

The New TAC Accessible Pedestrian Signals Guidelines

Gregg Loane, IBI Group (Co-Author)  
Kaman Pang, IBI Group (Co-Author)  
Ron Stewart, IBI Group (Co-Author)

Paper prepared for presentation at the  
“Innovation in Traffic Operations and Management” Session  
of the 2007 Annual Conference of the  
Transportation Association of Canada  
Saskatoon, Saskatchewan

## **ABSTRACT**

This year the Transportation Association of Canada (TAC) will adopt new guidelines that update the accessible pedestrian signal provisions within the TAC Manual of Uniform Traffic Control Devices for Canada (MUTCDC).

The Guidelines have been prepared in response to the evolving needs of people with vision loss, technological advances in the APS industry, and the need to address the high degree of variability amongst Canadian APS installations. The objective of the Guidelines is to act as a set of stand-alone instructions for the understanding, use and implementation of APS in Canada, and to expand upon the APS provisions within the TAC MUTCDC. The Guidelines are to provide deploying agencies with practical and uniform information on public liaison, APS installation prioritization and design, installation, operations and maintenance. Above all, they are to provide the instructions necessary to meet the accessible pedestrian signal needs of people with vision loss. It should be noted that these are strictly 'guidelines' and do not constitute a set of 'standards'. Deploying agencies should consult the TAC MUTCDC for specific standards related to APS.

The Guidelines now provide details on all stages of an APS installation starting with community liaison and APS prioritization, design, installation, operation, and maintenance. This report will present the approach taken to update these Guidelines and key operational updates that represent changes from the earlier APS provisions within the TAC MUTCDC.

## 1.0 BACKGROUND

This year the Transportation Association of Canada (TAC) will adopt new “*Guidelines for the Understanding, Use and Implementation of Accessible Pedestrian Signals*” (the Guidelines) that update the accessible pedestrian signal provisions within the TAC Manual of Uniform Traffic Control Devices for Canada (MUTCDC). The primary objective of these Guidelines is to provide deploying agencies (typically provincial and municipal jurisdictions) with the uniform installation, operation and maintenance instructions necessary to meet the accessible pedestrian signal needs of people with vision loss.

Accessible Pedestrian Signals (APS) are technologies that supplement traditional traffic control signal technology to assist pedestrians with vision loss (and those with both vision and hearing loss) in their road crossings. These technologies provide audible and vibrotactile indications that act as the ‘Walk’ signal for this community and any other users who may benefit from additional sensory prompts (e.g. senior citizens and children).

The Guidelines focus exclusively on accessible pedestrian signal guidelines for use at signalized intersections employing pedestrian crossing signal (i.e. ‘Walking Person’ and ‘Steady Hand’) displays. They do not address other crossing elements such as alternate pedestrian crossing strategies (crosswalks employing amber beacons, signs and pavement markings, island refuges, etc.), effective pedestrian walkway planning, sidewalk design, street furniture layout, pole locations, lighting, etc. Practitioners should seek additional guidance concerning the full range of pedestrian design elements.

There have been three catalysts necessitating an update to the 1991 TAC MUTCDC APS provisions:

- a) In the years since the 1991 MUTCDC, there has been on-going research into the needs of people with vision loss. Their stated needs have also been evolving as APS are installed and new operational experiences are gained;
- b) The private sector has continued to develop new and increasingly effective technologies to assist in road crossings. These technological advancements have been in reaction to needs, and have sometimes also influenced stated needs. In the years since the 1991 TAC standards for APS were established, APS technology has advanced significantly, and the potential opportunities and impacts need to be better understood by deploying agencies; and
- c) Despite previous TAC guidance, it was determined that new Guidelines were needed to address the high degree of variability amongst Canadian APS installations. Common variance in operation and design including:
  - the APS indications used (e.g. the common ‘bird sounds’)
  - the duration of the APS tone
  - the concurrent signal displays
  - means of actuation
  - strategies for non-conventional intersection geometries
  - the type of APS technology
  - strategies for sound impact abatement
  - use of beaconing
  - placement of pushbuttons
  - use of pushbutton poles
  - use of conflict monitoring

In all instances, the Guidelines were developed to meet needs of the pedestrian in the roadway environment. Pedestrian safety was the primary objective in the preparation of the guidelines. Cost and roadway capacity were considered secondary objectives in the preparation of the Guidelines.

