportation Research Record*, *1828*, 116–123.

Federal Highway Administration. (1994). Selecting Roadway Design Treatments to Accommodate Bicycles (Publication No. FHWA-RD-92-073). Federal Highway Administration.

Federal Highway Administration. (2009). *Manual on Uniform Traffic Control Devices*. Washington D.C.: Federal highway Administration.

Fietsberaad. (2003). *The Bicycle friendliness of traffic control systems*. Amsterdam: Fietsberaad. Retrieved from http://www.fietsberaad.nl/library/repository/bestanden/The%20bicycle%20friendliness%20of%20traffic%20control%20installations.doc

Fischer et al. (2010). *Pedestrian and Bicyclist Safety and Mobility in Europe* (No. FHWA-PL-10-010). Alexandria, VA: Federal Highway Administration and the American Association of State Highway and Transportation Officials.

Geller, R. (2009). *Four Types of Cyclists*. Portland, OR: Portland Bureau of Transportation. Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44597&a=158497.

Jacobsen, P. L. (2003). Safety in numbers: More walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, *9*, 205–209.

Johnson, M., Newstead, S., Charlton, J., & Oxley, J. (2011). Riding through red lights: The rate, characteristics and risk factors of non-compliant urban commuter cyclists. *Accident Analysis and Prevention*, *43*, 323–328.

Koorey, G. (2010, August 25). *Attracting the Next 10% of Cyclists with the Right Infrastructure*. Presented at the Transportation Seminar, Portland State University. Retrieved from http://www.cts.pdx.edu/seminars/datearchives.php

Krizek, K. J., & Roland, R. W. (2005). What is at the End of the Road? Understanding Discontinuities of On-street Bicycle Lanes in Urban Settings. *Transportation Research*, *D*(10), 55–68.

Mekuria, M. C., Furth, P. G., & Nixon, H. (2012). *Loss-Stress Bicycling and Network Connectivity* (No. MTI Report 11-19). San Jose, CA: Mineta Transportation Institute.

Opiela, K. S., Khasnabis, S., & Datta, T. K. (1980). Determination of the Characteristics of Bicycle Traffic at Urban Intersections. *Transportation Research Record*, (743), 30–38.

Pein, W. (1997). Bicyclist Performance on a Multiuse Trail. *Transportation Research Record*, (1578), 127–131.

Pucher, J., & Buehler, R. (2009). Cycling for a Few or for Everyone: The Importance of Social Justice in Cycling Policy. *World Transport Policy & Practice*, *15*(1), 57–64.

Pucher, J., & Dijkstra, L. (2000). Making Walking and Cycling Safer: Lessons from Europe. *Transportation Quarterly*, *54*(3).

Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An International Review. *Preventive Medicine*, (50), S106–S125.

Raksuntorn, W., & Khan, S. I. (2003). Saturation Flow Rate, Start-Up Lost Time, and Capacity for Bicycles at Signalized Intersections. *Transportation Research Record*, (1852), 105–113.

Robinson, D. L. (2005). Safety in numbers in Australia: More walkers and bicyclists, safer walking and bicycling. *Health Promotion Journal of Australia*, *16*(1), 47–51.

Rubins, D. I., & Handy, S. (2005). Times of Bicycle Crossings: Case Study of Davis, California. *Transportation Research Record*, (1939), 22–27.

Shladover, S., Kim, Z., Cao, M., Sharafsaleh, A., & Li, J.-Q. (2009). Bicyclist Intersection Crossing Times: Quantitative Measurements for Selecting Signal Timing. *Transportation Research Record*, (2128), 86–95.

Shladover, S., Kim, Z. W., Cao, M., Sharafsaleh, A., Li, I., & Johnston, S. (2011). *Bicycle Detection and Operational Concept at Signalized Intersections: Phase 2* (No. UCB-ITS-PRR-2011-02). California PATH Research Program.

Taylor, D. B., & Mahmassani, H. S. (2000). Coordinating Traffic Signals for Bicycle Progression. *Transportation Research Record*, *1705*, 85–92.

Transportation Research Board. (2010). *The Highway Capacity Manual* (5th ed.). Washington D.C.: Transportation Research Board.

Wachtel, A., Forester, J., & Pelz, D. (1995). Signal Clearance Timing for Bicyclists. *Institute of Transportation Engineering*, *65*(3), 38–45.

Wheeler, N., Conrad, R., & Figliozzi, M. A. (2010). A Statistical Analysis of Bicycle Rider Performance: The Impact of Gender on Riders' Performance at Signalized Intersections. *89th Annual Meeting of the Transportation Research Board*.

Wu, C., Yao, L., & Zhang, K. (2011). The red-light running behavior of electric bike riders and cyclists at urban intersections in China: An observational study. *Accident Analysis and Prevention*, (2497). doi:10.1016/j.aap.2011.06.001

APPENDICES

APPENDIX A – ODOT POLICY
APPENDIX B – SURVEY INSTRUMENT
APPENDIX C – STATE OF THE PRACTICE SUMMARY SHEETS

APPENDIX A – ODOT POLICY

Section VI. Special Applications – Cont'd

C. Bicycle Signal Phases

Signalized intersections may be operated with phases specifically intended for bicyclists. These bicycle phases are used in combination with an intersection traffic control signal to control the movements of bicycles through an intersection. While less restrictive means of handling conflicts between bicyclists and motorists should be considered first, bicycle signal phases can be a useful tool to improve the safety or service of bicyclists through an intersection. Bicycle signal phases shall direct bicyclists to take specific actions and may be used to improve an identified safety or operational problem involving bicyclists.

Alternative means of reducing or eliminating the bicycle-motor vehicle conflicts may include:

- Striping to direct a bicyclist to a lane adjacent to a traffic lane such as a bike lane to the left of a right-turn-only lane.
- Redesigning the intersection to direct a bicyclist from an off-street path to a bicycle lane at a point removed from the signalized intersection.

1. Basis for Installation

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. Proximity to schools, parks, and popular bike routes should be considered. Additional delay to all roadway users should be considered. One of the following criteria below should be met:

a. Two or more reported bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over three years.

b. Geometric factors are present that are best mitigated through the use of a bicycle signal phase.

c. 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:

- a bike lane to the right of a high volume right turn; and,
- a multi-use path that comes into the intersection in such a way that motorists may not see or yield to bicyclists approaching the intersection.

2. Standard Practice

The bicycle signal phase indications shall use the special bicycle symbol as described below. Only green, yellow and red lighted indications shall be used to implement bicycle signal phases at a signalized intersection. A bicycle signal phase may be operated exclusively or in conjunction with other compatible vehicle or pedestrian phases.

The primary bicycle signal head should utilize eight or twelve-inch displays. Near-side or supplemental heads may utilize smaller displays. The bicycle symbol should closely resemble the figure shown in sign W11-1 as depicted in the current MUTCD and the FHWA Standard Highway Signs manual.

The bicycle signal indications should be placed to maximize visibility for bicyclists and minimize visibility for motorists. The bicycle signal indications may need to be shielded or programmed to reduce visibility to conflicting motorists.

3. Optional Practices

a) A near-side display may be added to improve bicyclist compliance with the bicycle signal.

b) The bicycle signal head may be designated as a bicycle-specific signal with a sign posted above or below the signal head. A bicycle signal head may also be designated by placing a bike symbol directly on the signal backplate.

c) On approaches where more than one bicycle signal head is used to direct different bicycle movements through an intersection, an arrow may be marked on each back plate or sign below the green (bottom) display to indicate the intended direction of bicycle movement.

d) A full or part-time restriction of right turns on red may be posted to prevent motor vehicles from turning right on red when bicyclists have a green indication.

e) A bicycle signal may be used to implement a leading bicycle interval.

Sample pictures

The installations pictured below would all meet the intent of the above policy

Davis, CA

Portland, OR

Switzerland

APPENDIX B – SURVEY INSTRUMENT

General Information

Q1. **This survey is being conducted to help establish the current state-of-the practice regarding bicycle-specific traffic signals. It is part of a research project being conducted at Portland State University funded by the Oregon Department of Transportation and the Oregon Transportation Research Education and Consortium. The investigators and contact information are listed below.**

We hope to use the information collected in this survey to produce a synthesis of practice to guide the next steps in the research. Your input would be indispensable to our project and greatly appreciated. In addition to the basic questions about the signals themselves, we are hoping to acquire additional information such as the signal timing, signal plans, and any pictures of the signals and their accompanying signage.

The survey should take between 5-7 minutes to complete. We realize that you may not have all the information that we are requesting. Even if you don't all of the details, your responses will still be helpful to us. But if you feel we should send this survey to someone else, please let us know or forward this survey to them. If you would like a copy of the results of this survey, you can tell us that in the survey.

Thank you in advance for completing this survey.

Sincerely,

Christopher Monsere, Principal Investigator, monsere@pdx.edu, 503-725-9746
Miguel Figliozzi, Co-Principal Investigator, figliozzi@pdx.edu
Sara Thompson, Graduate Research Assistant, s.r.thompson@pdx.edu

Q2. **Your Contact information**

Name

Email

Phone

Agency or Firm Name

Q3. Would you like us to send you a copy of the compiled survey results to the email address above?

- Yes
- No

Q4. **We are aware of bicycle-specific traffic signals in:**

Alexandria, VA
Arlington, VA
Ashland, OR
Austin, TX
Clackamas Cnty, OR
Davis, CA
Denver, CO
Eugene, OR
New York City, NY
Montreal, QC
Portland, OR
San Francisco, CA
San Luis Obispo, CA
Seattle, WA
Tucson, AZ
Vancouver, BC
Washington DC

Are you aware of bicycle-specific traffic signals in any other U.S. or Canadian jurisdictions? If yes, please tell us (include a contact if you know):

Q5. **The survey is configured to ask you a set of questions about each bicycle-specific signal in your jurisdiction. The number you enter in the box below will determine how many sets of questions you are presented. There are 15 questions are about engineering aspects of the signal such as placement, mounting height, lens diameter, backplate color, type of actuation, interval times, use of louvers, and performance . You may skip any question that you do not know the answer.**

If two or more signals are very similar in their characteristics and operation, you can count them as 1 signal to reduce your burden in responding (just indicate the locations of the multiple signals in the next question).

How many bicycle traffic signals, for which you would like to provide information, are currently implemented in your jurisdiction? (this answer determines the number of question sets you will be given)

Set of Questions About Signal Characteristics - 1 per typical installation

Q6. **Please specify the intersection location (cross streets) for ${lm://Field/2}. If you are planning to provide information about multiple signals in one set of questions, please list the locations**

Q7. **What motivated the installation of this signal?**

Q8. Is the signal head placed on the near or far side of the intersection?

- Near
- Far
- Both
- Other

Q9. **What is the signal head mounting height (ft)?**

Q10. The mounting height is measured from

- ground to bottom of signal housing
- ground to top of signal housing

Q11. What is the color of the signal housing?

- Black
- Yellow
- Other

Q12. What is the color of the signal head backplate?

- Black
- Yellow
- No backplate
- Other

Q13. What is the lens size (diameter, inches) used in the signal head?

- 12 inches
- 10 inches
- 8 inches
- Other

Q14. **Which insignia is presented in the lens housing?**

Bicycle faces left	Bicycle faces right	Bicycle but not sure of direction	No bicycle insignia used	Other
○	○	○	○	○

Q15. Is there additional signage used to indicate the signal controls the bicycle movement only?

- ○ Yes
- ○ No

Q17. Are louvers employed to restrict visibility of this signal from motorists?

- ○ Yes
- ○ No
- ○ Don't know

Q18. How is the signal actuated? (check all that apply)

- ☐ Loop detection
- ☐ Video detection
- ☐ Push-button
- ☐ No detection - on recall
- ☐ Other

Q19. **What is the length of the following intervals (in seconds) for the bicycle-specific signal?**

Minimum Green interval	
Yellow interval	
All-red interval	

Q20. Are drivers restricted from making certain movements when cyclists have the green indication?

- ○ Right turn on red
- ○ Other

Q21. Has your jurisdiction been collecting data before and/or after the installation of this signal?
(If so, please check types of data collected.)

- ☐ Bicycle volumes
- ☐ Bicycle compliance
- ☐ Pedestrian compliance
- ☐ Motorist compliance
- ☐ Crash data
- ☐ Other

Q22. Would you be willing to share these data?

- ○ Yes
- ○ Maybe, under certain conditions
- ○ No

Q23. **Describe how well you think the bicycle-specific signal is working. Both empirical and anecdotal evidence are welcome and helpful.**

Q24. **Please upload any or all of the following for this signal if you have them available. We would appreciate photos! If you have any problems with uploading files or any other files that you think may be relevant (and are not listed below), please e-mail them to Sara Thompson at s.r.thompson@pdx.edu**

signalization plan

Browse...

Q25. **detector plan**

Browse...

Q26. **pictures of the signals and their accompanying signage**

Browse...

Q27. **additional pictures**

Browse...

Q28. **additional pictures**

[ ] Browse...

Block 2

Q29. **Does your jurisdiction have decision criteria that are used to decide on when to use bicycle specific-signals? (If "Yes," please detail them or attach them in question 30.)**

Q30. **Upload decision criteria**

[ ] Browse...

Q31. What guidance was used to determine cyclist performance for signal timing or other design issues?
(i.e. how were cyclist performance measures such as speed and acceleration determined). Check all that apply.

- ☐ AASHTO Guide for the Development of Bicycle Facilities
- ☐ Design Manual for Bicycle Traffic (CROW Dutch Guide)
- ☐ Bicycle Transportation: A Handbook for Cycling Transportation Engineers (Forester)
- ☐ Field Measurements
- ☐ NACTO Urban Bikeway Design Guide
- ☐ Other

Q32. **Do you see any clear research questions / research needs that are related to bicycle specific signals that has not been asked in the survey?**

Q33. **Is there anything else you would like to tell us before completing the survey?**

APPENDIX C – STATE OF THE PRACTICE SUMMARY SHEETS

Municipality: **Alexandria, VA**
Contact: William Schultheiss
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Mount Vernon Trail & Porto Vecchio driveway

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	70	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	8	Faces right	No	Yellow	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
x			x	

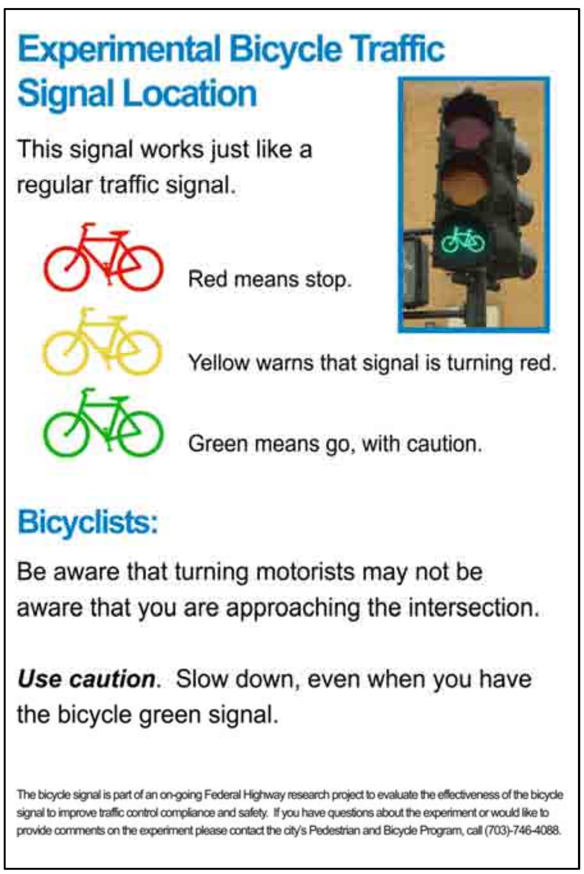
Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
0	11.7	6	4	1.4

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:



Municipality: **Arlington, VA**
Contact: Dave Kirschner
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x	x		x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
3	2	60	60

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	8	Yes	No	Yellow	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
x				

Signal Timing – Bicycle Signal(s)

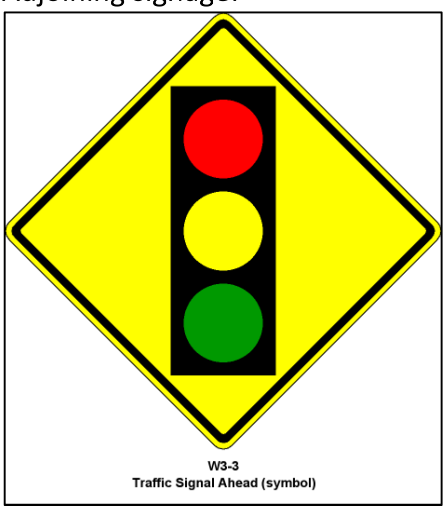
Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Lee Highway (US 29) and N Oak Street

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:



with "Bike Signal Ahead" placard

Lee Highway (US 29) and N Scott Street

Municipality: **Arlington, VA**
Contact: Dave Kirschner
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x	x		x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	50	50

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	8	Yes	No	Yellow	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
x				

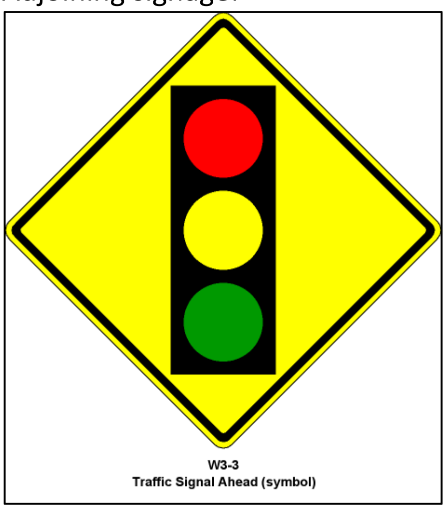
Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:



with "Bike Signal Ahead" placard

Municipality: **Austin, TX**
Contact: Nathan Wilkes
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Red River Street & 4th Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	100	100

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	none	No	Yellow	Yellow	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

