# How to Regulate Traffic in a Sustainable World

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## Abstract

Busy intersections have been regulated by traffic lights for more than a century. In 1868, downtown London had so much horse and wagon traffic that a British railroad signal engineer designed the first traffic semaphore to regulate movements near the Parliament. The device was indeed the first traffic "light", as lenses in the semaphores where lighted by gas lanterns at night. Besides traffic regulation, one of the goals behind the creation of the device was the protection of pedestrians.

Various manually-operated devices appeared in the following decades, usually manned by policemen whose whistle took care of the clearance interval. In the golden years of the horseless carriage, rapidly increasing traffic required a new way to regulate movements. The first electric traffic lights appeared in 1912, but only in 1914 did the first traffic light controller made in way to Ohio streets. The blueprint for modern traffic signals, the three-color signal head, bowed in 1920.

The first dedicated pedestrian signals appeared a decade later, and a prototype that defined a clear, exclusive pedestrian phase was tried out in New-York in 1934. The Big Apple also saw the first document "WAIT" / "WALK" signals in 1939.

In the following years, with the ever-increasing vehicular traffic, pedestrians made little gains at traffic signals despite prodigious advancements in technology. More and more, they had to push buttons or step on pressure plates to get the "WALK" signal, and even then pedestrian signals mostly worked parallel to vehicular signals, eschewing any form of priority by function.

Fast forwarding to the 21st century, walking has come back in force as the backbone of active transportation, as society strives to promote more sustainable transportation. Transit is getting the lion's share of attention and research in the traffic field, while cycling is integrated into public infrastructures through upgrades or "complete streets" rebuilds.

Pedestrians … are still on the sidewalk. What can be done to help them put a foot forward in the transportation hierarchy? Exclusive phases are back in vogue and now called "scrambles". Countdown timers remove hazardous situations by clearly indicating how much time is left before the "DON'T WALK" signal comes up. Visually impaired pedestrians benefit from improved mobility in urban centers thanks to standardized Accessible Pedestrian Systems. Modern traffic controllers offer tremendous computing power, giving traffic engineers increased flexibility when orchestrating movements at an intersection. Measures that both protect the pedestrian and allow vehicular traffic to progress elevate the status of walking while not impeding the flow of transit and other vehicles are hidden in that computing power, and have been there for years.

This paper relates the historical steps in the pedestrian signalling world. It is intended as a toolbox of pedestrian-friendly measures for practitioners, some actively putting walking front and forward … at no cost. Measures like the Leading Pedestrian Interval and the Walk phase extension are simple functions available in modern traffic controllers. Other measures like the pedestrian countdown timer and the "Through Arrow Leading Walk Interval" are simple to retrofit during traffic signal upgrades and are of much benefit to pedestrians.

## Introduction

As populations moved from rural settings to dense, urban areas, increasing traffic ensued. The Romans have not heard of the MUTCDC (Manual for Uniform Traffic Control Devices for Canada), but they are credited with the invention of the classic urban landscape: organized cities, with private and public areas, elaborate living spaces, fresh water supply conduits and sewers, planned development grids and of note the blueprint for the modern road. Large populations moved about for work, leisure or military purposes, with pedestrians mixed with animal-drawn carriages.

From the ruins of the Roman Empire, Europe’s large cities grew, and with the dawn of the industrial age, even more people moved into the cities, increasing trips and conflicts as horse buggies became more available to citizens, on top of all the goods and merchandises being moved about by horse-drawn wagons. In this context, it not surprising that the busy city of London, England, saw the birth of traffic regulating, way before motorized transportation became common.

In 1868, downtown London had so much horse and wagon traffic that a British railroad signal engineer designed the first traffic semaphore to regulate movements near the Parliament. The device was indeed the first traffic “light”, as lenses in the semaphores where lighted by gas lanterns at night. Traffic regulation, the science of managing traffic through active devices, was born. Besides traffic management, one of the main goals behind the creation of the device was … the protection of pedestrians.

As devices evolved over time, pedestrian signals often became an accessory to the main vehicular traffic lights, forcing people to press a button to get the privilege of crossing the street. For decades, walking took a back seat to driving, and devices targeted at pedestrians did not evolve at the same pace than advances for motorists.

The following paper discusses the historical steps pedestrian signals have gone through over the years, to better understand where the current standards came from. History also puts into perspective the lengthy period of the automobile boom, where very little progress was made regarding treatment of pedestrians at regulated intersections.