## 2.0 APPROACH

The official kick-off for the Guidelines update took place in February 2006. The preparation of the Guidelines included the following tasks:

- a) *Literature Review* – This Industry Operational Review investigated best practices and industry standards for APS within Canada, the United States, and internationally. The review generated a preliminary list of functional requirements and a list of unresolved issues that provided a basis for the Deployers' Survey.
- b) *Deployers' Survey* – The objective of this task was to gather input from deployers across Canada regarding local practices and technical experiences/ lessons learned. Based on these surveys, the functional requirements were updated.
- c) *Vendor Interviews* – Vendor telephone interviews were used to validate proposed directions, and to obtain additional inputs to the functional requirements.
- d) *Stakeholder Consultation* – A draft of the Guidelines was released for circulation to advocacy groups for feedback and recommendations. These inputs were used to further refine the functional requirements within the Guidelines.
- e) *Draft Preparation* – The Guidelines were developed in three stages, first was the 50% draft, then the 70% draft (the draft released to the public for comment), and finally the Draft Final. The Draft Final of the "Guidelines for the Understanding, Use and Implementation of Accessible Pedestrian Signals" was submitted to the TAC Project Steering Committee in late March 2007 and presented at the TAC semi-annual meeting in Ottawa in mid April 2007. At the time of writing of this paper, the TAC Chief Engineer's Council has approved that the Guidelines be reviewed by letter ballot.

Throughout these project tasks, the Project Steering Committee was responsible for reviewing the evolving functional requirements, debating outstanding issues, and maintaining focus on user needs and safety.

## 3.0 PEDESTRIAN CONTEXT

Pedestrian travel for people with vision loss typically requires careful consideration of the local traffic conditions. Therefore, it is important for agencies deploying APS to understand how people with vision loss cross at signalized intersections, and how APS technology (and these Guidelines) may be used to mitigate risks for these pedestrians. The recommendations presented in the Guidelines will assist people with vision loss in the different stages of crossing at signalized intersections.

A brief summary of the steps taken by people with vision loss to cross a street is generally as follows:

- a) *Locating the street or intersection* – The first step is for pedestrians with vision loss to determine that they have arrived at a street or intersection. To determine this, they use indications such as the curb, downslope of a ramp, textured surface treatments (e.g. truncated dome surfaces), sound of traffic, and the presence of other pedestrians etc. to recognize the edge of the street environment.
- b) *Identifying the street* – Next, the pedestrians with vision loss must identify the street that has been reached. To accomplish this, the individuals can either use their knowledge of the area from past experience (including auditory and kinaesthetic information), any accessible media that provides local street information (e.g. tactile or audible street indicators), or other pedestrians by asking for the street name.
- c) *Assessing the intersection* – The pedestrians must obtain critical information concerning intersection geometry and operation before crossing the street. The types of information needed include: where the traffic is located, whether the intersection shape is irregular (T-intersection, offset intersection, etc.), whether the site has traffic control signals, whether they need to push a pedestrian button, whether the intersection is equipped with APS, where they must walk to and in

what direction, the location of the crosswalk, and when to start walking. Ideally, they would also be able to determine if there is a median island that would act as a barrier, or alternatively as a refuge. Usually, some of this information is gathered by listening to a few cycles of traffic signal operations. In some locations, pedestrian pushbuttons and pedestrian information signs may be used to (a) identify the presence of APS via the pushbutton locating tone, and (b) align the pedestrian with the crosswalk. However, traffic conditions may have a significant impact on the pedestrian's ability to assess their crossing requirements. For example, advanced turn phasing, fully actuated control, right turns on red, excessive ambient noise, and locations that are quiet (e.g. due to low traffic volume, low vehicle noise, etc.) all represent circumstances that may be atypical of the pedestrian's normal experiences in crossing the street. Consequently, these situations may pose challenges for people with vision loss.

- d) *Crossing the street* – Before leaving the curb, pedestrians need to determine if the Walk interval has begun. They typically listen for one stream of traffic to stop, and for traffic moving on the parallel street to accelerate from stop. If the signalized intersection is equipped with APS, then the pedestrian will listen for the tone and begin walking. Once they have started to walk, maintaining alignment can be problematic if the sound of turning vehicles masks the sound of the parallel traffic stream, if there is unusual intersection geometry, or if the volume of parallel traffic is low.

## **4.0 RECOMMENDATIONS**

The following sections outline the major recommendations of the new Guidelines. These new Guidelines speak to the various pedestrian needs identified above.