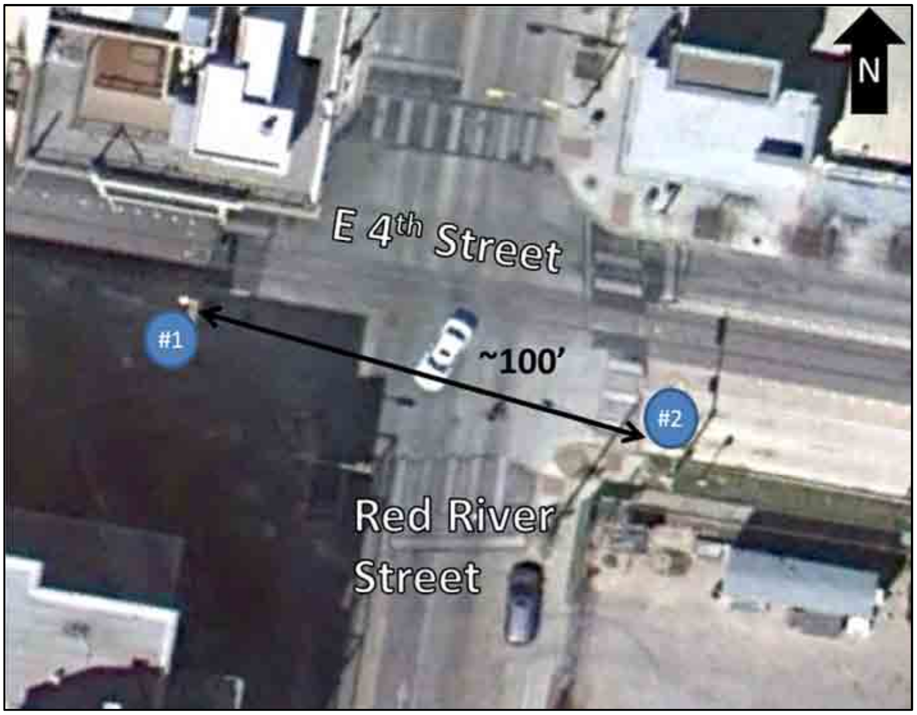
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Austin, TX**
Contact: Nathan Wilkes
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Rio Grande Street & Martin Luther King Jr. Boulevard

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	130	130

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	none	No	Yellow	Yellow	video

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

SE Johnson Creek Blvd, Bell Avenue (Springwater Trail)

Municipality: **Clackamas County, OR**
Contact: Richard Nys
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
6*	2	90	90

* including two legs of the Springwater Corridor Trail

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	Faces right	Yes	Black	Yellow	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

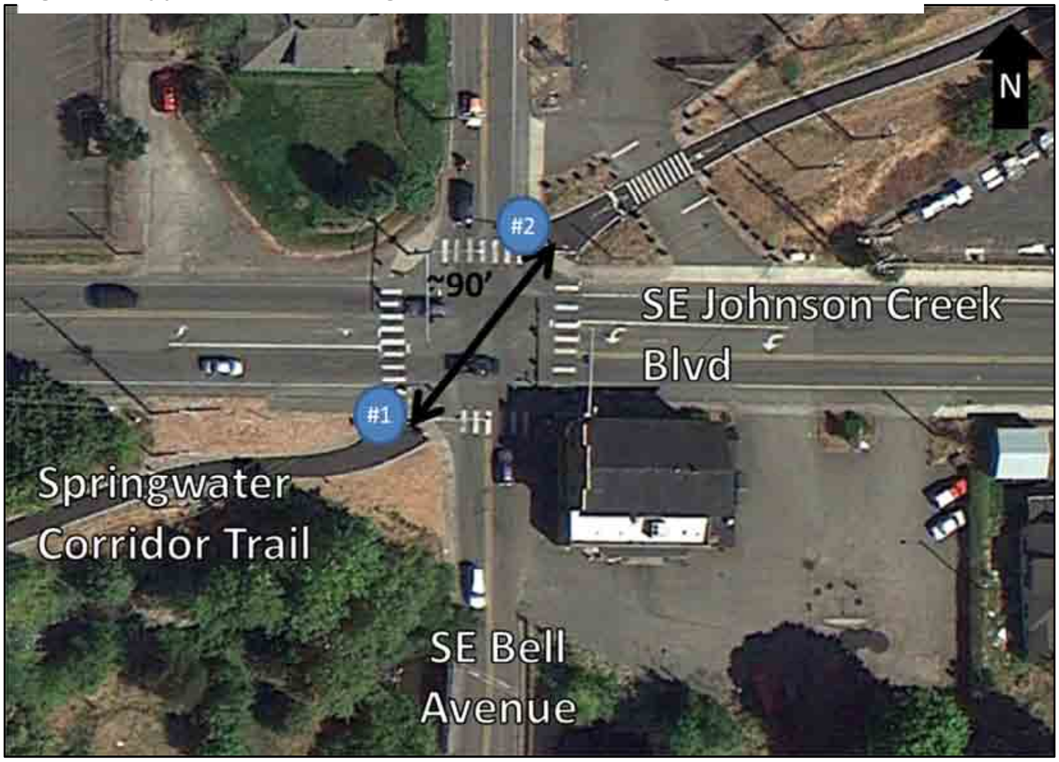
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x	x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	7.3	8	3.5	5.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining Signage:

Municipality: **Denver, CO**
Contact: Amy Rens
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Bannock Street and 14th Avenue

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
4	1	100

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
0	5.5	14	3	5

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Municipality: **Eugene, OR**
Contact: Christina Knierim
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Alder Street and E 18th Avenue

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x	x		x	x

*Bicycle Transportation: A Handbook for Cycling Transportation Engineers (Forester) was also used for this signal

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	70	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	17	12	Faces right	Yes	Black	Yellow	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Left-turn movement from trail to street	Other
	x		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	3.8	18	4	0.5

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Rue Berri & Rue Cherrier

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	80	80

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	14	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

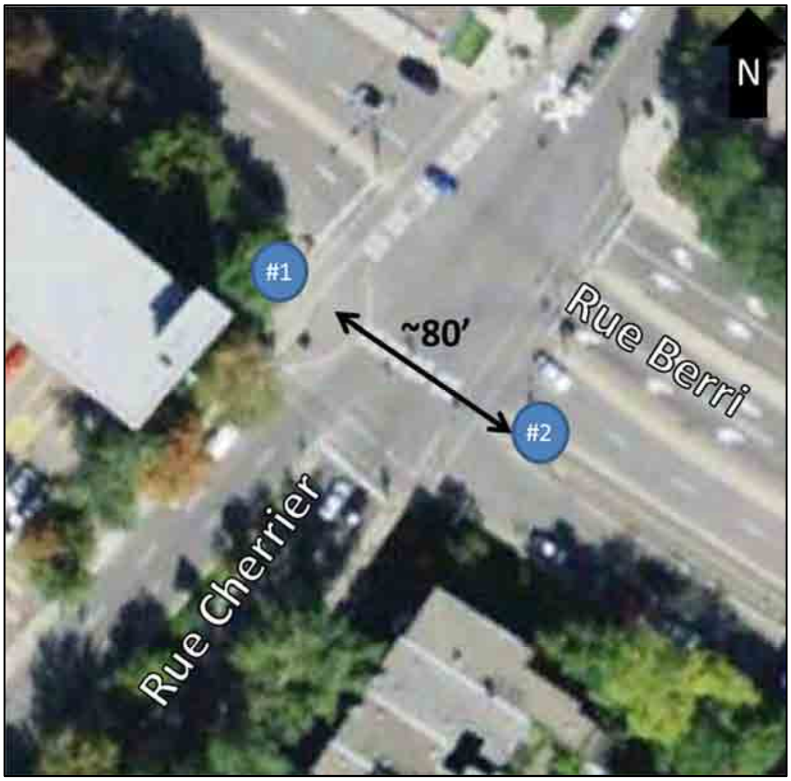
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x	x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	16.2	5	4	2

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Christophe-Colomb & Saint-Grégoire

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	65	65

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

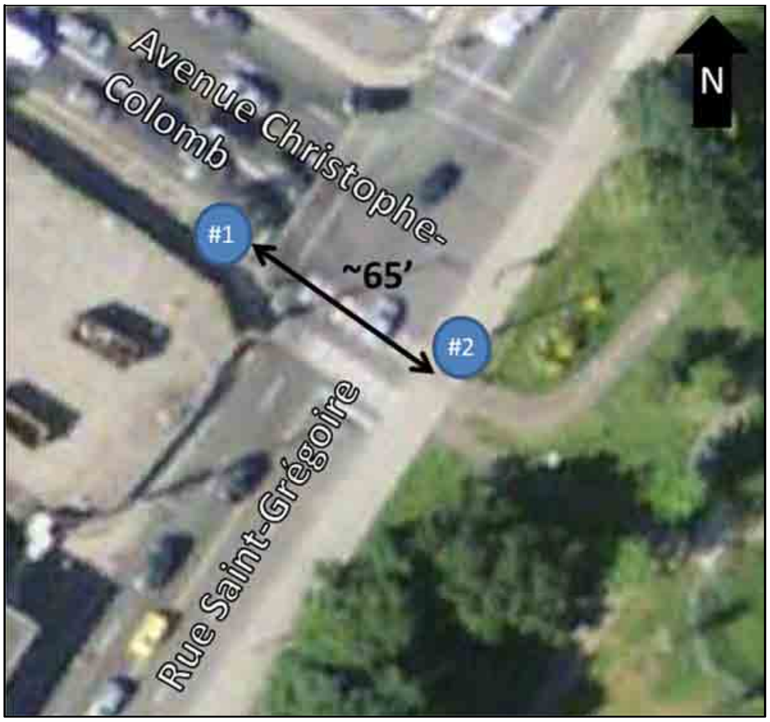
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	4.9-6.6	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Rue de la Commune & Rue McGill

Municipality: **Montreal, Canada**

Contact: Roger Bibaud

Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
3	2	95	80

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	14	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

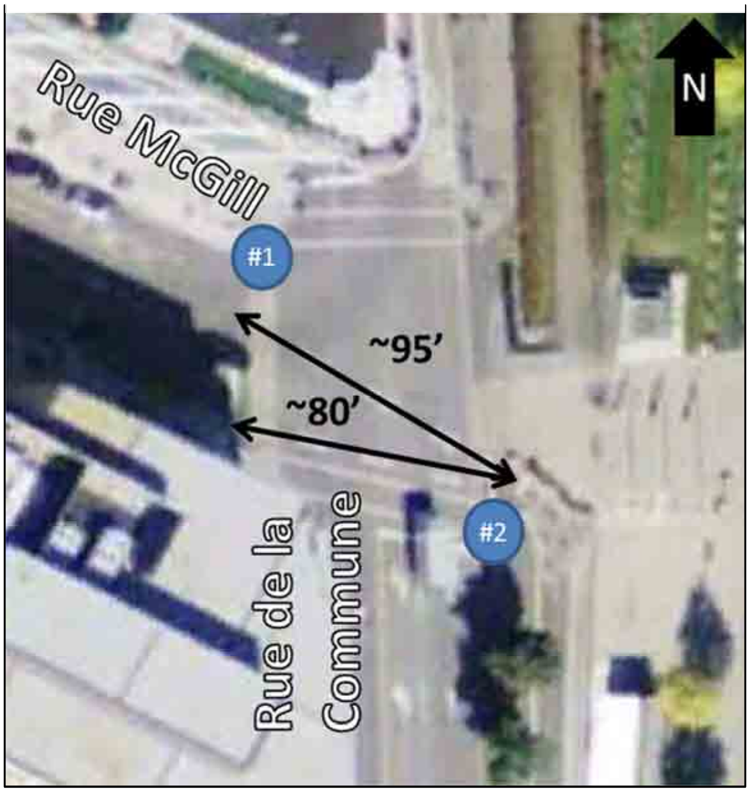
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	17.4	5	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Park Avenue & Avenue du Parc

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)	Crossing Distance for Bike Signal #3 (ft)	Crossing Distance for Bike Signal #4 (ft)	Total Crossing Distance (including median, ft)
3	4	50	50	70	70	135

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far*	14	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing
* on median and far side of intersection for both directions

Motivation for Signal Installation

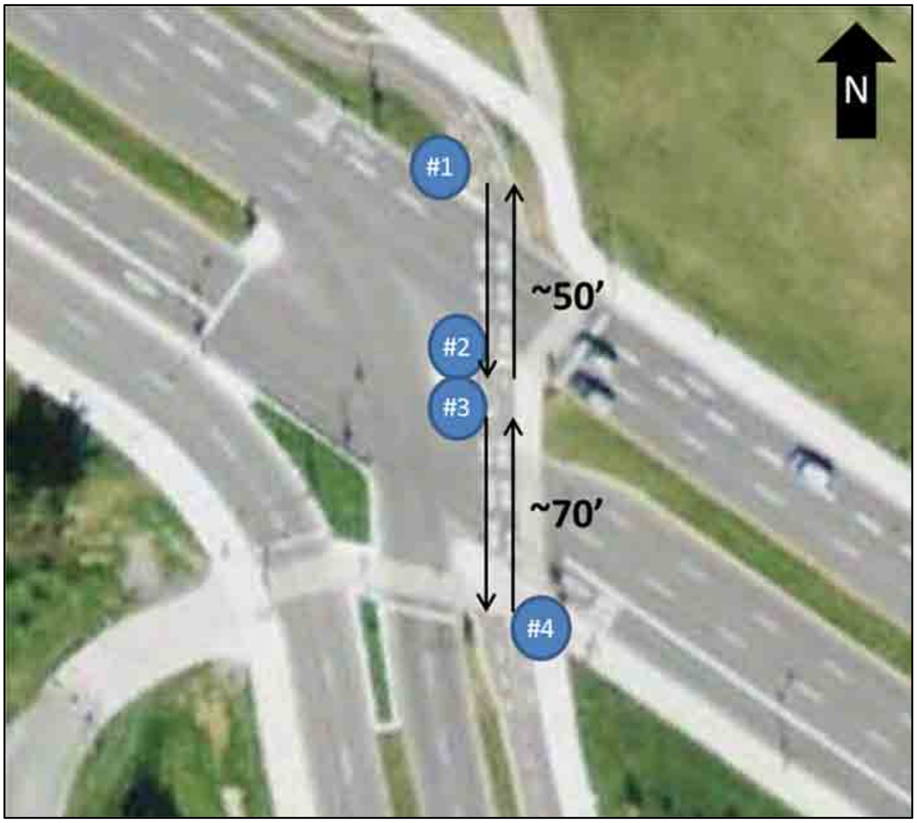
Non-compliance with previous traffic control	Presence of contra-flow bike lane	Unique bicycle path through intersection	Safety concerns	Left-turn movement from trail to street	Other
	x	x	x		New construction opportunity

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red
	4.6	25	5	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



***Signals #1 and #3 face South, signals #2 and #4 face North**

Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM WEB VERSION	

Park Avenue & Avenue des Pins Ouest

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)	Crossing Distance for Bike Signal #3 (ft)	Crossing Distance for Bike Signal #4 (ft)	Total Crossing Distance (including median, ft)
4	4	45	45	40	40	95

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far*	14	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing
* on median and far side of intersection for both directions

Motivation for Signal Installation

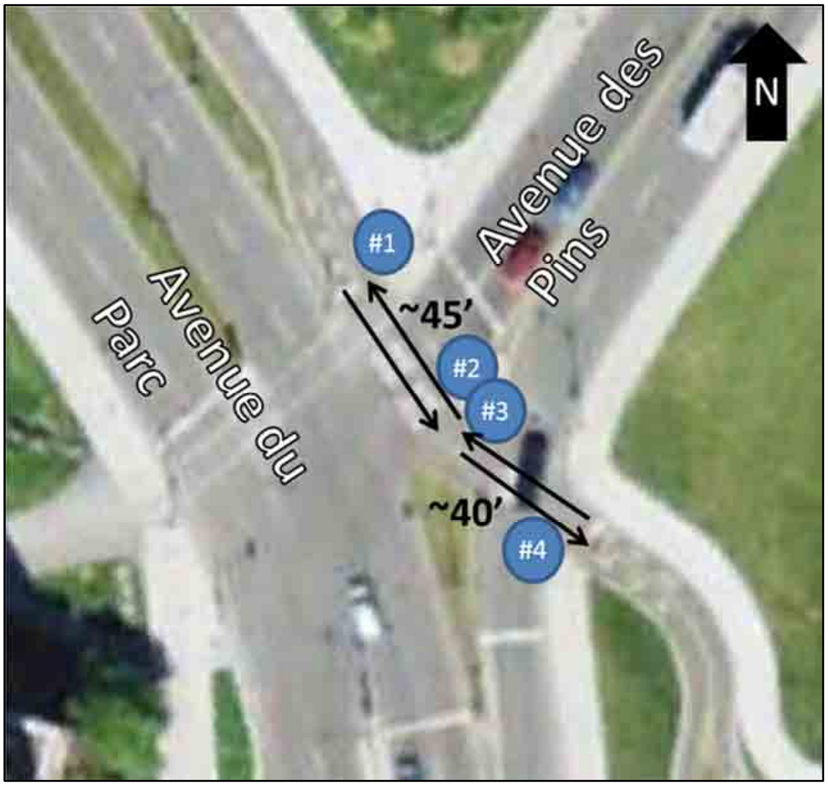
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	New construction opportunity

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red
	7.5	10	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Avenue Viger Est & Rue Berri

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	75	75

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	14	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	11	5	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Beaubien & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	70	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