The last twenty years have been rich in developments, though, and in today’s sustainable world, many measures can be implemented to actively promote pedestrian priority at traffic signals. We will walk through these measures, highlighting the benefits pedestrian can reap from them and how to apply them.

## 1. The early days of pedestrian signals

History has not retained where or when the first pedestrian-only illuminated traffic signalling device has appeared, but according to a paper by Weingroff published in 2011 for the FHWA's (Federal Highway Administration) Highway History series, the time-frame of the late 1930's seems about right.

As vehicular traffic rose, so did the death and injury tolls amongst pedestrians. City officials first intervened legally, creating the pedestrian priority rules we still have today, but also made physical interventions, like adding barriers so pedestrians would not cross at the wrong time. Many different ideas also came up on the operation of the era's traffic lights. One of these was simple enough: add a light indicating that pedestrians could walk while vehicles got the red signal to stop at all approaches, as illustrated in Figure 1.1. In other words, this was the birth of the scramble crossing.

More thorough work was done by Dr. John Harriss. He published an article in the February 1934 issue of Public Safety on an experimental traffic light he developed.

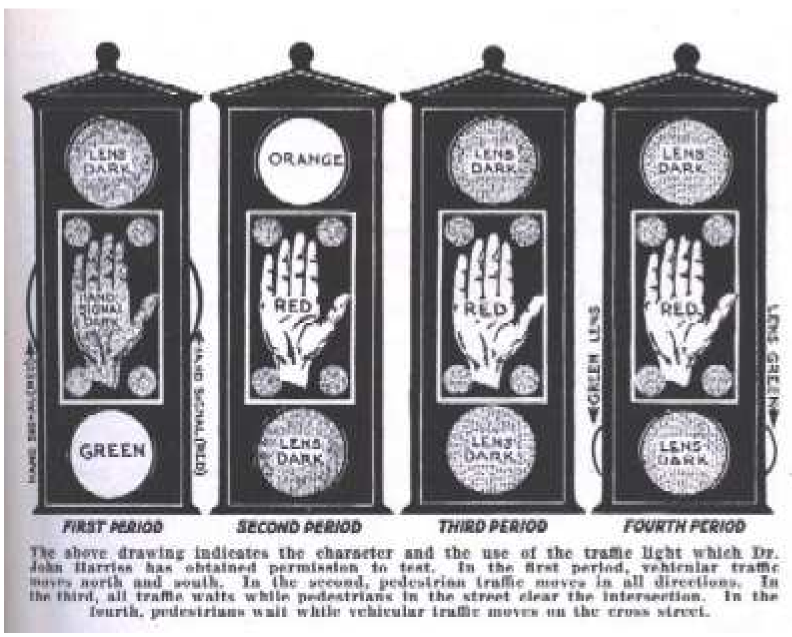


**FIGURE 1.1: TRAFFIC SIGNAL PROTOTYPE BY DR. JOHN HARRISS (SOURCE: WWW.FHWA.DOT.GOV)**

In the display, the amber signal was replaced by a red hand. The display had four phases, from left to right:

- East / West vehicles;
- Pedestrian from all directions;
- Pedestrian clearance;
- North / South vehicles.

It was installed in New-York City, on 5$^{th}$ Avenue between 40$^{th}$ and 45$^{th}$ streets. Right turns on red were prohibited, and a fixed 120s cycle was used. Pedestrian would get a 20s phase where the fixed red hand would be displayed, along with flashing amber lenses around it, followed by a 5s clearance where only the fixed red hand is displayed.

Most American cities used the basic, traffic control device from New-York City, allowing adaptation of the new pedestrian display. However, many cities experimented with different types of displays for pedestrians before common ground was found. In Boston, Los Angeles and San Francisco, the amber ball was meant as a pedestrian signal. Paris employed one red lamp followed by a dark lens for pedestrians, while other towns in Europe tinkered with the basic red-amber-green display.

In December of 1934, *Public Safety* magazine had a feature article on a new progressive traffic control system used in the city of Chicago. The display featured a Walk indication for pedestrians, and it utilized synchronization with other traffic lights so motorists could, at a steady speed, progress through intersections without stopping. The system was called “revolutionary”.