### **4.1 PUSH BUTTON LOCATING TONES**

The Guidelines recommend the use of pedestrian pushbutton locating tones to increase pushbutton accessibility. Specifically, where an intersection is equipped with APS technology, and the APS operation is actuated, pushbutton locating tones will (a) assist pedestrians in identifying that an intersection is APS equipped, and (b) in locating the pushbuttons. The volume of the pushbutton locating tones should automatically adjust (up and down) with the volume level of the ambient sound so that they can be heard in any traffic conditions. To mitigate the noise impacts on the adjacent neighbourhood, the Guidelines also identify the range (or limit) within which the pushbutton locating tone should be heard. Lastly, the tone length, repetition rate for the tone, operating times, and mounting location are also identified within the Guidelines.

### **4.2 Orientation Guides**

In addition to the APS indications, the Guidelines support the use of supplemental information at each APS location to assist pedestrians in orienting themselves for their crossing of a signalized intersection. As a minimum, APS sites should be accompanied by a pedestrian information sign (for sighted pedestrians) and a tactile arrow indicating the direction of crossing for the subject pushbutton.

- a) *Pedestrian Information Signs* – The signs provide sighted pedestrians with information concerning the use of the pushbutton and the meaning of pedestrian clearance display and may be used to assist people with vision loss in orienting themselves to their intended crosswalk. The Guidelines provide details concerning the signs alignment, mounting position and appearance.
- b) *Tactile Arrows* – Tactile arrows point in a direction parallel to the crosswalk that is controlled by the associated pushbutton. The Guidelines provide details concerning the arrow location, alignment, and appearance.

However, it is noted that on a case-by-case basis, supplemental guidance features, such as Braille characters, tactile characters, high-contrast lettering, and audio street announcements may also provide needed guidance for crossing the street. The Guidelines discuss these features and how they benefit the users.

### 4.3 APS ACTUATION

Currently in Canada, agencies that have deployed APS have done so in either a fixed (always on) operation, or an actuated operation. The Guidelines do not recommend a change to this approach. Thus, the Guidelines do not specifically advocate that APS be actuated. However, should there be a need to reduce sound impacts of the APS on the local community, actuation for the APS should be considered. A person with vision loss will determine that a particular site has APS, and that it is actuated, through the use of the pedestrian pushbutton locating tone.

#### The Pedestrian Pushbutton

To maintain flexibility for both users and deployers, the Guidelines indicate that APS may be either a fixed operation (active with each Walk indication), or actuated through the use of pushbutton technology. A common pushbutton should actuate both the visual Walk indication and the APS signals (audible and vibrotactile). Where desired, supplemental forms of active detection may be used (e.g. personal actuation devices such as audible sign technology), but not as an alternate to the pushbutton. The Guidelines provide direction in terms of the button size and operation to ensure accessible operation for people with low gross motor skills as well as those with vision and hearing loss.

#### Types of Pushbutton Actuation

As part of the industry and community feedback obtained through this project, it was identified that there is a strong user preference for a simplified form of APS actuation. Currently, many jurisdictions use a press-and-hold (or 'beacon') actuation. As a consequence, the Guidelines advocate a method of actuation that is more typical for pedestrians, specifically, that used for a normal pedestrian Walk indication display (referred to in the Guidelines as a 'normal' actuation). These two types of actuation are defined as follows:

- Normal actuation* Occurs with the simple 'press-and-release' of the pedestrian pushbutton. With a simple press-and-release actuation, the traffic control signals cycle to the visual Walk indication requested, and the APS features (i.e. audible and vibrotactile) of the associated pedestrian crosswalk are actuated.
- Beacon actuation* 'Beaconing actuation' occurs when the pedestrian pushbutton is pressed and held for a predefined time period (e.g. 3 to 6 seconds). With this 'press-and-hold' actuation, the traffic control signals cycle to the visual Walk indication requested, and the APS features (i.e. beacon and vibrotactile) of the associated pedestrian crosswalk become active. At these locations, should a pedestrian use a simple 'press-and-release' of the pedestrian pushbutton, the traffic control signals will cycle to the visual Walk indication requested without the APS features.

While this may be considered a significant departure from the actuation methodology commonly deployed today (i.e. the beacon actuation), there has been strong user support for this form of actuation.

#### Acknowledgement of Actuation

The APS Guidelines are intended to support the needs of people with hearing loss as well as vision loss. Therefore, upon actuation of the APS, the Guidelines provide for an audible, visual, and vibrotactile acknowledgement of the actuation. This applies to both 'normal' and 'beacon' actuations as described above. For a normal actuation, these acknowledgements should be provided immediately upon the 'press-and-release' of the pedestrian pushbutton. For a beaconing actuation, these acknowledgements should be provided only once the pedestrian pushbutton is pressed and held for the predefined time

period. The Guidelines provide additional information concerning the audible, visual and vibrotactile acknowledgement operations, and system response to these actuations.