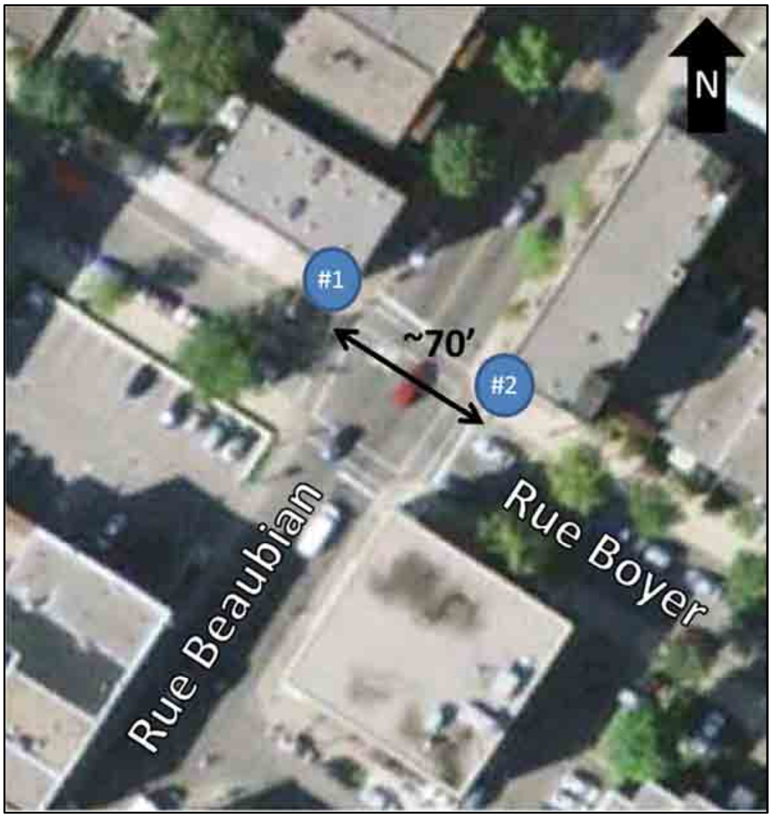
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	5.3-7.2	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **<u>Montreal, Canada</u>**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Belanger & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	75	75

Signal Characteristics (for both directions of travel)

Mounting[*]		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

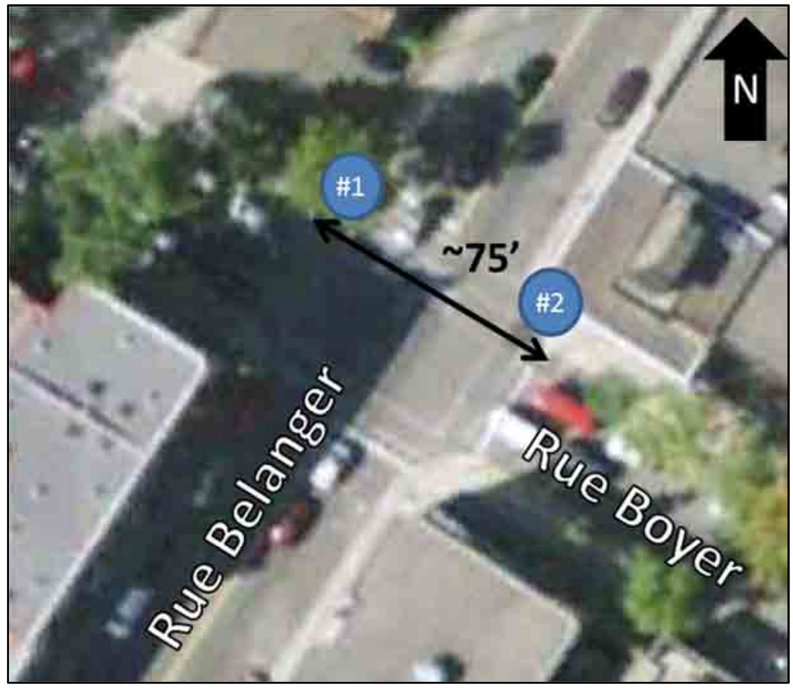
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	5.7-7.8	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Bellechasse & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	70	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

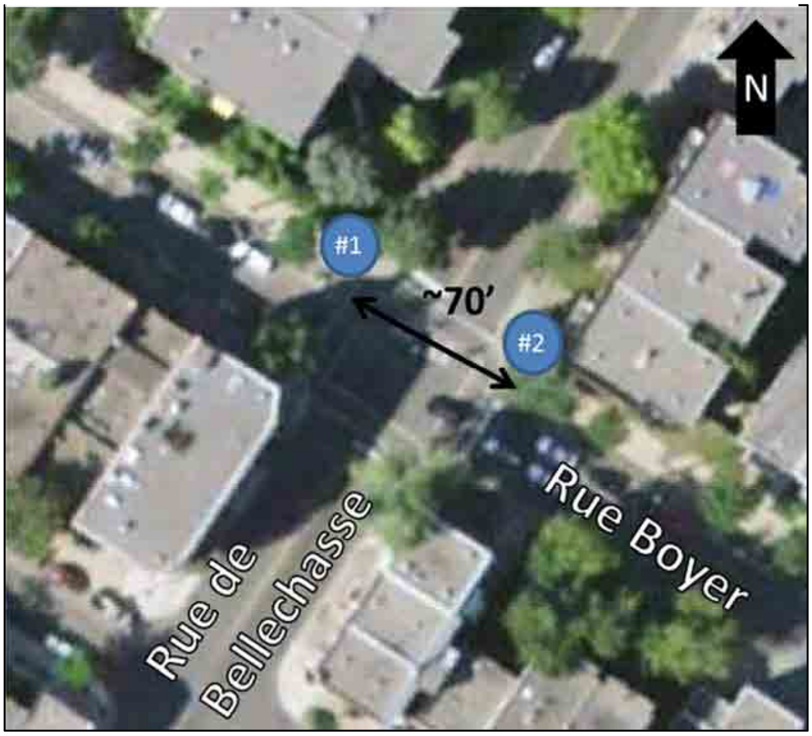
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	5.3-7.2	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Jean-Talon & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	85	85

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

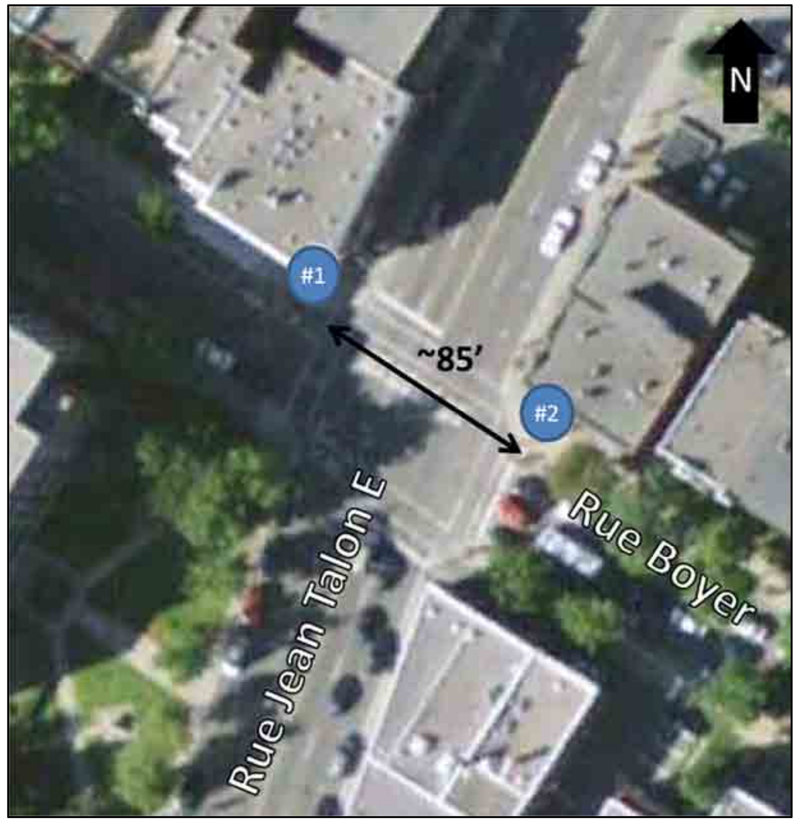
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	6.6-9.1	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Rosemont & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	70	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

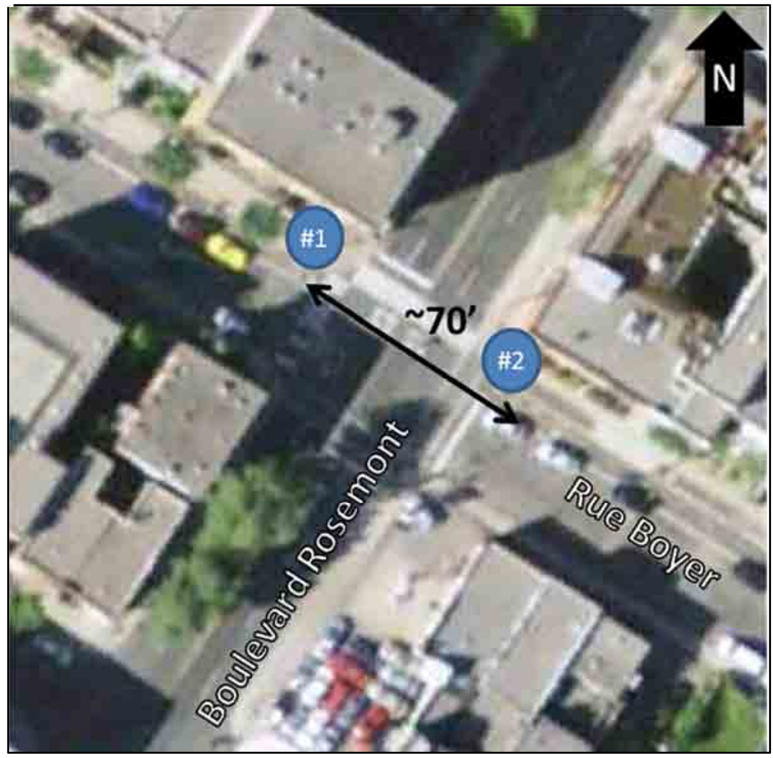
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	5.3-7.2	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **<u>Montreal, Canada</u>**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Saint-Zotique & Boyer

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	65	65

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	4.9-6.6	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining signage:

Villeray & Boyer

Municipality: **Montreal, Canada**
Contact: Roger Bibaud
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
		x		x

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	65	65

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	13	8	Faces left	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

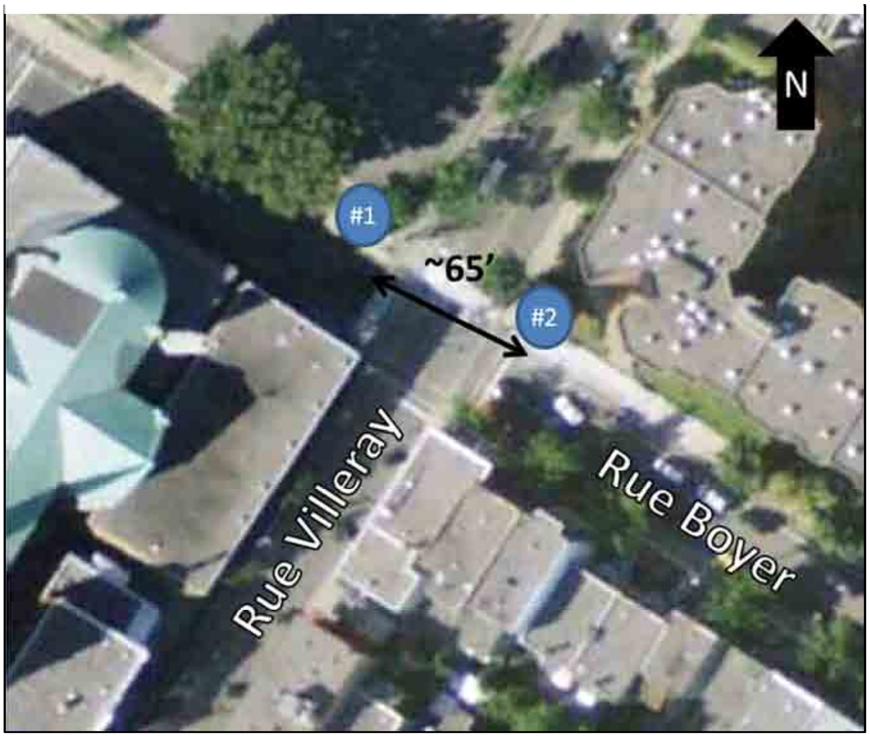
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x		x	Demonstration project

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	4.9-6.6	7-11	4	3

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

NE 22nd Avenue & Sandy Boulevard

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
4	1	100

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	19	8	Faces	No	Black	Black	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	11.5	10	3.0	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Rosa Parks Way & Interstate 5

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signals #1 & #2 (ft)
4	2	90

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both			N = Faces Left F = Faces Left	N = Yes F = Yes	N = Black F = Black	N = No Backplate F = Black	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
			x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
0	9.2	10	3.5	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

57th Avenue & Sandy Blvd

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
5	1	110

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		8	Left	No	Black	No Backplate	Push-button

[1] from ground to bottom of signal housing

Motivation for Signal Installation

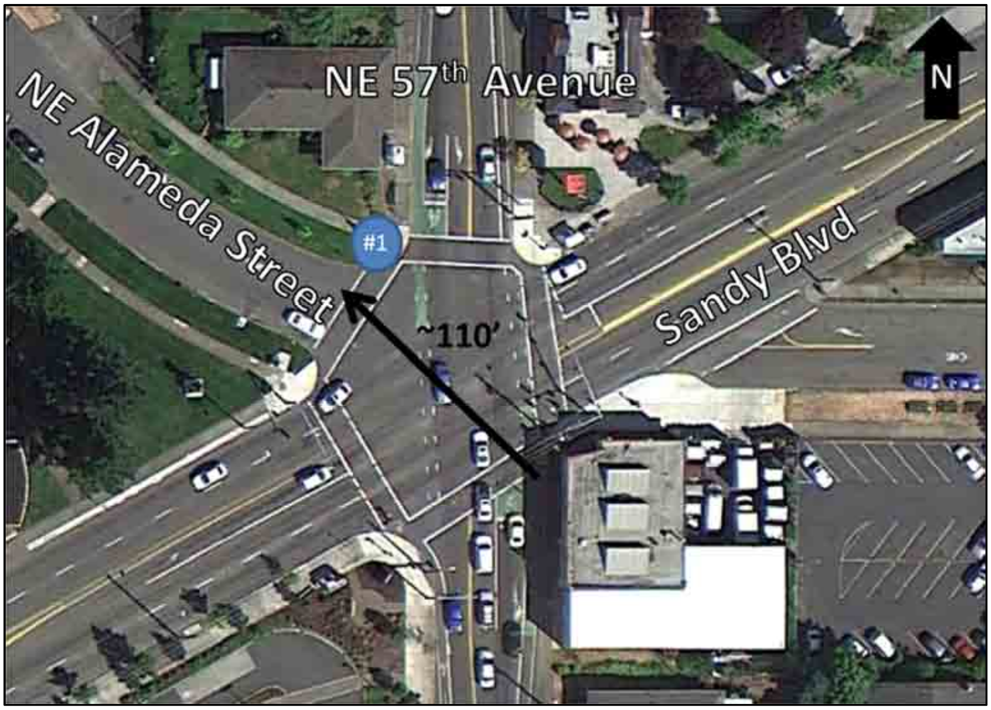
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	18.7	8	3.0	2.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining Signage:

SE 87th Avenue & SE Division Street

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
3	1	75	75

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	None	Yes*	Black	No Backplate	Push-button & Loop

[1] from ground to bottom of signal housing
*for SB signal head only

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
			x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	9.0	10	3.0	0.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Broadway and NW Lovejoy Street

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
3	1	90

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	Faces left	Yes	Black	Black	Video

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
			x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red
	6.5	12	4.0	2.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

NE Broadway and NE Victoria Avenue

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
4	1	60

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	11.25	12	Faces right	Yes	Yellow	Yellow	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
				experimental

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
Leading interval	Standing Start[1]	Min. Green	Yellow	All-red
	5.6	10	3.6	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

NE Broadway and N Williams Avenue

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	75	75

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	N = 9.5 F = 11.25	N = 8 F = 12	N = Faces left F = Faces left	N = No F = Yes	N = Black F = Yellow	N = Black F = Black	Push button & Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

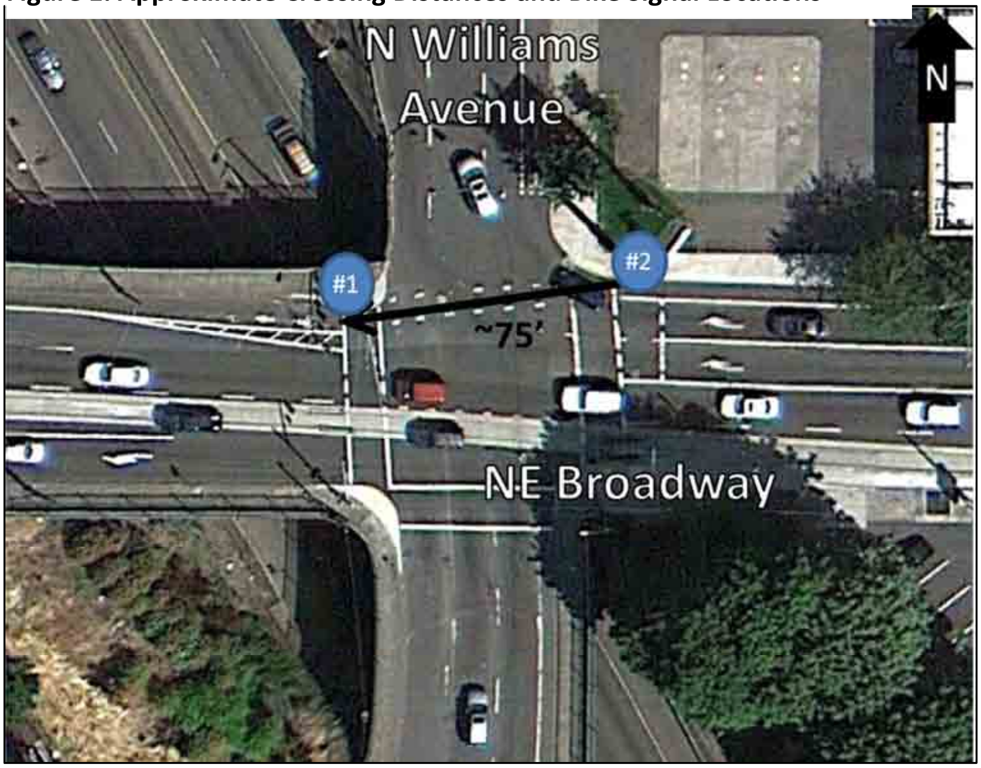
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
			x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red
	6.3	12	3.0	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