The Chicago system displayed the Walk during part of the green, and was timed to get the pedestrian to the central island on Michigan Avenue. Pedestrians then had to wait for the following Walk phase. This staged crossing gave a clear indication of when the pedestrian should be crossing, but opposite to New-York’s scramble, the crossing had to be shared with turning vehicles. However, the incoming left-turning traffic was stopped during the Walk indication, so the only conflicts came from nearby right turns. This is the way most staged crossings are still operated in 2011.

Following pedestrian complaints about waiting on the island, and not knowing that they had to wait there, the City added illuminated signs indicating that only half a crossing should be attempted on the Walk signal.

This was, however, a pretty advanced traffic signal control for the era. Most traffic signals were still of the “Stop and Go” variety, operated with lighted paddles also called semaphores. Depending on how the paddles were inclined when viewed from the pedestrian crossings, they were confusing to read and this led to incidents.

The semaphore is the very first traffic signal. It appeared in 1868 in London, England, at the intersection of Bridge and George Streets near the Houses of Parliament (see Figure 1.2). It seems that horse and buggy traffic had become so problematic that pedestrians, and especially parliament members, needed a safe way across the intersection. The light part came from a gas lantern on top that lighted the paddles at night. The signals were manually operated by policemen, and the change interval came in the form of a whistle being blown.

The classic, 4-way tri-colour traffic lantern was invented in 1920 by a Detroit police officer named William L. Potts. Operation was still manual, but automated timers came about later in the same decade. In 1935, the MUTCD (the American Manual for Uniform Traffic Control Devices, in one of its earliest editions) standardized the tri-color lenses for the United States. This led to the modern age of standardized traffic control, and the next step in pedestrian signals.


**FIGURE 1.2: POSTER EXPLAINING LONDON'S FIRST TRAFFIC SEMAPHORE (SOURCE: WWW.FHWA.DOT.GOV)**

## 2. Pedestrian signals enter the Modern Age

As traffic signal hardware moved towards standardization in the mid-1930's, the topic of pedestrian signals also came up on the agenda following the revolution of the Chicago system.

In 1937, at the National Safety Congress in the US, a report on "Pedestrian Control and Protection" was presented to the attendees. One of the main conclusions, still valid today, was that "unreasonable delays due to unnecessarily long cycles of operation of Stop and Go signals are conducive to disobedience by pedestrians". The report went on with a trend towards using shorter cycles in urban areas to reduce waiting time for all users. Gradually, using a white or purple light to indicate to pedestrians to walk in parallel to the vehicular green was preferred to the lengthy scramble phase. The pedestrian light would go off before the end of the green, since pedestrians need more time to clear the intersection. The report went on to state that where many vehicles went across the crosswalk, a special walk indication and phase (neither detailed) should be used to protect pedestrians. Caution was expressed as to how the "Stop" and "Go" paddles were placed at semaphore signals as to avoid confusing pedestrians.

Still, jaywalking was still an issue, and in December of 1938, the first "Wait" and "Walk" worded signs appeared in New-York City.

## 2.1 The Blueprint of Things to Come

The 1930's saw many ideas on traffic regulating as applied to pedestrians, and a certain convergence towards a more universal standard. It seems politicians had a key role once again: after London's parliament members dictating the first traffic signal in 1868, Washington D.C. saw the first installation of the "Walk" and "Don't Walk" signs (shown in Figure 2.1).


<u>**FIGURE 2.1: THE FIRST WALK INDICATION IN WASHINGTON D.C. (SOURCE: WWW.FHWA.DOT.GOV)**</u>

The neon signs were installed at the busy intersection of Thirteenth Street and Pennsylvania avenue N.W. These signs were the result of a prior, less successful pilot at another intersection. The new lights were bigger and brighter, to better grab the pedestrian's attention.

Washington's Traffic Director, William A. Van Duzer, was so happy with the success of the pedestrian lights that he expressed his intentions to expand the display to other intersections. That project became the blueprint of today's pedestrian signals.

By the 1950's, the format of "Don't Walk" over "Walk" signal heads became the standard, and the next step in the evolution was the use of pictograms over worded messages. In Europe, where borders are always near and languages diverse, the "walking man" already ruled the crosswalks. In North America, Canada led the way this time. In 1967, the ancestor of TAC (Transportation Association of Canada), the CUTD (Council on Uniform Traffic Devices), published a study (as cited by the FHWA in the reference below) in which the conclusion stated that the white man outline over a raised hand was the preferred pedestrian signal display. White was specified for the walking man, while the raised hand was orange.