#### **4.4 APS OPERATIONS**

To accommodate the new approach to actuation (noted above), it was decided that a new approach to APS audible indication volume levels was necessary. The 'normal' type of actuation advocated within the Guidelines will result in a higher frequency of APS actuation than the previous press-and-hold actuation. There is a resulting potential for higher noise impacts on the surrounding community. Literature generated by organizations representing people with vision loss recognizes the need to mitigate sound impacts on the surrounding neighbourhood, and advocates that the practical sound range be limited. Therefore, to mitigate this potential noise impact, the Guidelines recommend a lower APS volume level. In effect, the audible and vibrotactile signals for APS are generally to be provided as an indication of the 'start of Walk', and not as a guide to cross the street. This significant update from the earlier TAC MUTCDC provisions is discussed in more detail in the following sections.

##### **APS Operations During The Walk Interval**

The Guidelines provide several recommendations concerning the proposed operation for APS. The recommendations that represent the key updates to the MUTCDC are those that state that APS:

- Be provided for the entire Walk interval;
- Adjust automatically its volume level to be heard above the surrounding ambient sound; and
- Should be audible at no more than 3.7m from the pushbutton, or at the closest building line, whichever is less.

These measures will provide an effective indication of 'start of Walk' while limiting the APS noise impacts for the surrounding community. The Guidelines also provide information concerning:

- Setting appropriate APS volume levels;
- Use of Voice Messages for APS;
- Operation of the vibrotactile signals;
- Factors that may be taken into consideration when establishing pedestrian signal timing; and
- Why the use of APS during the pedestrian clearance interval is not a recommended practice.

##### **APS Audible Indications**

As part of the development of these Guidelines, TAC has considered the replacement of the 'chirp' indication (commonly used in Canadian deployments) with a melody comprised of multiple tone frequencies. Studies indicate that the 'chirp' sound is not as easily discerned as an APS, nor can it be easily 'localized' (found) by users. Specifically, there has been widespread concern that the 'chirp' indication is too readily mistaken for birds commonly found in the North American environment. This leads to higher rates of lateral deviation in the pedestrian walking path. Representatives of people with vision loss broadly advocate a change away from the use of the 'chirp'. Therefore, the Guidelines recommend that intersections equipped with APS technology should employ the distinct audible indications indicated in Table 1.

**Table 1: APS Indications**

<b>Direction of Travel</b>	<b>APS Concurrent with Visual Walk Display</b>
<b>North-South</b>	A 'cuckoo' sound *
<b>East-West</b>	The 'Montreal Melody'

*\* Using the industry standard cuckoo sound that is prevalent amongst major APS vendors.*

The 'Montreal Melody' APS indication incorporates multiple (i.e. mixed or changing) frequencies, that are ideal for localization of sounds, mitigating lateral deviation, and for pedestrians with age-related hearing loss. It has also been tested favourably (relative to the 'chirp' APS indications currently used) for user comprehension and directionality.

The Guidelines also provide details concerning the use of additional tones at locations requiring more than the standard two APS indications.

### **Use of APS Beaconing**

APS beacons use the same APS indications but operate at a higher volume so that they can be heard throughout the crosswalk and from across the street. Beacons have been widely deployed in North American applications. However, recent research indicates that the broader community of organizations representing people with vision loss no longer favours the use of APS beacons. The reasoning provided is that beacons tend to mask parallel traffic noise, and people with vision loss consider this traffic noise to be the primary guide for crossing the street. Consequently, the Guidelines promote lower-volume APS that provide a 'start of crossing' indication, as described above.

While the Guidelines recommend the use of a quieter operation than typically used for beaconing, audible beaconing may provide benefits under a number of scenarios, including locations with unusual geometry, long pedestrian crossings, and where pedestrian scramble phasing is used.

The Guidelines provide additional details concerning the beacon actuation, volume levels, accompanying vibrotactile operation, and beacon operation (including how to improve directionality and use during pedestrian scramble phasing).

## **4.5 PUSH BUTTON LOCATION DESIGN**

Pushbutton locations play an important role in helping pedestrians with vision loss in crossing the street. The proper location will allow the pedestrian to hear the APS walk indication and to orient themselves to the street. Presented below is a summary of the sections in the Guidelines related to pushbutton locations, appearance, mounting height and alignment.