N Interstate Avenue & NE Oregon Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
5*	1	80

* including bike trail from East bank esplanade

Signal Characteristics

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	12.8	12	Faces left	No	Black	No backplate	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

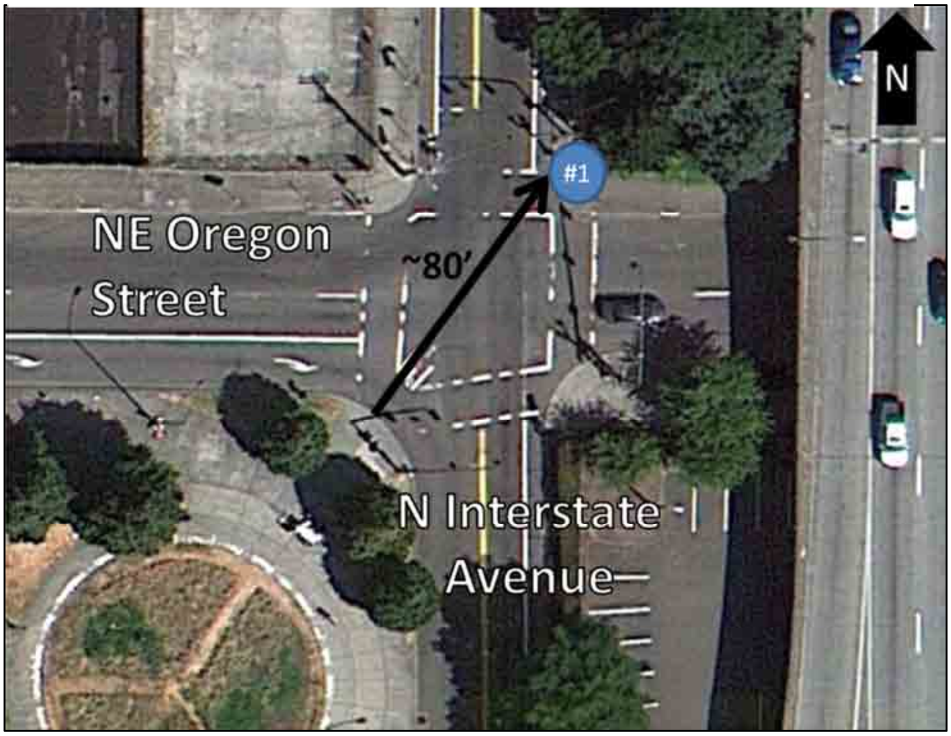
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	5.3	15	3.0	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining Signage:

Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

SW Moody Avenue & SW Gibbs Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
4*	4	30

* including bike lanes crossing Moody to OHSU campus

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	N = 5 F = 10.8	N = 4X4.5 (square) F = 12	None	No	N = Black F = Black	N = No backplate F = Black	Push button & Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		Complicated crossing with pedestrians and streetcar

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	2.1	15	3.0	1.0

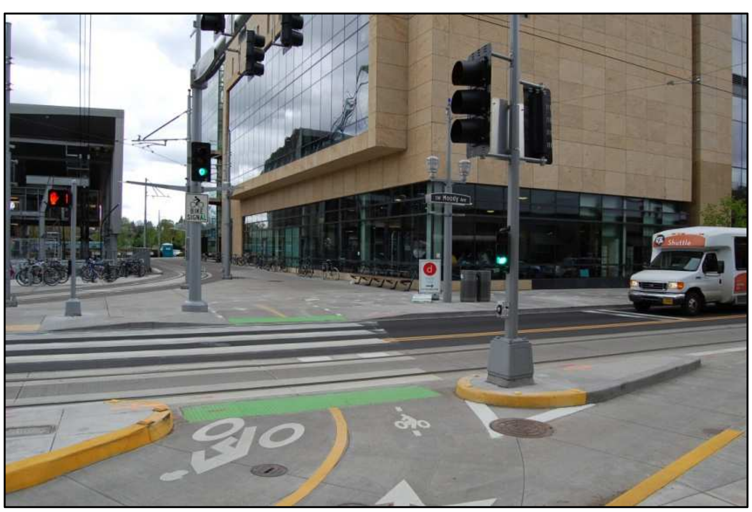
[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations*

*Bicycle infrastructure not shown

Adjoining Signage:

Current Bicycle Infrastructure:



Municipality: **Portland, OR**
Contact: Peter Koonce
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

SW Moody Avenue & SW Sheridan Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)
3	1	

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10.8	12	Faces right	No	Black	Black	Push button & Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

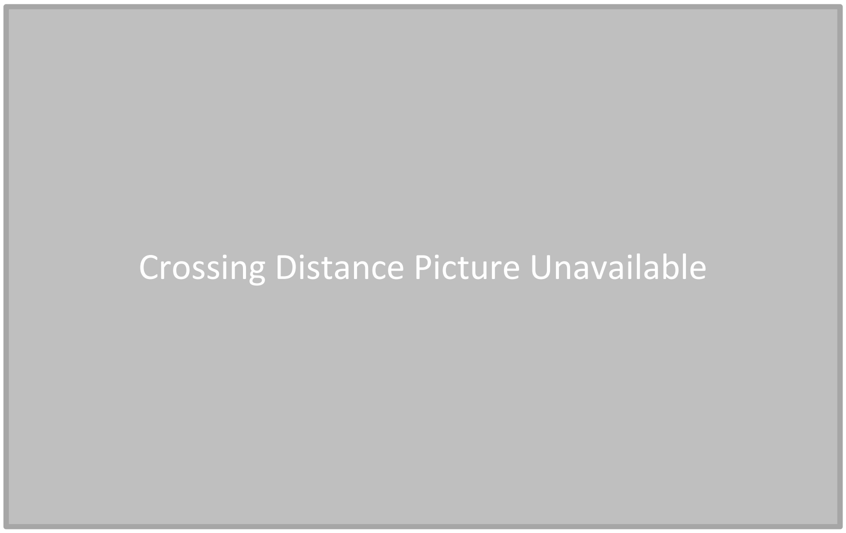
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Left-turn movement from trail to street	Other
		x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
		10	3.0	2.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining Signage:

Current Bicycle Infrastructure:

Municipality: **San Francisco, CA**
Contact: Damon R. Curtis
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM	WEB VERSION

Fell Street & Masonic Avenue

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x				

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)	Crossing Distance for Bike Signal #4 (ft)	Crossing Distance for Bike Signal #4 (ft)
4	2	90	90	90	90

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	7	12	Faces left	Yes	Dark Green	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

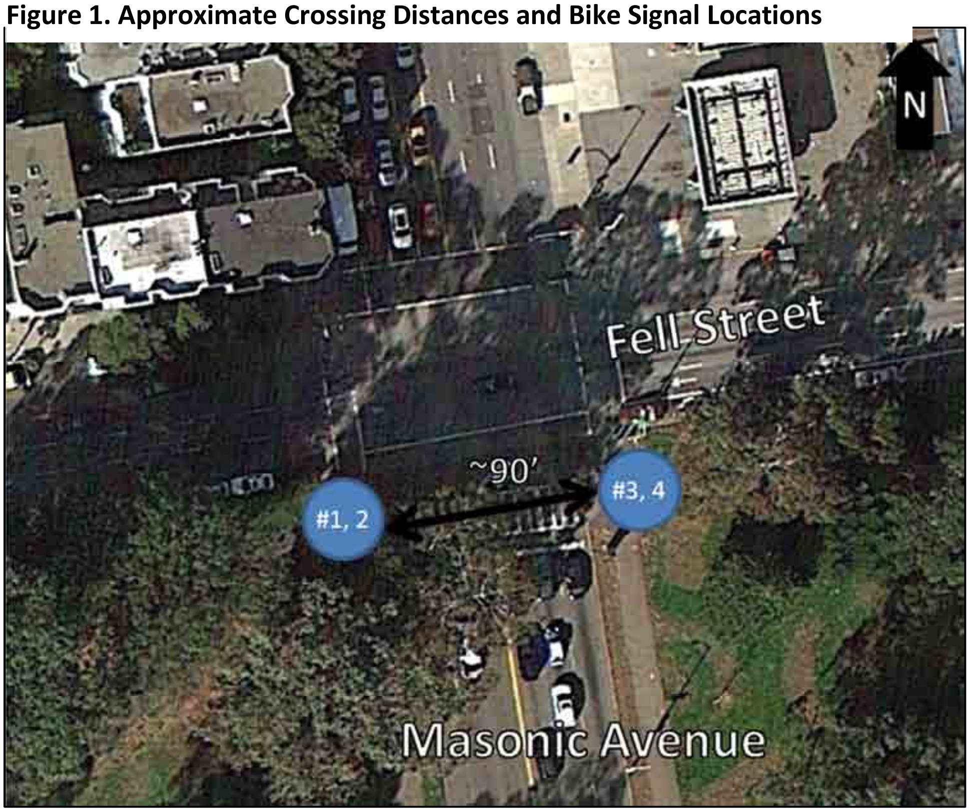
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
			x	

Signal Timing – Bicycle Signal(s)

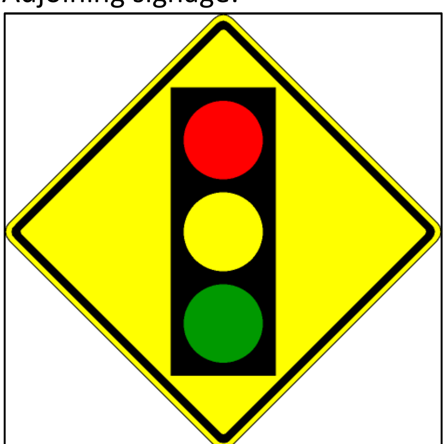
Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	4.7	19	4	0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:



W3-3
Traffic Signal Ahead (symbol)

with "Bike Signal Ahead" placard

Municipality: **San Francisco, CA**
Contact: Damon R. Curtis
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Fell Street & Shrader Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x				

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	90	75

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	7	12	Faces left	Yes	Dark Green	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	11.7	9	3.5	0.6

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Page Street & Stanyan Street

Municipality: **San Francisco, CA**
Contact: Damon R. Curtis
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM WEB VERSION	

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x				

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4*	2	70	70

* including trail from Golden Gate Park

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	7	12	Faces left	No	Dark Green	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		New signal construction

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	5.6	12	3	1.5

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Municipality: **Washington D.C.**
Contact: William Schultheiss
Contact Info

15th Street NW & E Street NW

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION	REMOVED FROM WEB VERSION	

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Bicycle Transportation: A Handbook for Cycling Transportation Engineers (Forester)	Field Measurements	NACTO Urban Bikeway Design Guide
x			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for Bike Signal #1 (ft)	Crossing Distance for Bike Signal #2 (ft)
4	2	100	100

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	15	12	Faces right	No	Black	No backplate	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

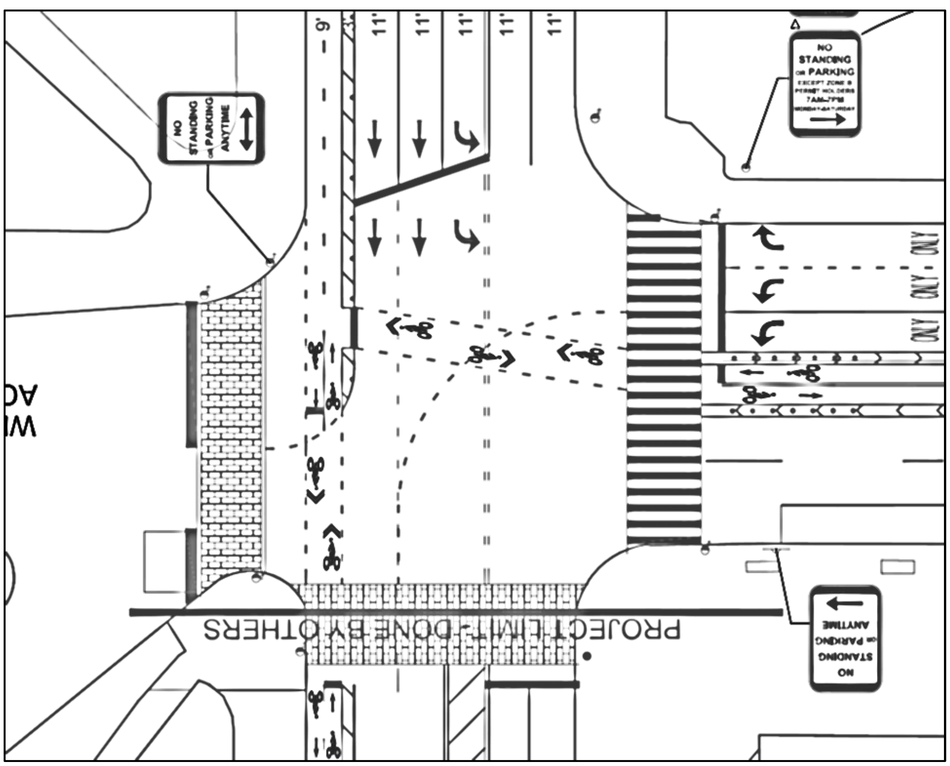
Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations (does not show bike infrastructure)

Figure 2. Bicycle Pavement Markings



Adjoining signage:

Municipality: **Washington D.C.**
Contact: William Schultheiss
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

16th, U, New Hampshire

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance from Bike Signal #1 to #2 (ft)	Crossing Distance from Bike Signal #3 to #4 (ft)
6	4	65	50

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10		Faces right	No	Black	No backplate	Loop

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Green	Yellow	All-red
	11.6	4	5	2

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Signal Timing Plan

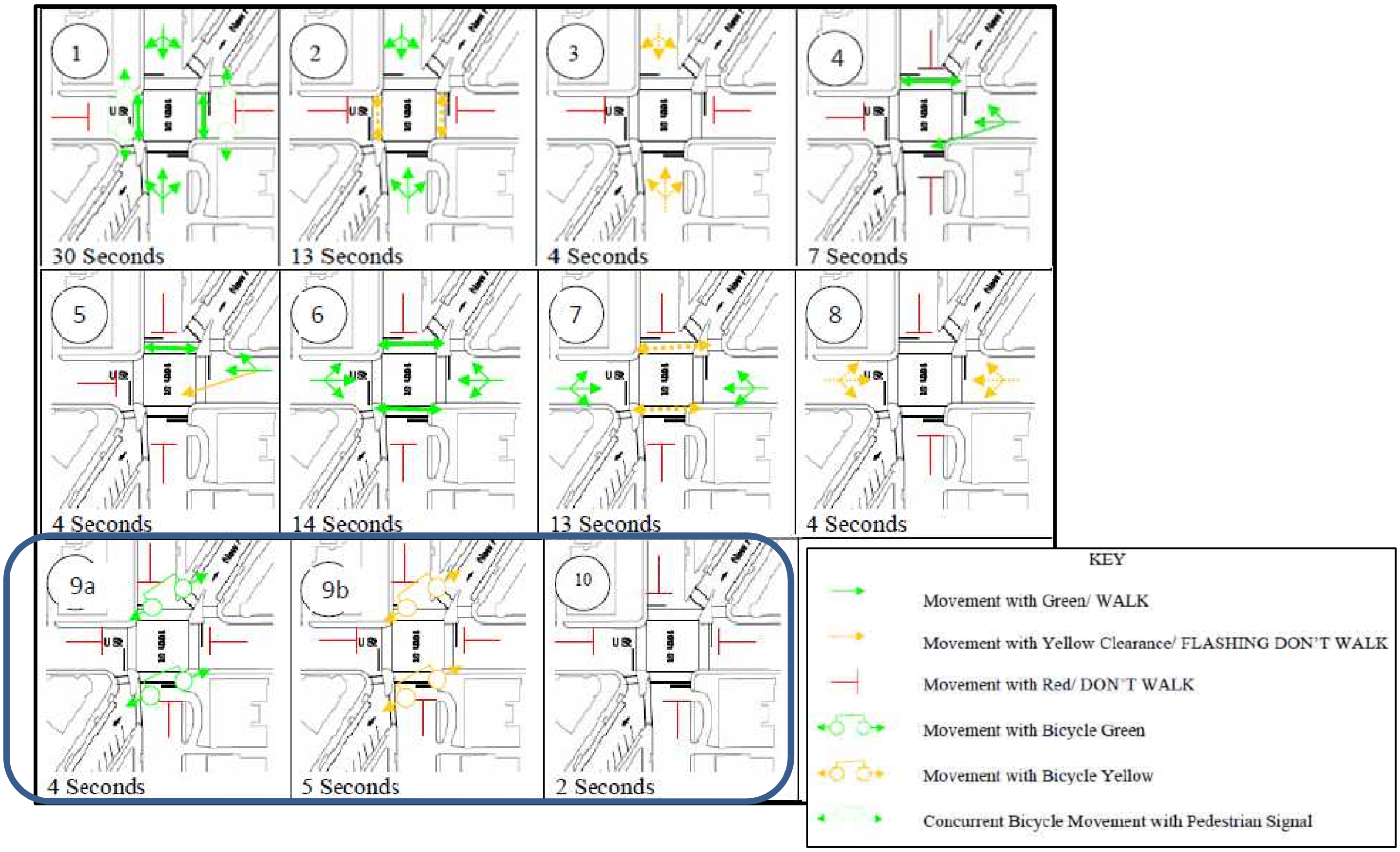
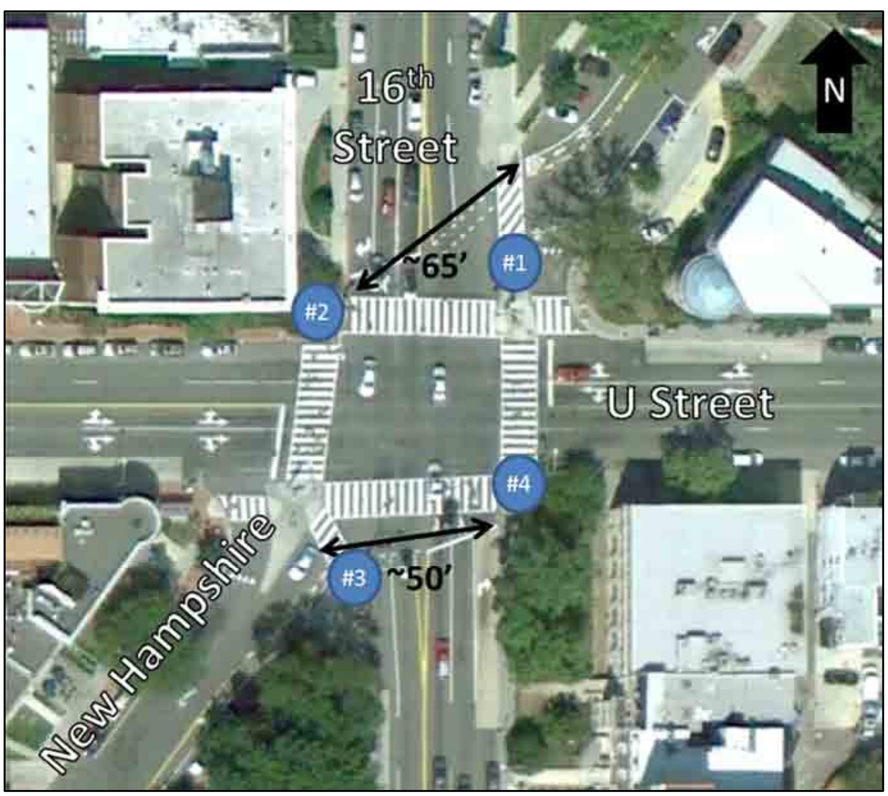