The FHWA published a study called "Urban Intersections Improvements for Pedestrian Safety" by Robertson et al in 1977. In it was a very thorough analysis of the pictographic pedestrian display versus the worded one. After conducting surveys with engineers, practitioners, regular pedestrians and school children, the authors narrowed down the dozen options they had at the beginning and did field tests in various regions of the country on the top displays from the surveys. In the end, they concluded that the orange hand / white man pictographic pedestrian display presented a significant improvement relative to the standard Walk / Don't Walk display, just in time for the computer age.

### 2.2 Pedestrians and the Microchip

Earlier signal controllers were electro-mechanical devices with limited possibilities. They could feature pushbutton-controlled pedestrian phases, or vehicular phases activated by regular, in-ground loop detectors. Sturdy and durable, some of these controllers are still in service despite having more than 40 years of age. The pedestrian signal head worked very well in tandem with these devices, and has done so for years, until the pedestrian countdown signals appeared.

Electronic controllers first appeared in the late '60s, but it wasn't until 1975 that operational standards first appeared on the market. Two families of signal controllers exist today: those that follow the CALTRANS standard (California Transportation, better known as the 170 / 2070 series), and the NEMA standard (for National Electrical Manufacturers Association), first released as TS1 and later replaced by TS2.

The latest trend in the signal controller industry is the move towards a hybrid platform that can support both the CALTRANS and NEMA standards, the ATC-type controller (for Advanced Transportation Controller). Thanks to the common platform, technical advances can be shared between both families of signal controllers. The ATC standard is a product of joint collaboration between NEMA, the ITE (Institute of Transportation Engineers) and AASHTO (American Association of State Highway and Transportation Officials).

Despite all of that progress, the pedestrian signal head remained mostly the same. The newer, smarter traffic controllers operated them as they always have been. The one difference came with the conflict monitor present in a modern controller's cabinet. This device ensures that no conflicts are displayed, whether they come from programming errors, component failures or burnt light bulbs. The conflict monitor watches over the Walk phase, giving the pedestrian protection against all possible gremlins that modern technology always seems to bring on board for the ride.

Still, NEMA hasn't foreseen the rapid acceptation of the pedestrian countdown timer, and that device is not watched over by the conflict monitor. As a result, practitioners must carefully consider all operating parameters when countdowns are used as they can behave erratically (such as abruptly skipping numbers or go straight to "00"). Pedestrians, it seems, are still left on the sidewalk when it comes to regulating technology.

### 2.4 Current Pedestrian Signal Operation

Other than the move to pictograms, little evolution was seen in the world of pedestrian traffic signals until the 1990's. Studies evolved around the use of silhouetted pictograms (current TAC standard) or solid ones (current MUTCD 2009 standard).

What mostly hasn't changed in all those years is the way pedestrian signals are operated. Typically, the pedestrian phase runs in parallel to the vehicular green. Often enough, that vehicular green already offers the minimum pedestrian crossing time. The only benefit the pedestrian gets from the signals is the information given by the FDW phase, the one he, statistically, doesn't understand (Singer et al, 2005). In the end, when pushbuttons are present, the pedestrian will often just cross on the green and ignore the pedestrian signals, whose value is not clear to him.

More recently, technological advances started to work in unison with the public's mindset and the neglected pedestrian signals gained interesting new features, for users as well as practitioners. Some of them, like the pedestrian countdown timer, are now part of standards in many jurisdictions. Chapter 3 will examine those advances.

# 3.0 Measures that Help Pedestrians Put their Foot Forward

## 3.1 Walking Becomes Active Transportation: The Sustainable Revolution

Change is in the air. The Green Movement that started in Europe is finally getting grip in North American soil. Walking used to be considered a poor person's way of getting around, or an intermediate step between travel modes and destination. Not anymore: walking has become Active Transportation, just like cycling.

While the health benefits have always been perceived, urban planners now see how efficient it is to develop land in a perspective where walking is a mode of travel, not just a pathway to follow between the parking lot and the front door. Juxtaposed with transit and non-recreational cycling, New Urbanism made walking an integral part of its concept. Walking is not only healthy; it is also a sustainable way of getting somewhere.

While pedestrians always had priority at traffic signals, the change in mentalities helped in going beyond that simple legal perspective and paved the way to new ways to operate pedestrian signals, actively showing that pedestrians come first and adding measures that benefit walking through intersections. No longer a "parasite phase" to practitioners, the pedestrian phase is now at the center of the urban intersection. As we will see below, a whole toolbox of pedestrian-friendly measures is now at the disposal of practitioners to help pedestrians put their foot forward.