### **Pushbutton Location Relative to Walking Path and Curb**

Wherever possible, APS pushbuttons should be located adjacent to a clear level ground surface acting as the pedestrian waiting area. This assists pedestrians who need to use the vibrotactile system. For this APS to be useful for a pedestrian, they need to be able to reach the pushbutton from their 'start to cross' position. The Guidelines provide a number of recommendations that assist pedestrians in locating and using the pushbutton. Specifically, the pushbutton should be:



- Accessible from the extended line of this crosswalk (see Exhibit 1 and 2);
- Placed on the side of the pole facing the pedestrian waiting area (see Exhibit 3);
- Aligned such that the face is parallel to the associated crosswalk (see Exhibit 3);
- Aligned such that the surface of the APS pushbutton control face is parallel to the direction of the crosswalk that the pushbutton controls. This should allow users to use the face of the signs and associated markings to orient themselves for the crossing.

The Guidelines also include provisions for variations related to suburban and urban environments, use of supplemental pushbuttons on median and refuge islands, mounting height instructions, and other considerations in locating and operating pedestrian pushbuttons.

### **Locating Pushbuttons on a Single Pole vs. Separate Poles**

Locating the pedestrian pushbuttons on separate poles assists pedestrians in orientation by associating separate pushbutton sites with specific APS indications. Where two separate APS pushbuttons are located on the same corner (i.e. for two separate directions of travel), the pushbutton and APS emitter for each crosswalk ideally should be separated by 3m. However, in some locations (e.g. proposed retrofit locations, dense urban locations, etc.) circumstances may dictate the placement of APS pushbuttons for two directions of travel on a single pole. In these instances, the same design principles identified above still apply, and the Guidelines outline how to apply these for two pushbuttons mounted on one pole.

### **Other Considerations**

The Guidelines provide Exhibit 1 through 4 to illustrate the preferred location for the placement of APS pushbuttons. Where poles are not suitably located to meet these placement criteria, one of the following strategies may be pursued:

- Realignment of the pedestrian crosswalk lines to better suit the needs of the pedestrians with vision loss; or
- Installation of supplemental pushbutton poles to achieve the desirable pushbutton placement.

It should be noted that in all instances, pole placement should provide approximately 1.5m of clearance for people in wheelchairs, powered chairs, and maintenance vehicles (e.g. snow and garbage clearance vehicles) to circulate.

## **5.0 SUMMARY OF UPDATED GUIDELINES**

The following summary describes the nine sections of the Guidelines and provides a brief overview of the guidance provided.

### *Section 1 – Introduction*

This section provides the background information, objectives and approach taken to update the accessible pedestrian signal provisions within the 1991 TAC MUTCDC. Definitions and acronyms are explained, and acknowledgements recognizing the many contributions of individuals can also be found in this section.

### *Section 2 – The Pedestrian Context*

It is important for agencies deploying APS systems to understand the experiences of people with vision loss when they cross at signalized intersections. This section provides a description of the user's road crossing procedures and the needs that may be addressed by APS.

### *Section 3 – Community Liaison*

Communication between the deploying agency and individuals, or organizations representing people with vision loss is highly recommended to ensure that community needs are identified and dealt with in a timely manner. This section provides guidance on establishing dialogue with local users and/or representatives of people with vision loss.

### *Section 4 – Establishing Installation Priorities*

Prioritizing sites for APS installation is an essential part of APS program management. This section may be used to help establish APS installation priorities. Factors that are considered include pedestrian safety, pedestrian usage, traffic conditions, mobility and other *site specific* factors. An 'Accessible Pedestrian Signal (APS) Installation Prioritization Procedure' is provided within the Guideline's appendix.

### *Section 5 – APS Operational Guidelines*

Direction regarding the preferred means of operating APS is described in this section, including the use of pushbutton locating tones, orientation guides, APS actuation, types of APS indications, volume adjustment, and the associated traffic control signal operations and phasing.

### *Section 6 – APS Design Guidelines*

Design criteria that are considered desirable for the effective operation of APS are described in this section, including the design and location of pushbutton installations, consideration of pedestrian walking path, APS unit location and alignment, use of pedestrian information signing, and pedestrian accessibility challenges related to intersection configuration and operation.

### *Section 7 – APS Deployment Guidelines*

This section identifies installation procedures to ensure that an APS deployment meets the needs of the person or agency that requested the installation. Pre & post-installation notifications are recommended as well as installation inspections and a user orientation walk-through. It should be noted that this section does not relate to electrical installation.