Figure 2. Approximate Crossing Distances and Bike Signal Locations



Adjoining signage:

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Hornby Street and Smithe Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	69

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

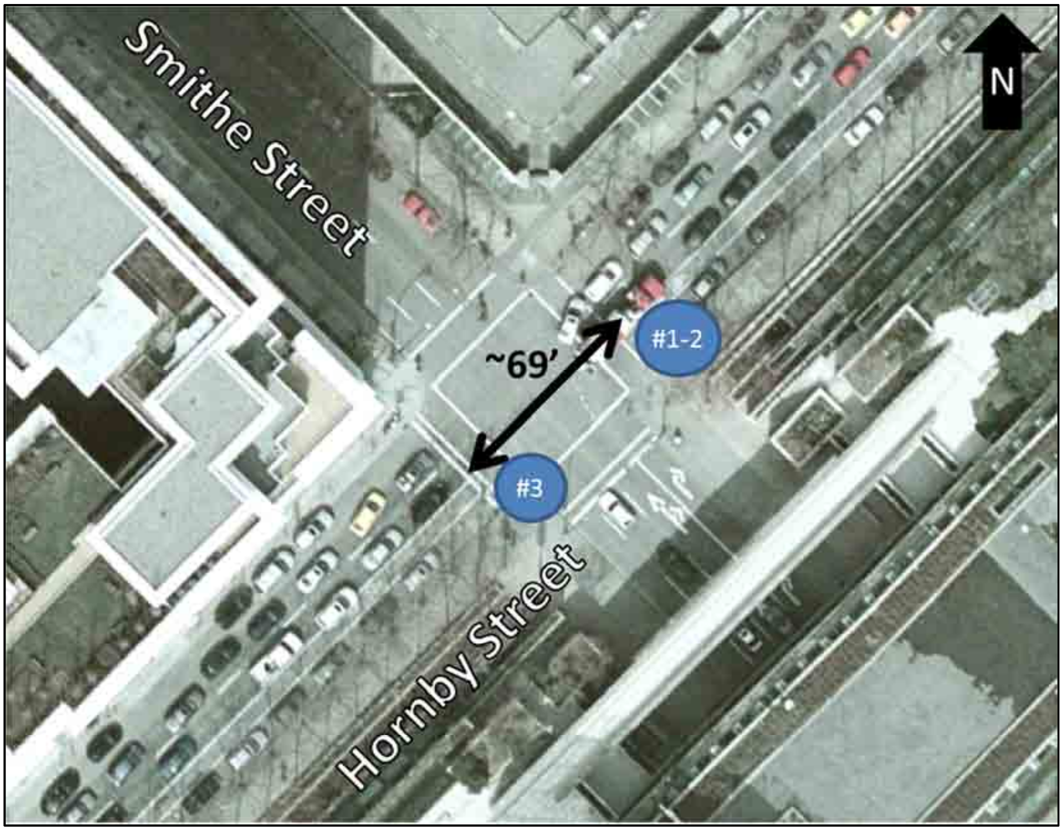
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Hornby Street and Robson Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	65

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

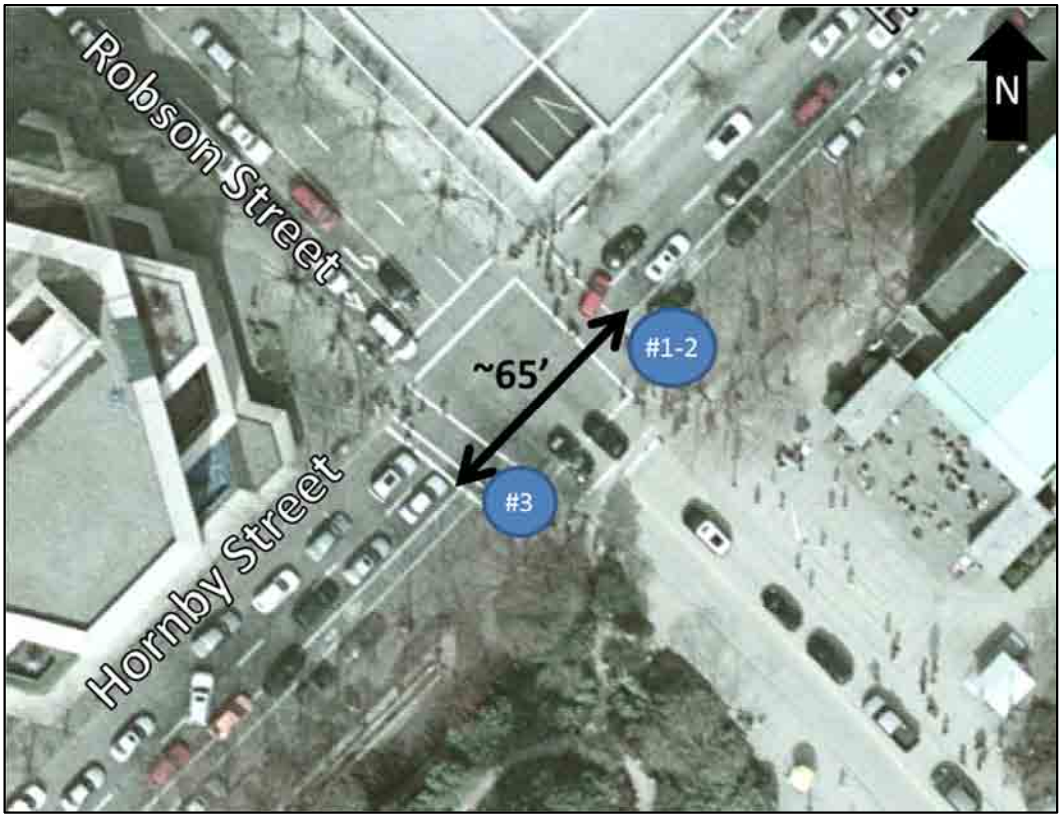
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Hornby Street and W Pender Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	4	77

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

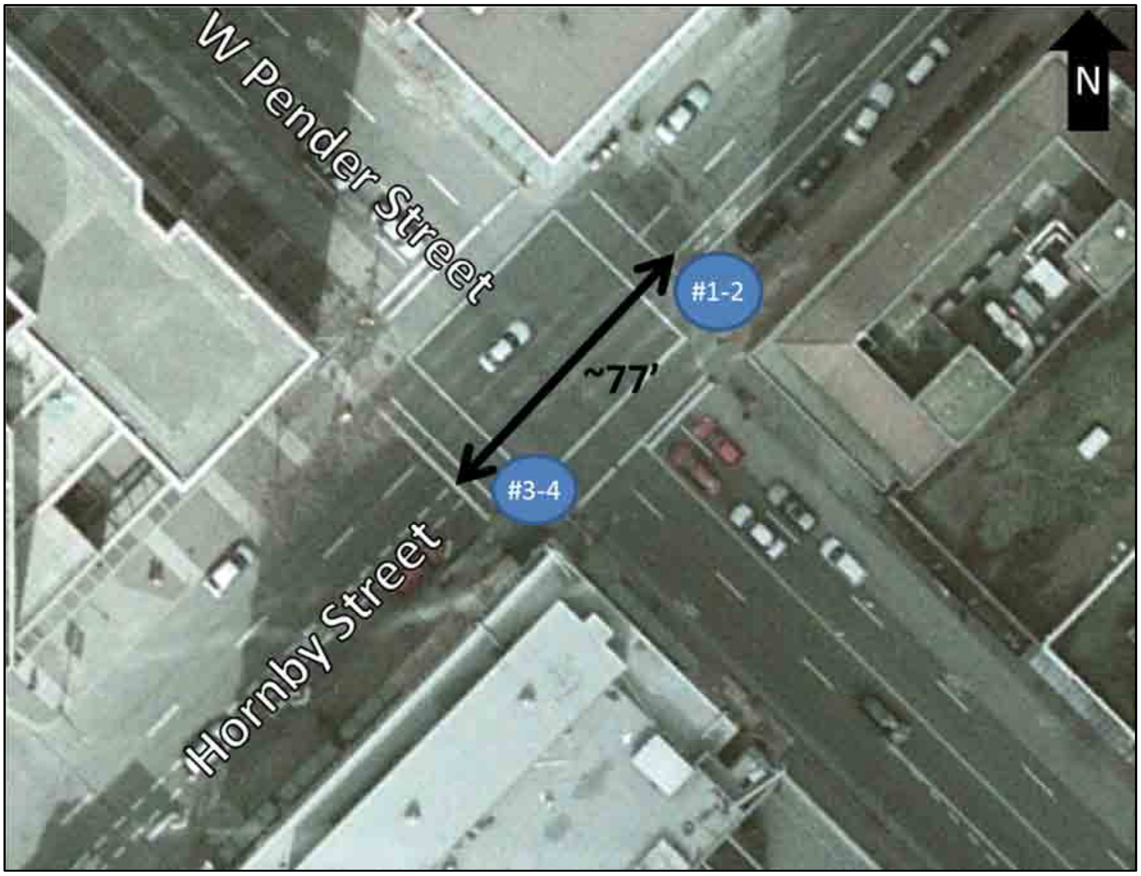
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Hornby Street and Pacific Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	79

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

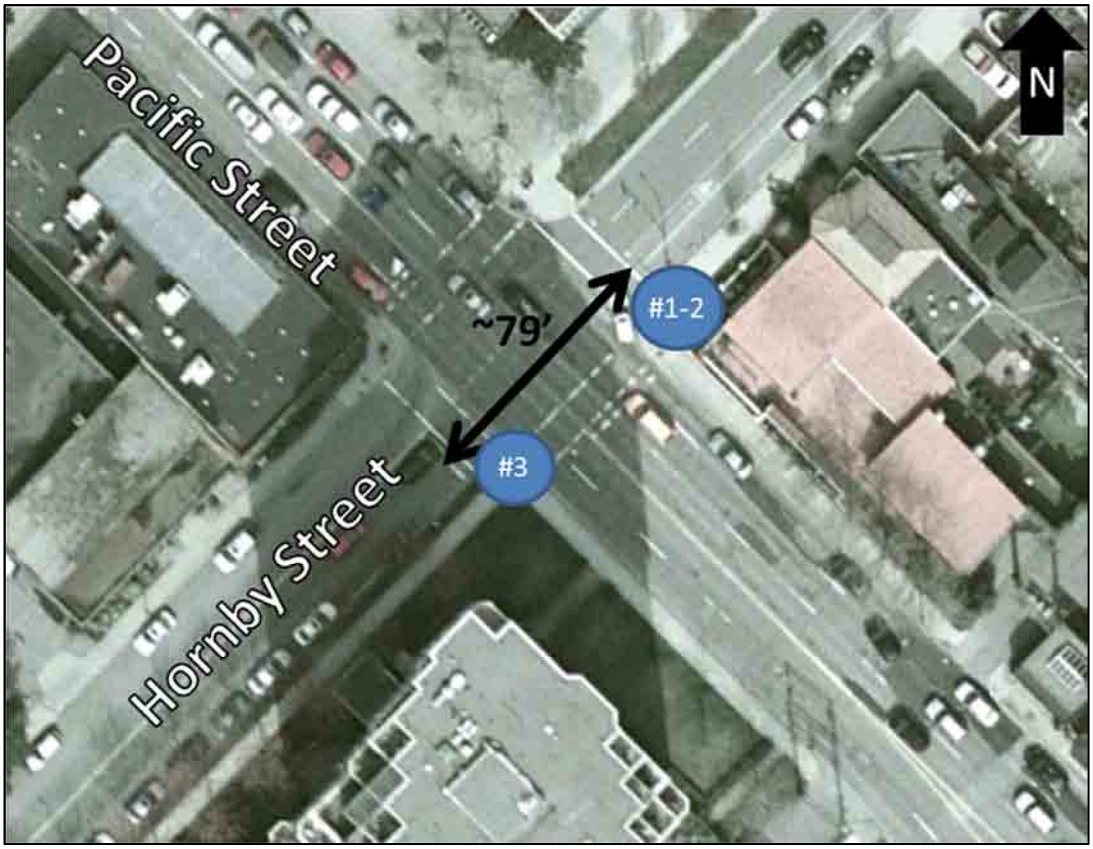
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Hornby Street and Nelson Street

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	4	71

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

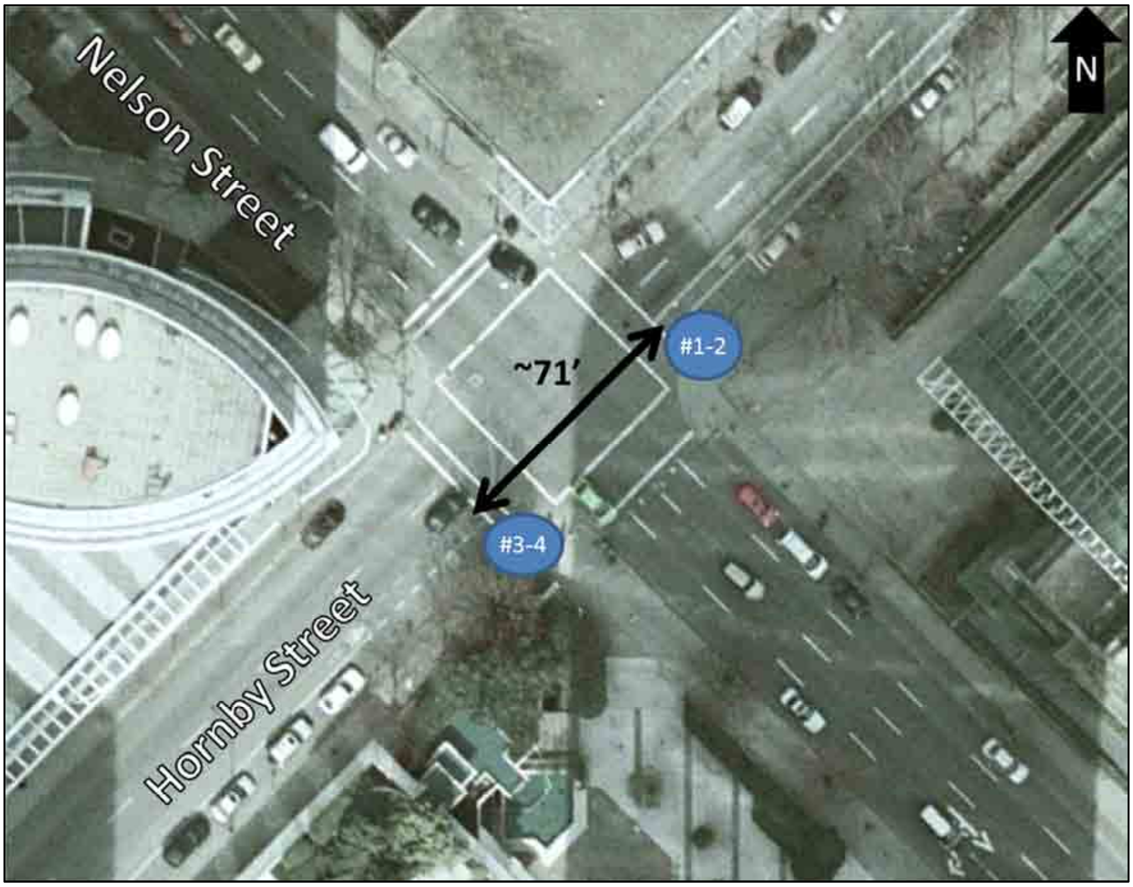
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Hornby Street and Helmcken Street

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
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Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	70

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

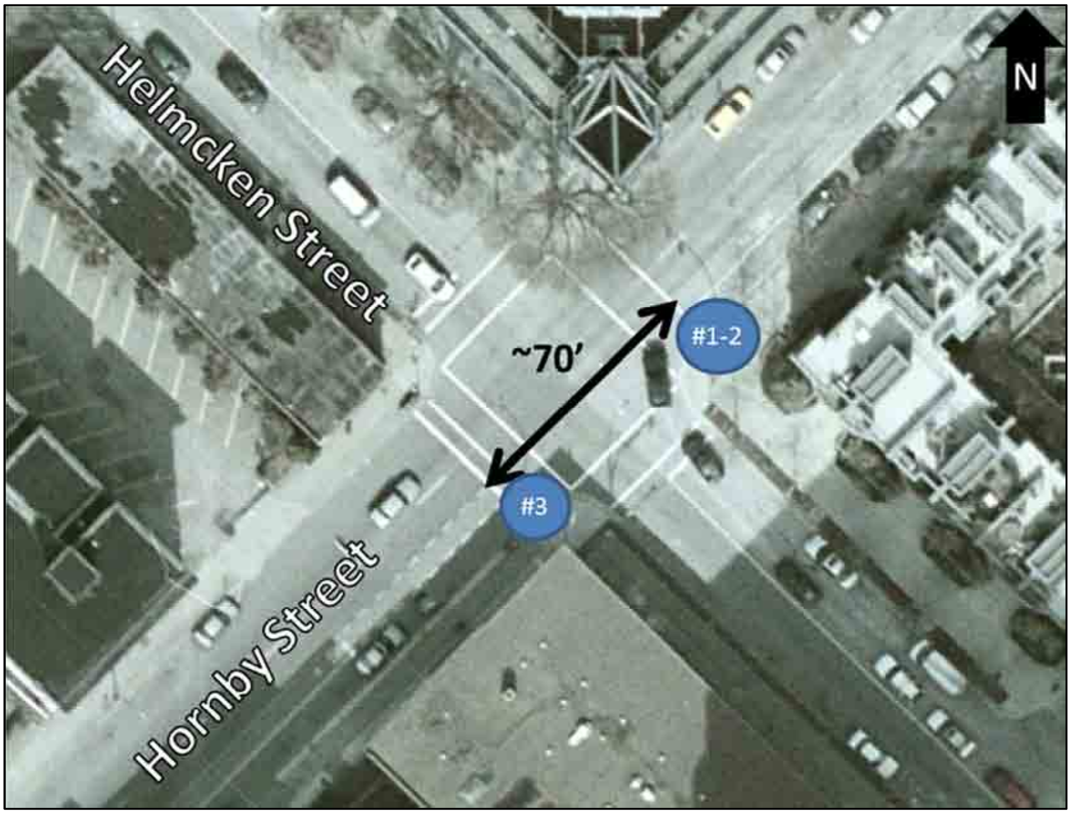
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Hornby Street and W Hastings Street

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
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Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
3	4	66

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10 & 14	8 & 12[2]	Faces left	no	Black & Yellow	none	On recall

[1] from ground to bottom of signal housing
[2] lenses in yellow housings = 8”, black housings = 12”

Motivation for Signal Installation

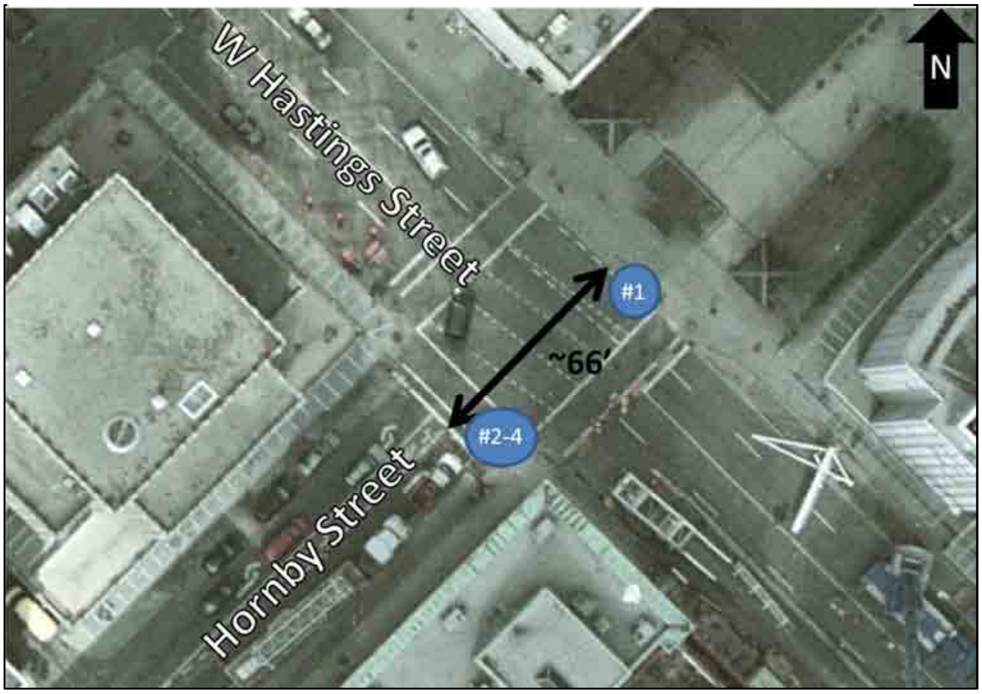
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO’s 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations (Bicycle Infrastructure not shown)



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

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Hornby Street and W Georgia Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	4	97

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

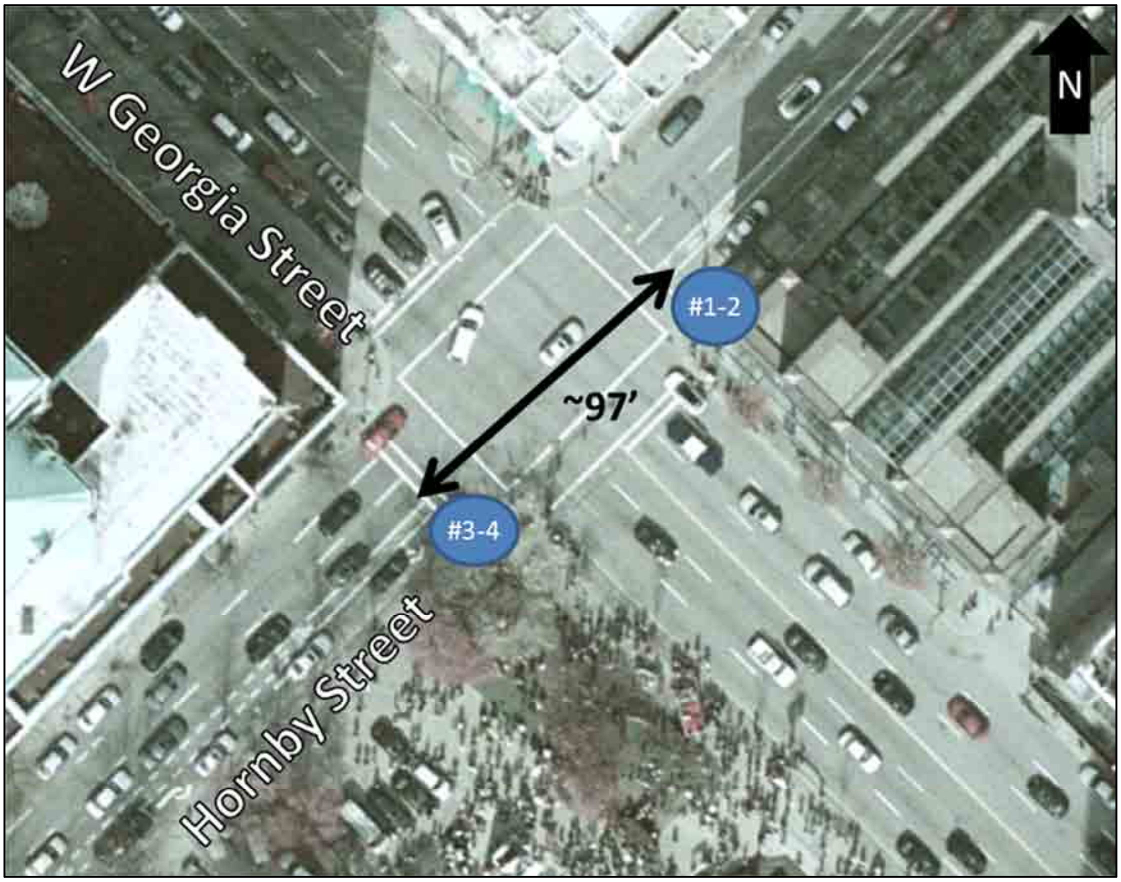
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Hornby Street and Dunsmuir Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	72

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

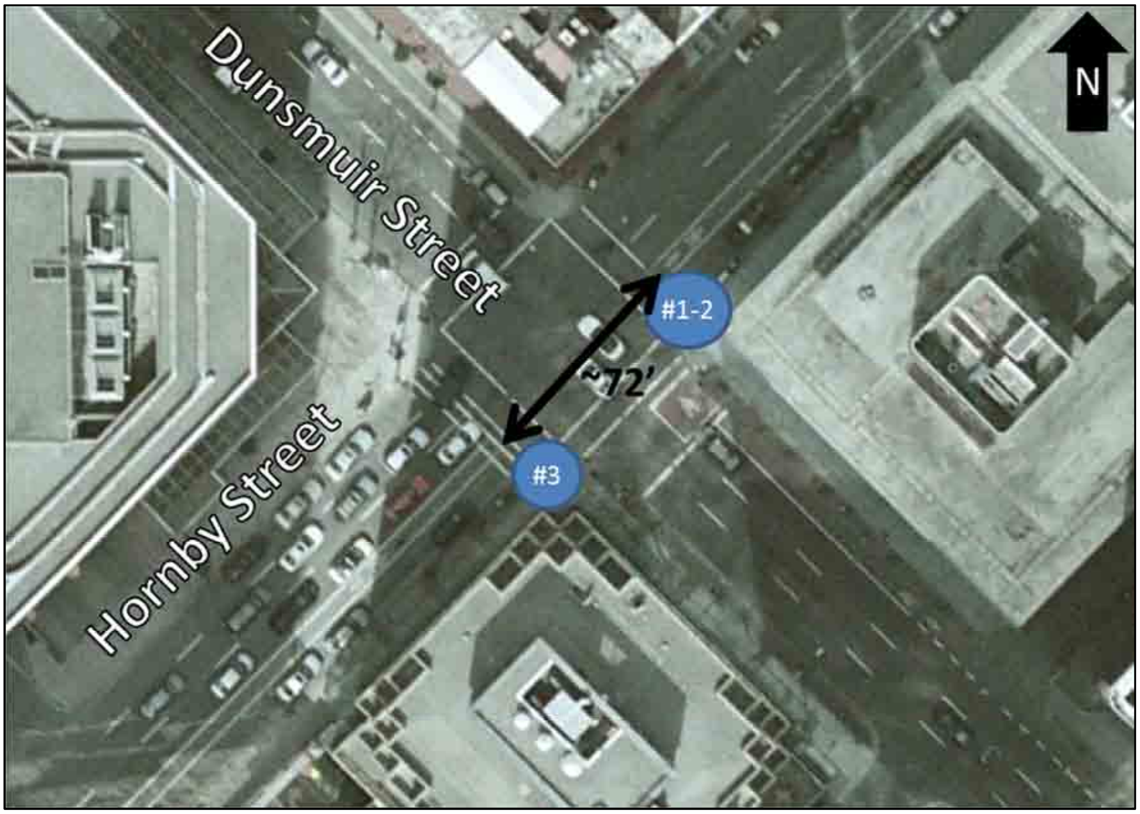
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Hornby Street and Drake Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	74

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

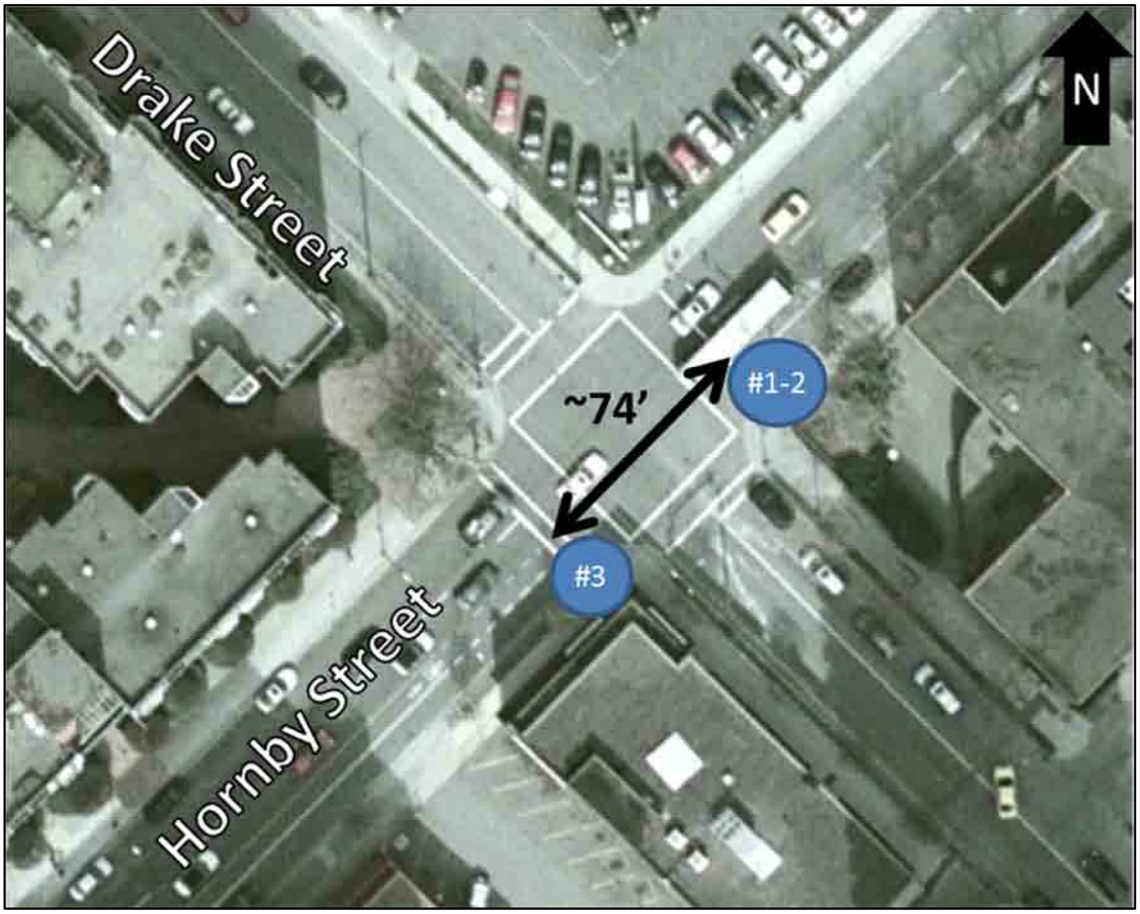
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
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Hornby Street and Davie Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	76

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

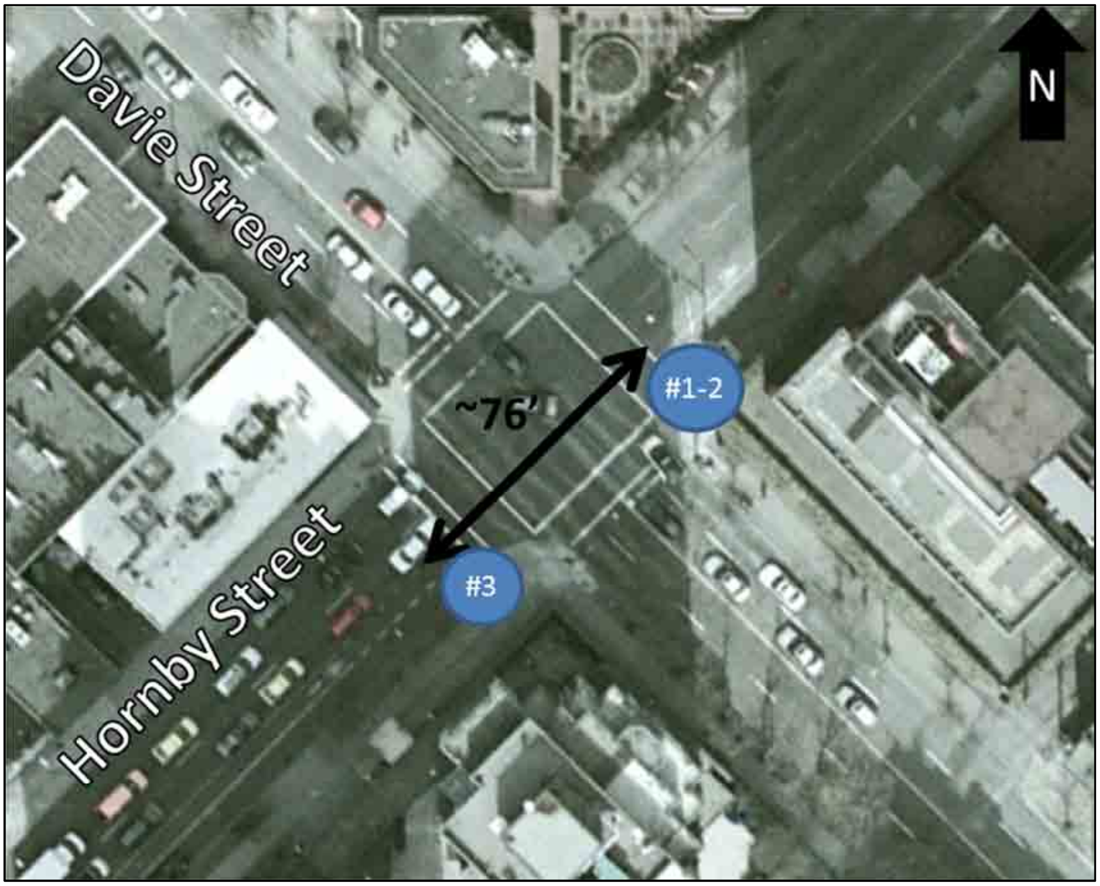
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM		WEB VERSION