### *Section 8 – APS Maintenance & Adjustments*

Operational adjustments may be requested by the user or the general public, and this section provides some common strategies for mitigating public concerns. Also described in this section are guidelines for monitoring APS and the different types of routine and emergency maintenance requirements.

## 6.0 ACKNOWLEDGEMENTS

The TAC Steering Committee would like to acknowledge the contributions of the following individuals:

Janet Barlow – Certified Orientation and Mobility Specialist	Dave Keenan – The City of Calgary
Roger Bibaud – City of Montreal	Steve Kemp – City of Toronto
Chris F. Brinkmann – City of Ottawa	Goran Lazic – City of Saskatoon
Neil Campbell – Newfoundland and Labrador	Linda E. Lee – City of Toronto
Richard Chow – Alberta	Don MacDonald – City of Edmonton
CNIB National Office	Michel Masse – Québec
Al Cunningham – City of Moncton	David McCusker – Halifax Regional Municipality
Marc Des Rivières – Québec City	Ben Rogers – Manitoba
Tamara Christensen – City of Regina	Patrick Ryan – City of Vancouver
Luis Escobar – City of Winnipeg	Dona Sauerburger – Certified Orientation and Mobility Specialist
Ed Foster – City of Edmonton	Hart Solomon – City of Hamilton
Valérie Gil – Transport Canada	Simon Trépanier – Québec
Egerton Heath – Regional Municipality of Waterloo	Rob Wasnea – City of Edmonton
Robert Kahle – City of Montreal	Ben Yarmuch – City of Edmonton

## 7.0 REFERENCES

CNIB Standard for Accessible Pedestrian Signals, The Canadian National Institute for the Blind (November 2003)

Manual on Uniform Traffic Control Devices for Streets and Highways (2003 Edition) Part 4 Highway Traffic Signals, Federal Highway Administration (2003)

Transports Quebec – Standard – Traffic Control Signals, Volume V, Chapter 8, Page 61, Section 8.9 ‘Audible Signals’ (February 2003)

“Assistive products for persons with vision impairments and persons with vision and hearing impairments – Acoustic and tactile signals for pedestrian traffic lights” ISO Standard ISO/TC173/WG7 (2005)

‘Accessible Pedestrian Signals – Synthesis and Guide to Best Practice’, Walkinginfo.org Pedestrian and Bicycle Information Center, Federal Highway Administration, (2006) (<http://www.walkinginfo.org/aps/home.cfm>)

Accessible Pedestrian Signals, Accessible Design for the Blind (Bentzen & Tabor) for the U.S. Access Board (1998)

“Recommendations to U.S. Access Board, Part III, Section X02.5, The Public Rights-of-Way Access Advisory Committee, or PROWACC (2001)

Accessible Pedestrian Signals in Canada, A Brief by The National Federation for the Blind: Advocates for Equality (NFB:AE) (2002)

2006 City of Winnipeg Accessibility Design Standards (DRAFT)

Functioning of APS (Sweden), as detailed in Walkinginfo.org Pedestrian and Bicycle Information Center, Federal

Highway Administration, (2006) (<http://www.walkinginfo.org/aps/4-11.cfm>)

Functioning of APS (Denmark), as detailed in Walkinginfo.org Pedestrian and Bicycle Information Center, Federal Highway Administration, (2006) (<http://www.walkinginfo.org/aps/4-14.cfm>)

“Guidelines for Accessible Pedestrian Signals – APS Prioritization Tool (interim product from NCHRP Project 3-62)” by The University of North Carolina Highway Safety Research Center and Accessible Design for the Blind, authors Harkey, Carter, Barlow and Bentzen (draft Dec 2005)

“Accessible Pedestrian Signals: Synthesis and Guide to Best Practice (interim product from NCHRP Project 3-62)” by The University of North Carolina Highway Safety Research Center and Accessible Design for the Blind, authors Barlow, Bentzen and Tabor (July 2003)

“Determining Recommended Language for Speech Messages Used by Accessible Pedestrian Signals” by Bentzen, Barlow & Franck, research supported by The Seeing Eye, American Council of the Blind, California Council of the Blind, Venter for the Visually Impaired in Atlanta, and the U.S. Access Board (2002)

“Manual of Uniform Traffic Control Devices for Canada, A6.10 Audible Pedestrian Indications”, Transportation Association of Canada (1998)