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	2	75

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

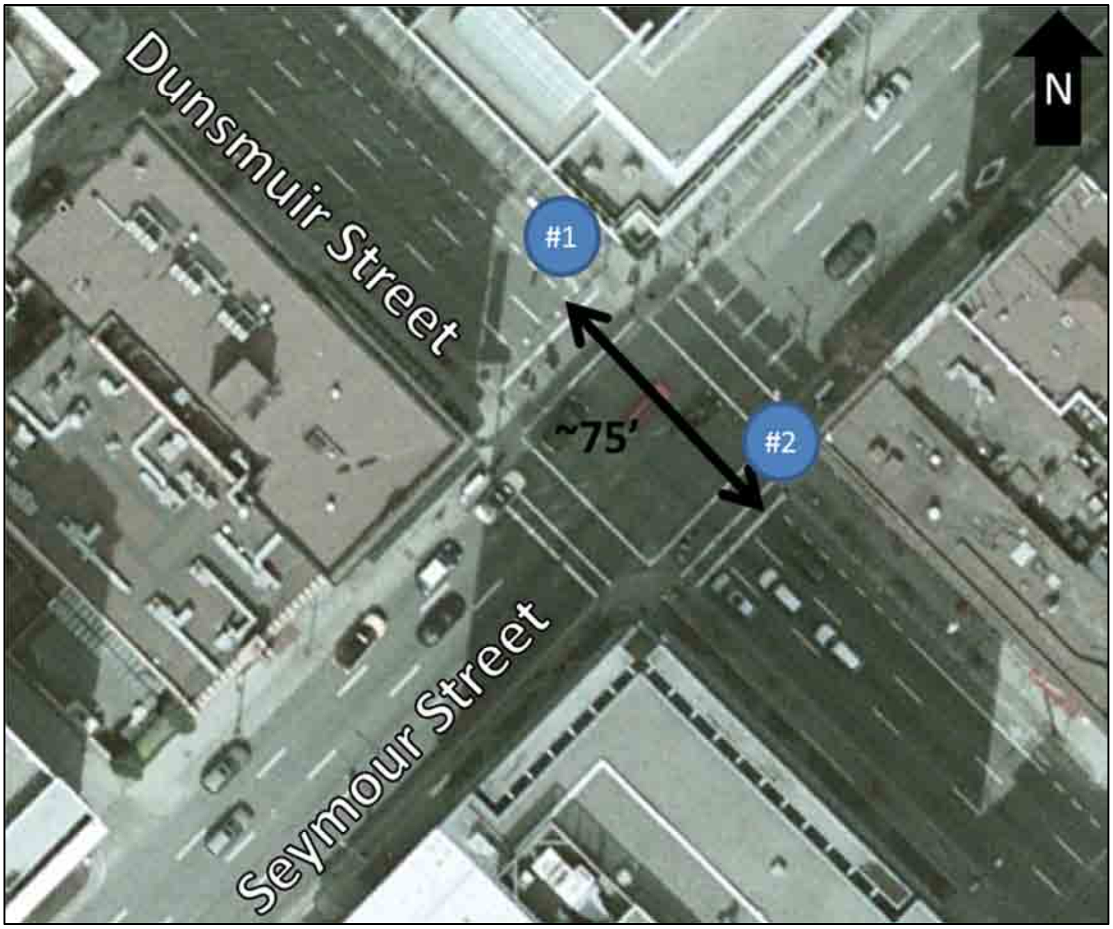
Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Dunsmuir Street and Seymour Street

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Dunsmuir Street and Richards Street

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	2	85

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

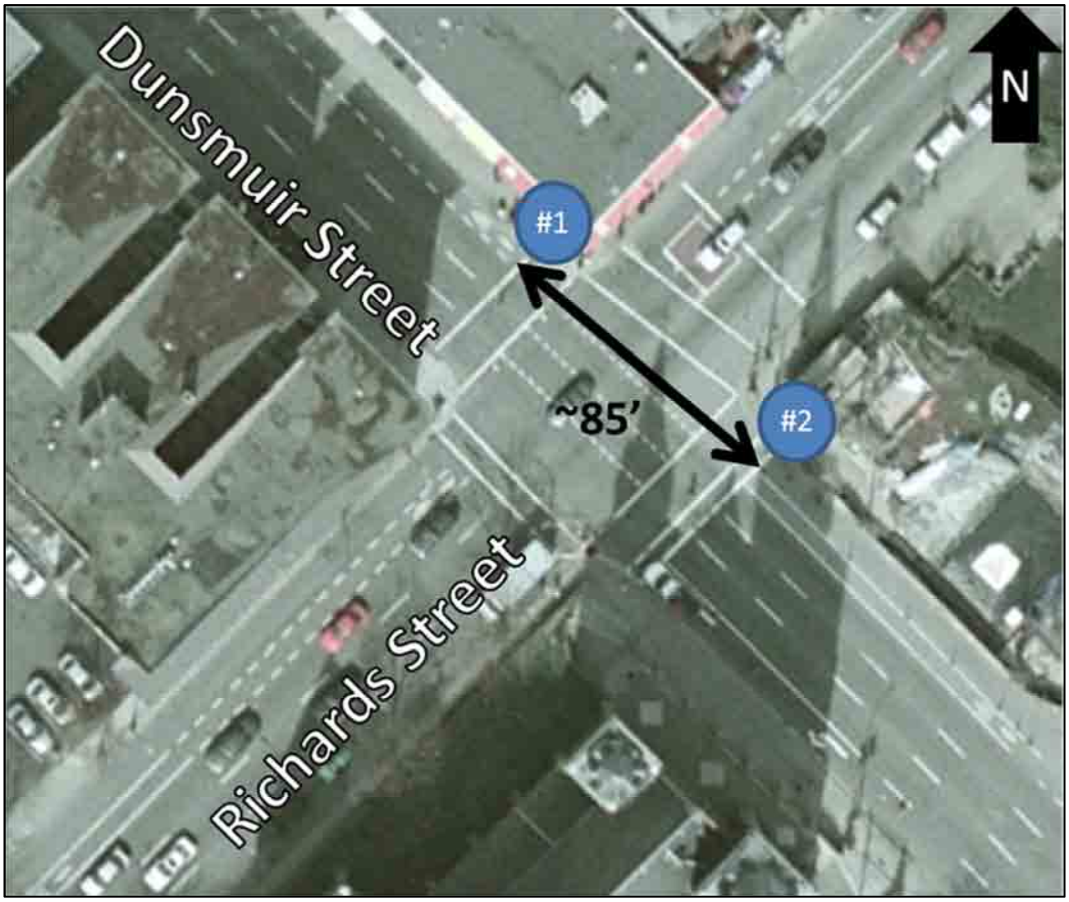
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Dunsmuir Street and Howe Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	78

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

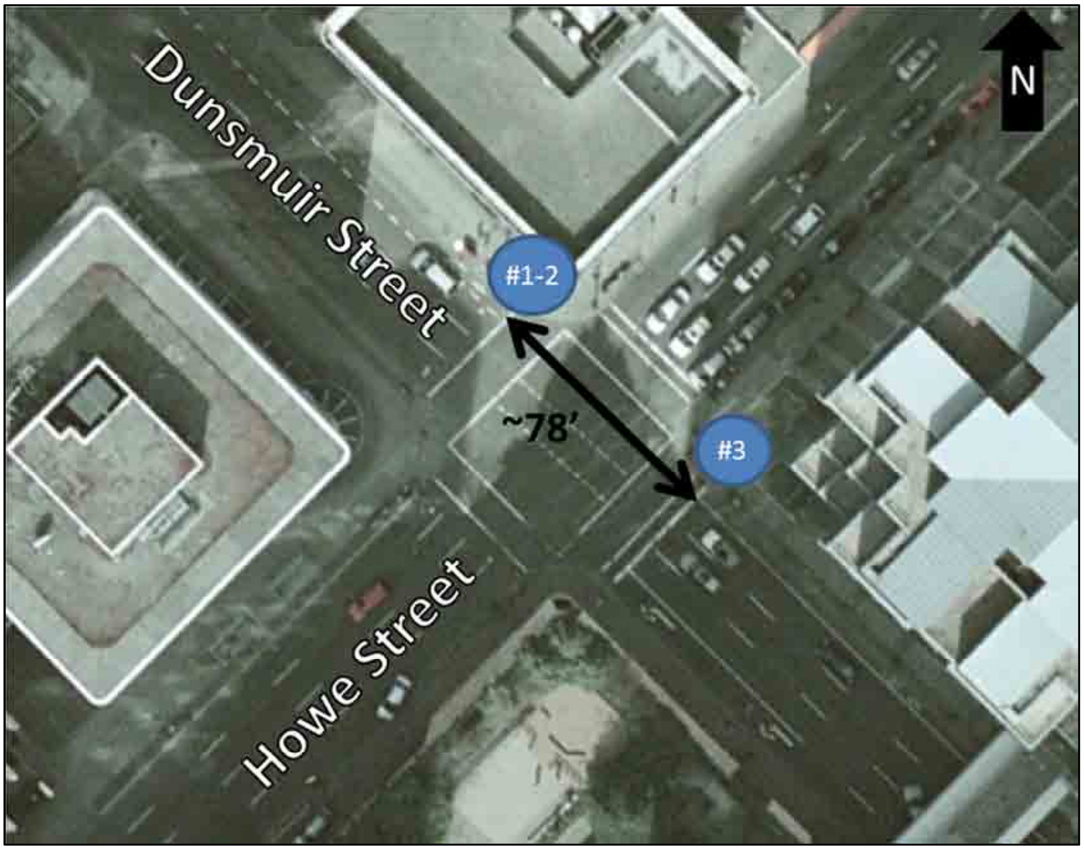
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Dunsmuir Street and Homer Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	71

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8 & 12[2]	none	no	Yellow & Black	none	On recall

[1] from ground to bottom of signal housing
[2] lenses in yellow housings = 8", black housings = 12"

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Dunsmuir Street and Hamilton Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	79

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8 & 12[2]	none	no	Yellow & Black	none	On recall

[1] from ground to bottom of signal housing
[2] lenses in yellow housings = 8", black housings = 12"

Motivation for Signal Installation

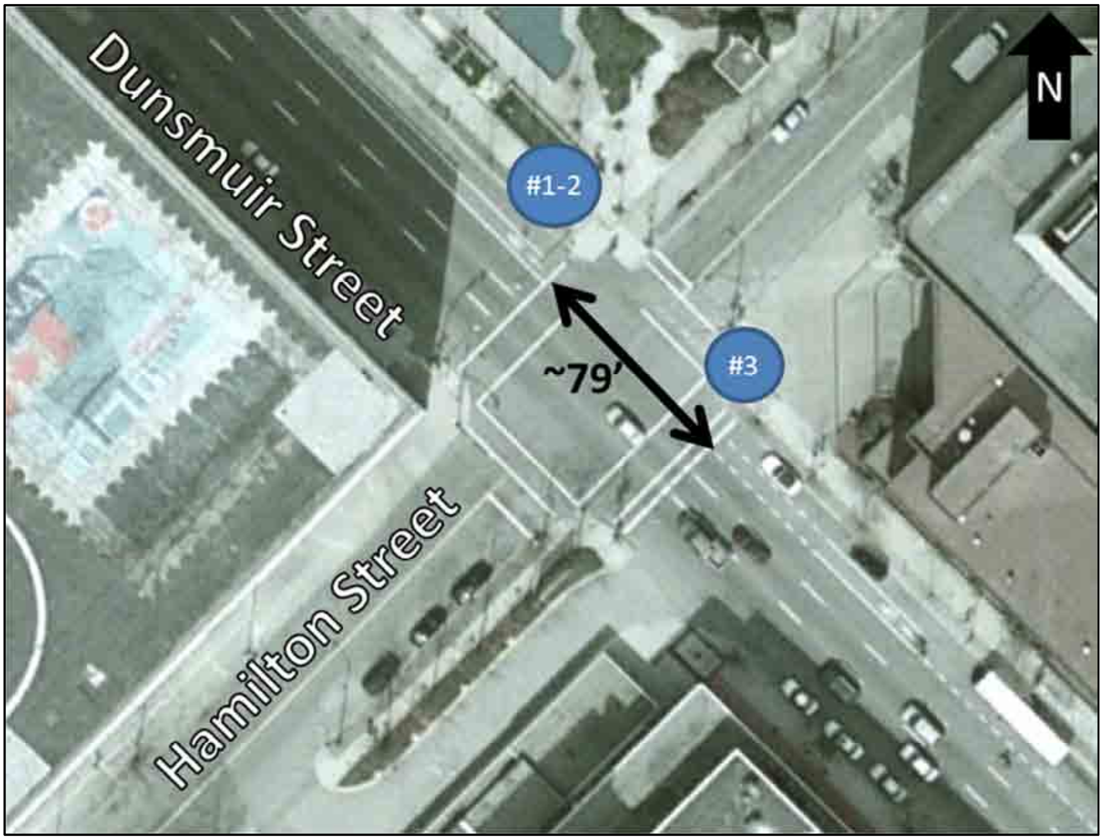
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Dunsmuir Street and Granville Street

Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	2	58

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

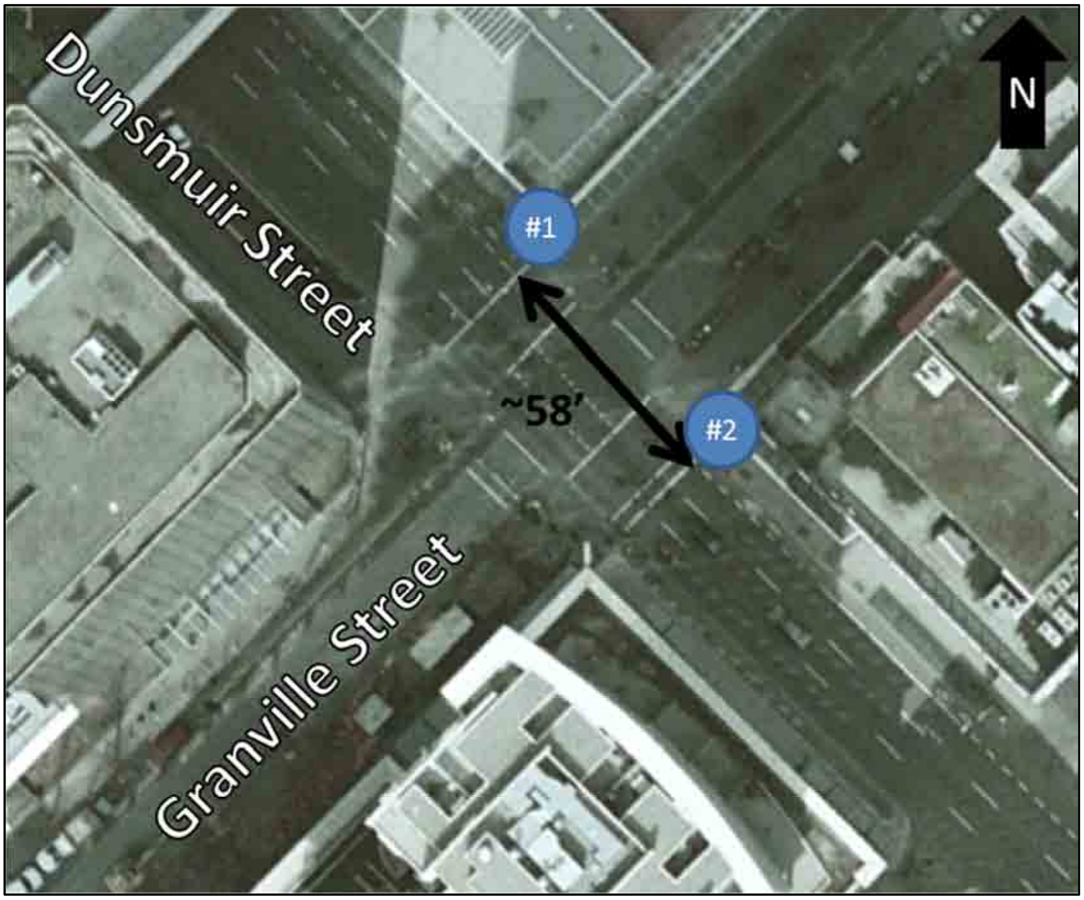
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Dunsmuir Viaduct and Citadel Parade

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
3	1	68

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

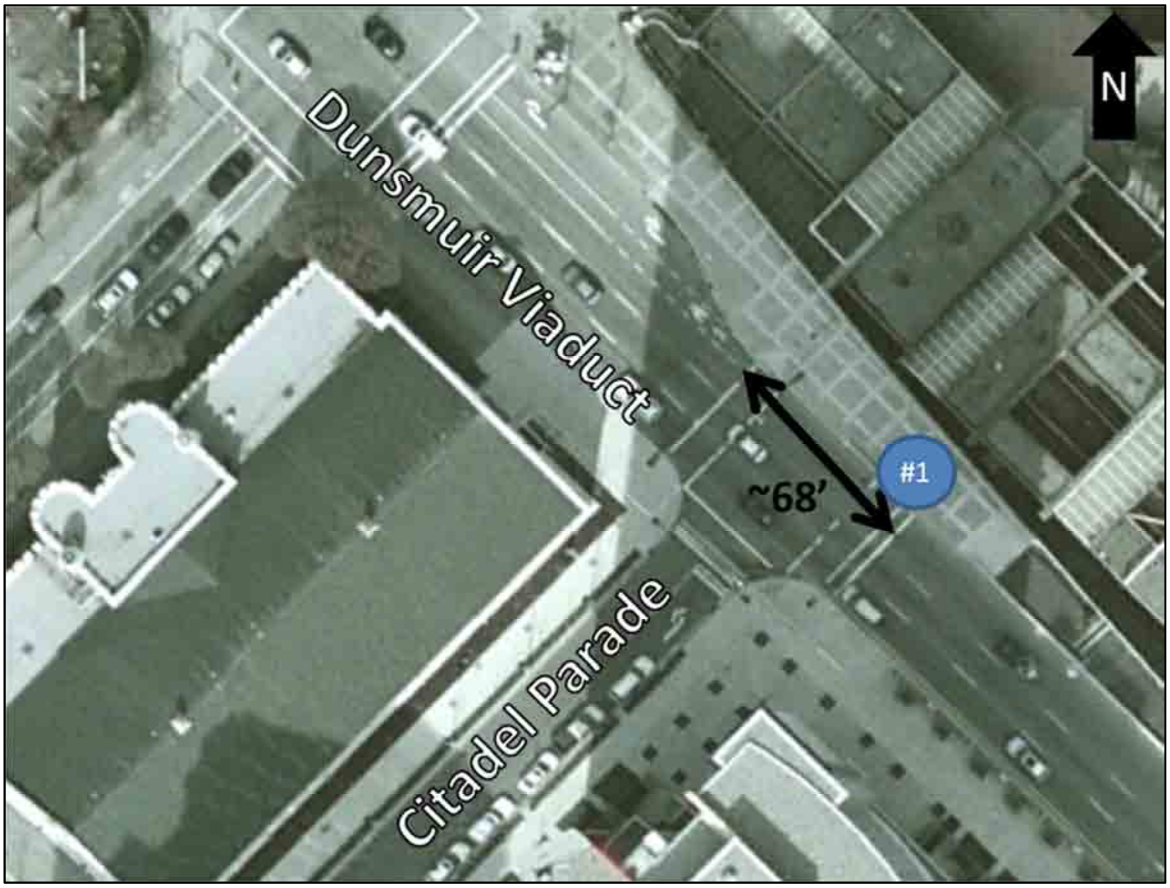
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Dunsmuir Street and Cambie Street

Municipality: **<u>Vancouver, BC, Canada</u>**

Contact: Winston Chou

Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	78

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	none	no	Yellow	none	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

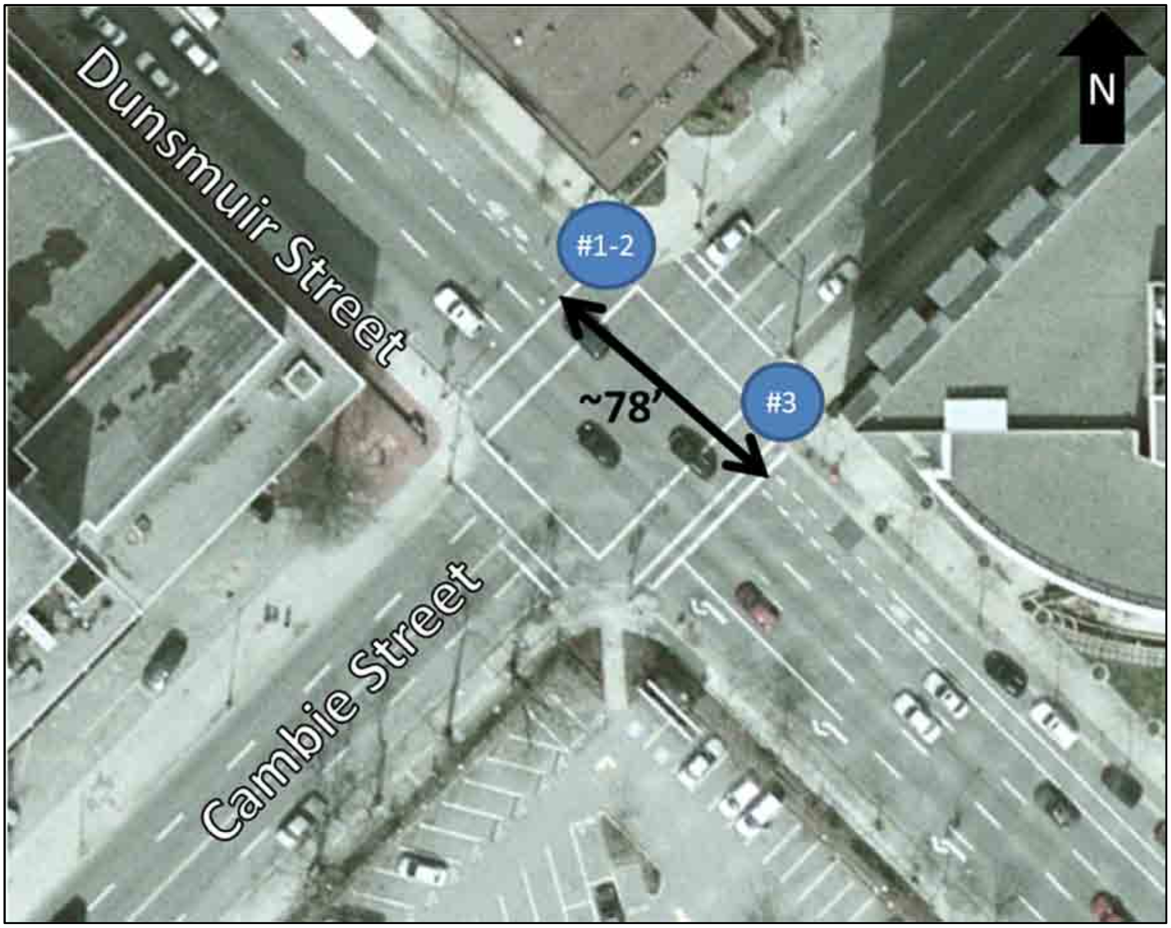
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Dunsmuir Street and Beatty Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	85

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8 & 12[2]	none	no	Yellow & Black	none	On recall

[1] from ground to bottom of signal housing
[2] lenses in yellow housings = 8", black housings = 12"

Motivation for Signal Installation

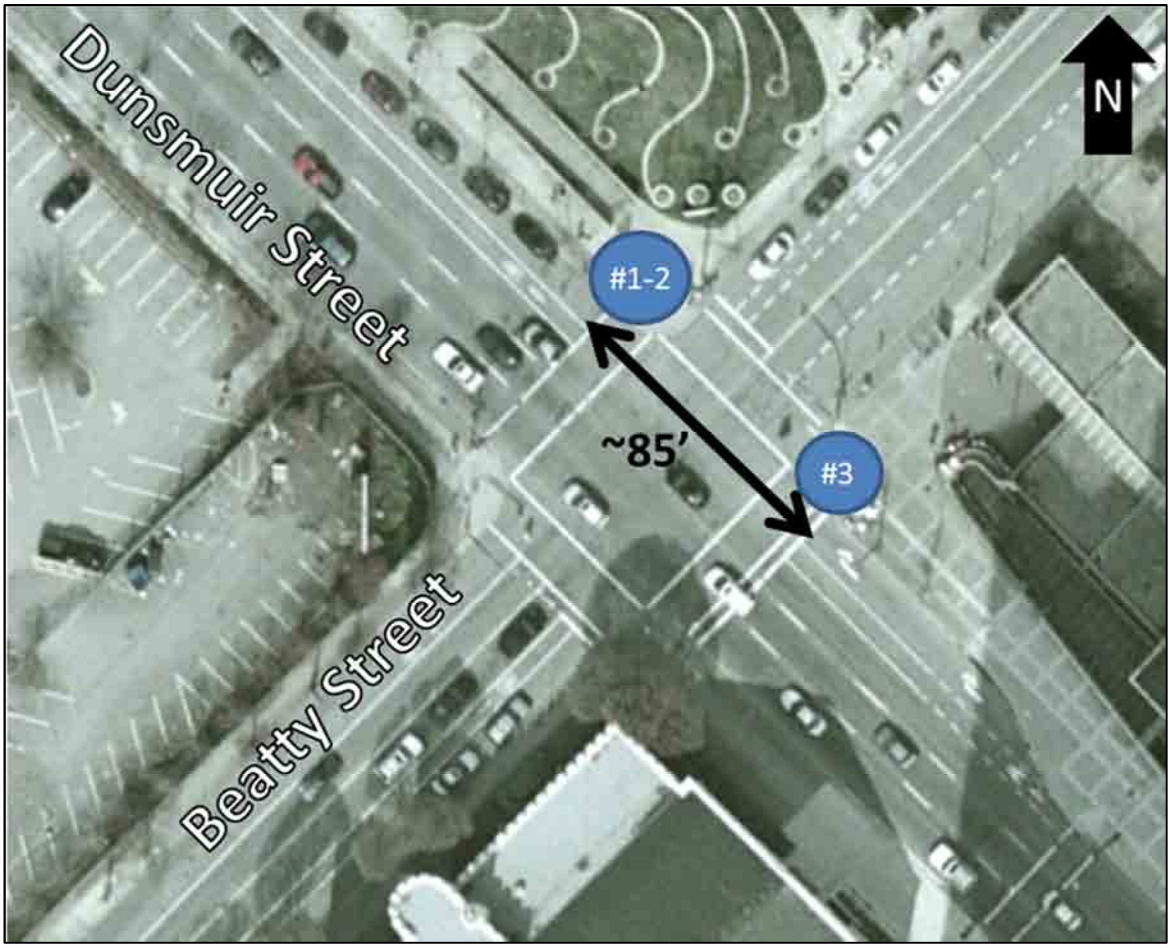
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Burrard Street and W Hastings Street

Picture Unavailable

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	3	89

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8 & 12[2]	Faces left*	no	Yellow & Black	none	On recall

[1] from ground to bottom of signal housing
[2] lenses in yellow housings = 8", black housings = 12"
* present for contra-flow signals only

Motivation for Signal Installation

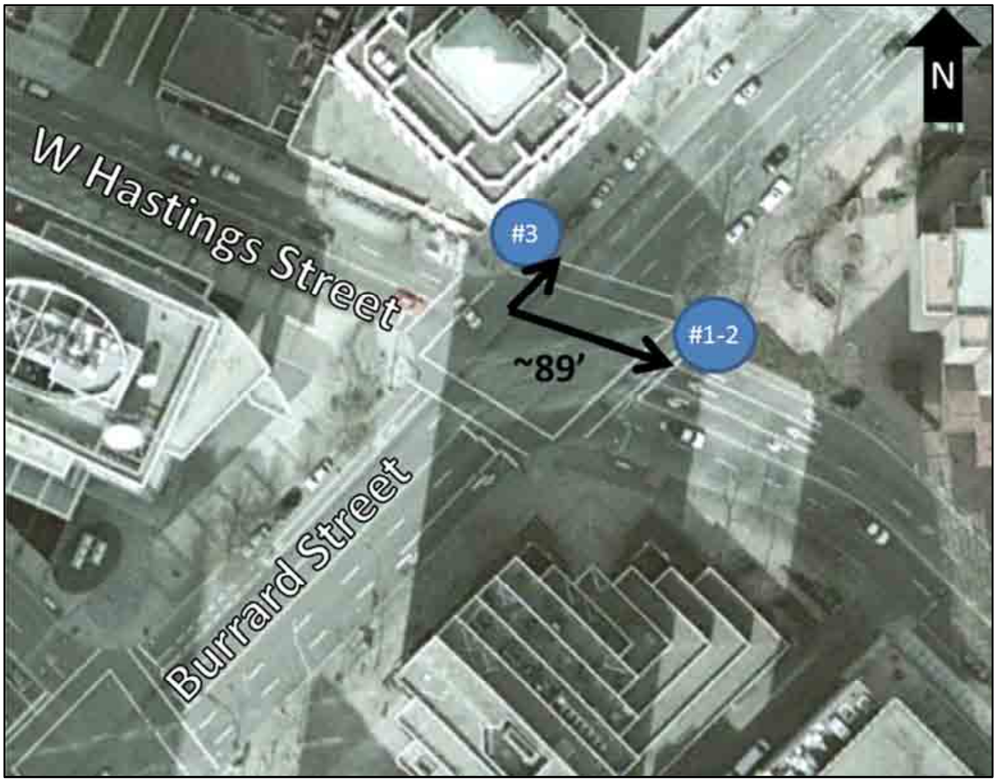
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Burrard Street and W Cordova Street

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
4	2	105

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10	8	Faces left*	no	Yellow	none	On recall

[1] from ground to bottom of signal housing
* present for contra-flow signals only

Motivation for Signal Installation

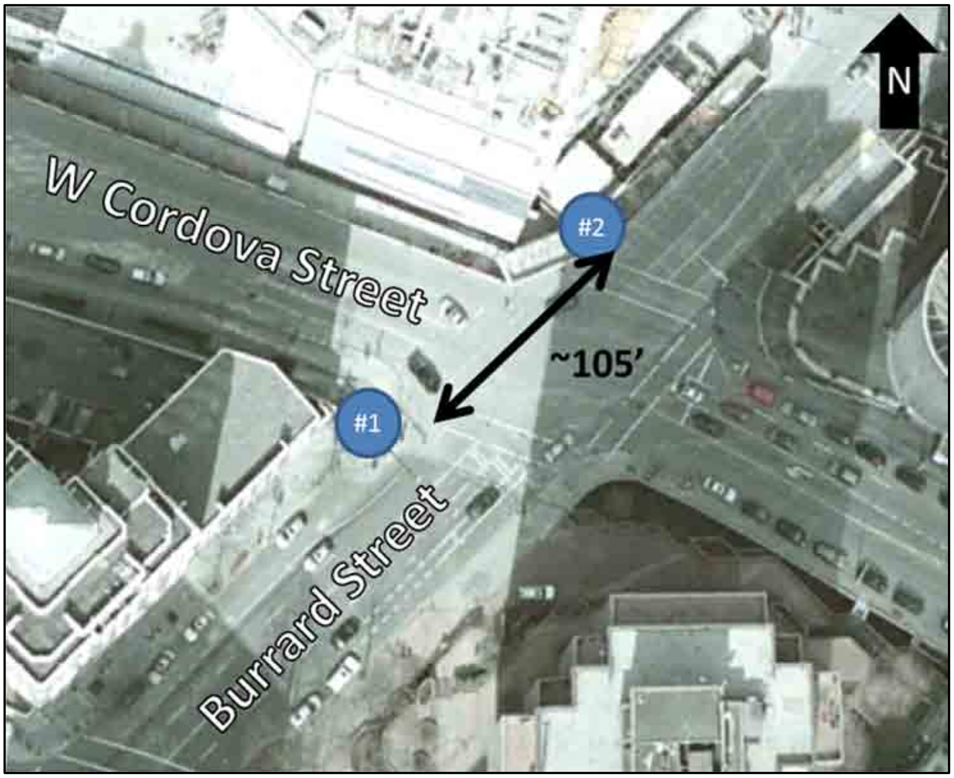
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x			

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Vancouver, BC, Canada**
Contact: Winston Chou
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Burrard Street and Canada Place

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
3	3	58

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Both	10 & 15	8 & 12[2]	Faces left[*]	no	Yellow & Black	none	On recall

[1] from ground to bottom of signal housing
2 lenses in yellow housings = 8", black housings = 12"
* present for contra-flow signals only

Motivation for Signal Installation

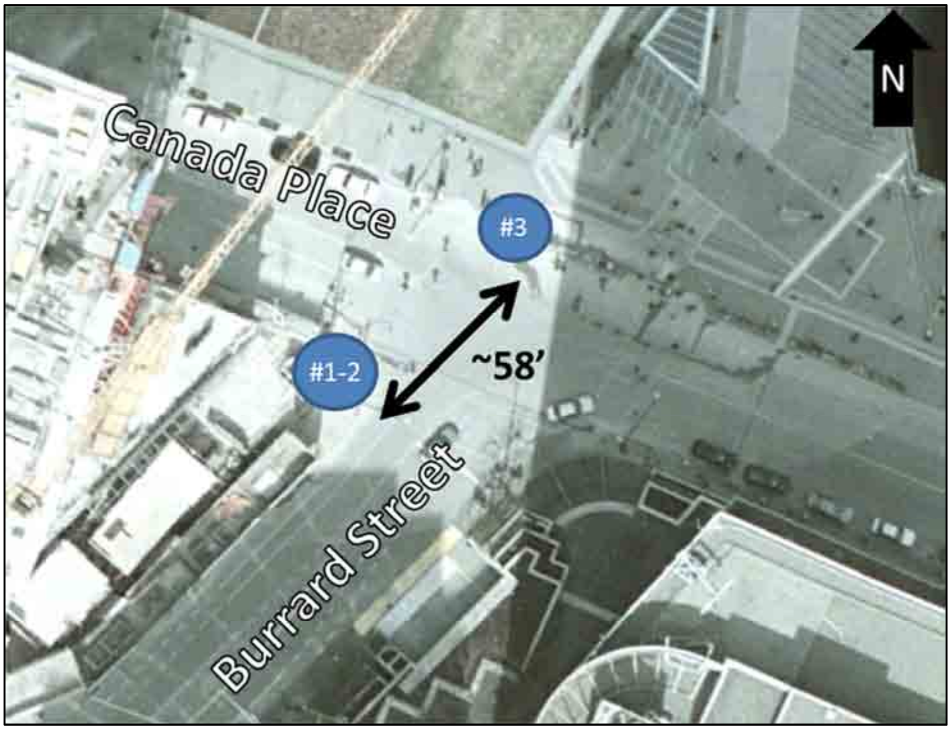
Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
	x	x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
0	Standing Start[1]	Min. Green	Yellow	All-red

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations



Municipality: **Minneapolis, MN**
Contact: Simon Blenski
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION REMOVED FROM WEB VERSION		

Broadway Street NE and 5th Street NE

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide
x			x	

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
5	4	60

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far		12	Faces right	Yes	Black	Black	Push-button

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x	x	

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
	Standing Start[1]	Min. Green	Yellow	All-red
1	4.9	10	4.0	2.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Adjoining Signage:

Municipality: **Cambridge, MA**
Contact: Jeffery R. Parenti
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Massachusetts Avenue and Somerville Avenue

No Picture Available

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
3	1	85

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	12	None	No	Black	Black	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	16.5	6	3.0	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations

Municipality: **Cambridge, MA**
Contact: Jeffery R. Parenti
Contact Info

E-mail	Phone	Agency or Firm Name
CONTACT INFORMATION RE	MOVED FROM	WEB VERSION

Massachusetts Avenue and Johnston Gate

No Picture Available

Design Guidance Used for Cyclist Performance

AASHTO Guide for the Development of Bicycle Facilities	Design Manual for Bicycle Traffic (CROW Dutch Guide)	Guide technique d'aménagement des voies cyclables (Transportation Association of Canada)	Field Measurements	NACTO Urban Bikeway Design Guide

Intersection Characteristics

# of legs	# of Bike signals	Crossing Distance for cycletrack (ft)
3	1	35

Signal Characteristics (for both directions of travel)

Mounting		Lens			Housing		Operation
Near- or Far-side?	Mounting Height[1] (ft)	Size (in.)	Bike Insignia?	Louvers?	Housing Color	Backplate Color	Detection Type
Far	10	12	None	No	Black	Black	On recall

[1] from ground to bottom of signal housing

Motivation for Signal Installation

Non-compliance with previous traffic control	Contra-flow bicycle movement	Unique bicycle path through intersection	Safety concerns	Other
		x		

Signal Timing – Bicycle Signal(s)

Number of Bike-only Phases:	Assumed Minimum Cyclist Speeds (ft/s)	Phase Lengths (s)		
1	Standing Start[1]	Min. Green	Yellow	All-red
	5.8	6	3.0	1.0

[1] using the equation for standing bicycle crossing time in AASHTO's 2012 *Guide*

Figure 1. Approximate Crossing Distances and Bike Signal Locations