“Evaluation Of The Effectiveness Of An Alternating And Pedestrian Activated Audible Traffic Signal At A Six-Lane Crossing For A Population Of Functionally Blind Persons” by Ratelle et al, research conducted for Institut Nazareth Et Louis-Braille, École D’optométrie, Université De Montreal, School Of Audiology (University Of Ottawa), Centre De Réadaptation Estrie, Centre De Réadaptation Le Bouclier, and the Montreal Association For The Blind (1999)

“Evaluation Of Audible Traffic Signals For Pedestrians With Visual Impairment”, Giguère, Laroche and Poirier, Programme D’audiologie et D’orthophonie, Université D’Ottawa, Ottawa (1999)

Functioning of Broadcast APS (Japan), as detailed in Walkinginfo.org Pedestrian and Bicycle Information Center, Federal Highway Administration, (2006) (<http://www.walkinginfo.org/aps/4-2.cfm>)

Functioning of APS (Australia), as detailed in Walkinginfo.org Pedestrian and Bicycle Information Center, Federal Highway Administration, (2006) (<http://www.walkinginfo.org/aps/4-7.cfm>)

“Field Evaluation of Audible Traffic Signals for Pedestrians with Visual Impairments” by Laroche, Giguère and Leroux, Audiology and Speech-Language Pathology Program, University of Ottawa and École d’Orthophonie et d’audiologie, Université de Montréal (2001)

“Audible Traffic Signal: A New Definition” by Hall, Ratelle & Zabihaylo, Institut Nazareth et Louis-Braille (1994)

“Locator Tones for Pedestrian Signals” by Bentzen, Barlow & Gubbe, Transportation Research Record 1705 (2000)

“Evaluation of Audible Traffic Signals for Blind Pedestrians on Quiet and Busy Road Intersections” by Giguère, Laroche and Leroux (2003)

“Detectable Warnings: Synthesis of U.S. and International Practice Work” by Bentzen, Barlow and Tabor, Accessible Design for the Blind (2000).

## 8.0 FIGURES

Exhibit 1: Pedestrian Pushbutton Locations – Dual Ramp Configuration

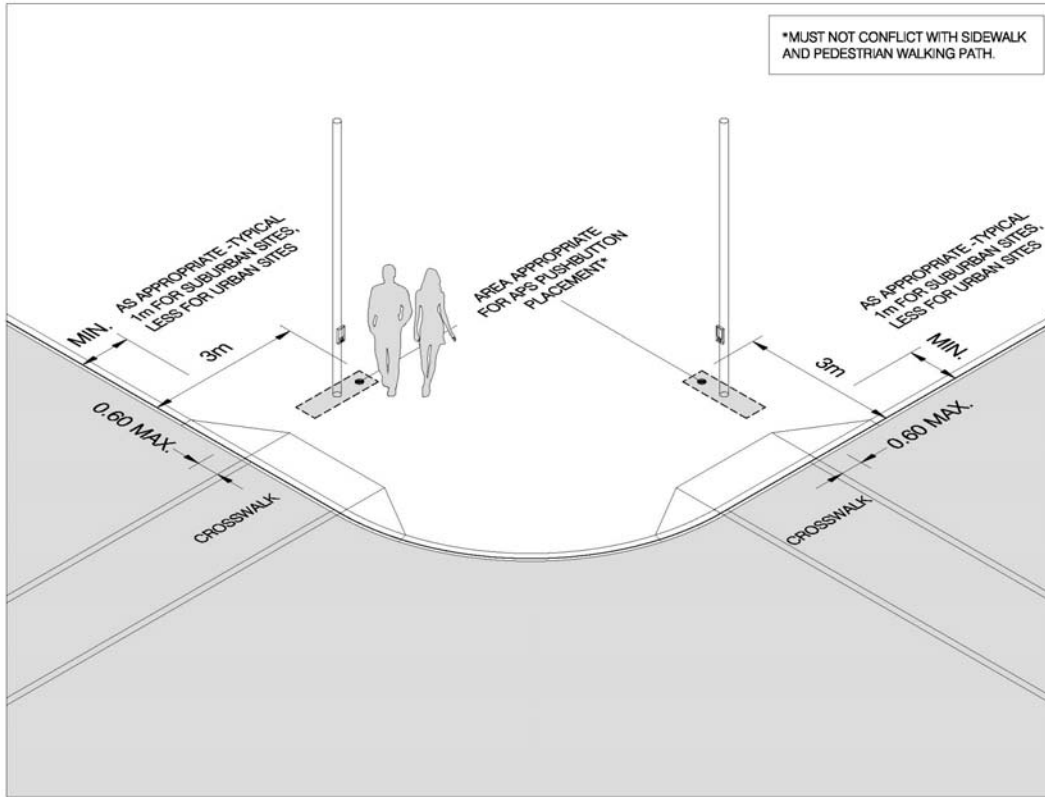


Exhibit 2: Pedestrian Pushbutton Locations – Single Ramp Configuration

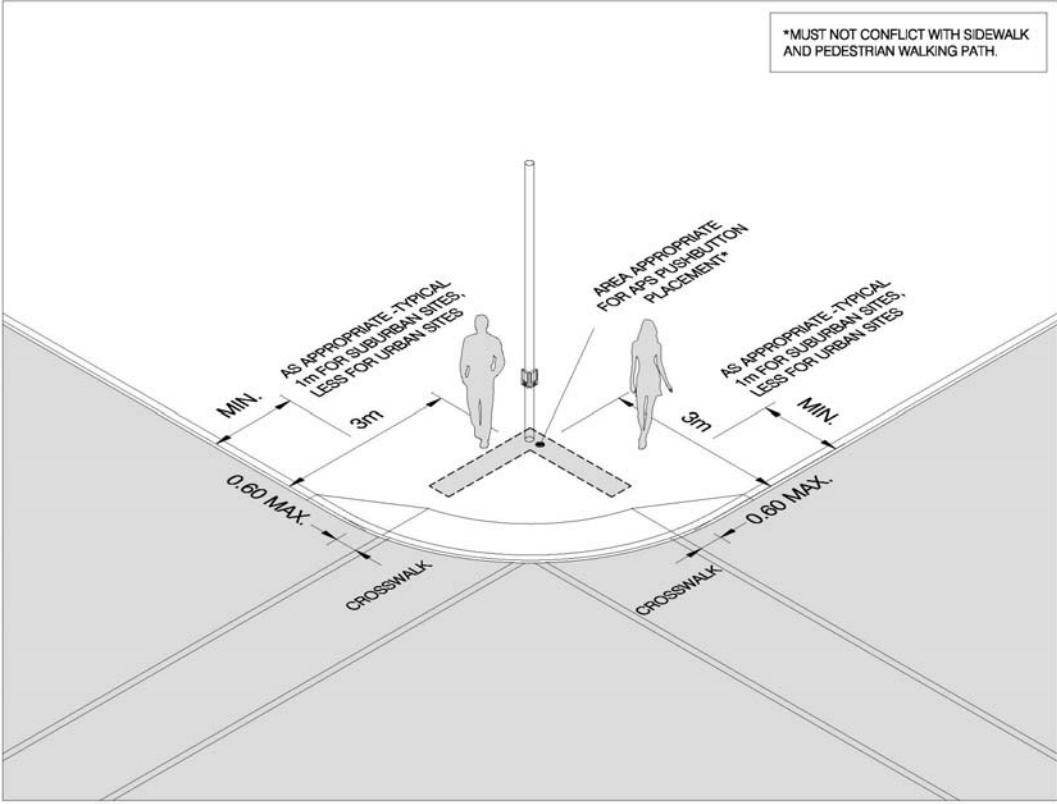


Exhibit 3: Pushbutton Alignment – Two Poles Available

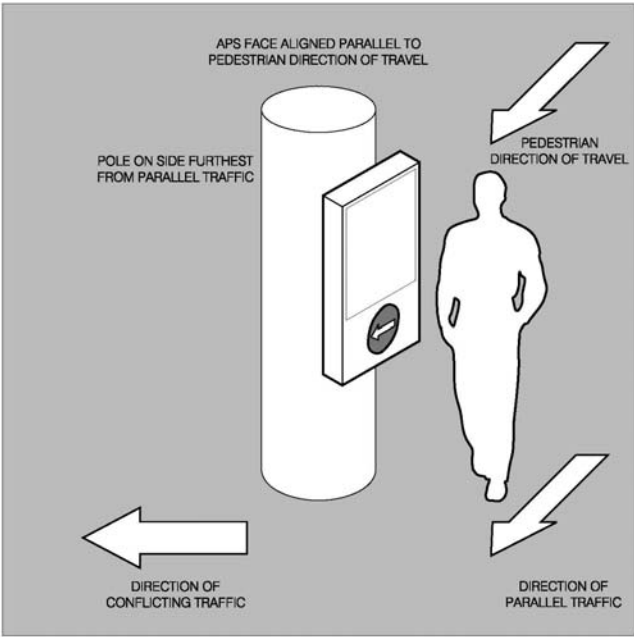


Exhibit 4: Pushbutton Alignment – Single Pole Available