## 3.2 Pedestrian recall modes

Simply put, there are only two ways to grant a pedestrian phase at a signalized intersection: *actuation* and *automatic recall*. Actuation implies that the pedestrian phase is only called when needed by a pedestrian; therefore, it is not serviced by default, to the benefit of the vehicular phases. Automatic recall on the other hand brings back the pedestrian phase at every cycle. No action is needed by the pedestrian; he only has to follow the signals.

The following section on pedestrian detection is not a comprehensive review of all existing technologies, but more a summary of what's out there and how it affects the average pedestrian. Specific planning and design of intersection crossings also needs to consider human factors such as age, demographics and physical abilities of the target population, but those human factors go beyond the scope of this paper.

### 3.2.1 <u>Pedestrian actuation</u>

*Why actuate?*

By definition, pedestrian actuation is not a pro-pedestrian measure, as it will not service pedestrian phases by default. Pushbuttons give the pedestrian the impression that he is not welcomed at the intersection, or that he will be “in the way”. They also give the impression that there will be a delay before the phase is serviced. This perceived or real lack of immediacy encourages many pedestrians to cross unlawfully during breaks in traffic, even if they did use the pushbuttons. This gap-crossing before the pedestrian phase is serviced will in turn stop vehicular traffic once the phase activates and that no pedestrians are present, giving motorists the impression that the pedestrian phase is a waste of time.

Pedestrian actuation is thus a choice that should be carefully considered by the practitioner. Standard practice suggests using pushbuttons when pedestrian volume is low, and / or if the crossing phase has serious impact on vehicular traffic. Where pedestrian traffic is heavy and vehicular traffic is little impacted by crossings, pushbuttons should be avoided. To further complicate choices, some crossings are heavily used in limited periods (school hours, shift changes near plants, etc.). For the practitioner, there is a significant grey area around the management of signalized crossings. However, no current standard in Canada offers objective guidance as to when actuation should be used (a current TAC sponsored project, initiated in 2011, is tackling that issue). Many jurisdictions install pushbuttons by default, but the proper approach in a sustainable transportation mindset is to put pedestrian phases on recall by default, and only use actuation when strictly needed.

When actuation has to be used, there are ways to do so that will improve both perception and service for the pedestrian.

*Active or passive?*

The detection of pedestrians can either be active (requiring an action by the pedestrian) or passive (automated detection of the pedestrian). The most common form of active detection for pedestrian is the pole-mounted pushbutton.

*Pushbuttons*

The pedestrian pushbutton is a device that goes back all the way to the dawn of the modern traffic controller. Although the components evolved through the years, the basic action remains the same: push a button to get a pedestrian phase. Traditional mechanical actuators are still installed at thousands of intersections, but they are rapidly falling out of favour. These devices are subject to wear, vandalism or weather.

Most modern pushbuttons now feature pressure-sensitive piezos instead of springs and moving components. While more durable and resistant, these devices also have the advantage of allowing additional features, such as a vibrating tactile interface for APS systems (Accessible Pedestrian Signals) and / or confirmation LED lights. This last item is a most worthy addition to pedestrian pushbuttons. With it, pedestrians get confirmation that the phase was called, in an analogy to the buttons used to call an elevator. The elevator’s not there right now, but you know it’s coming to get you eventually – same with a pedestrian phase. These lights contribute to pedestrians conforming to the traffic signals, reducing jaywalking and increasing safety. Better conformity also means more efficient operation of the traffic signal system, actual and perceived. Confirmation lights for pushbuttons have been made mandatory in certain jurisdictions, like Quebec.

*Pressure mats*

Pressure mats are another form of active pedestrian detection; some may consider them as passive, but that is not quite correct. The pedestrian has to stand precisely on the mat to be detected. Usually, a sign or marking on the mat indicates where the pedestrian has to stand. This type of device is popular in Europe, but is seldom seen in the harsher climate of North-America.

*Passive actuation*

A truly passive pedestrian detector requires no action other than presence to call a pedestrian phase. Three families of devices cover passive detection: infrared, microwave and video. As with all ITS devices (Intelligent Transportation System), caution must be taken as to their effectiveness in specific applications.

*Infrared*

Infrared detectors basically take their technology from the devices that operate shopping center doors everywhere, but repackaged to be applied at pedestrian crossings. While simple enough, there is very little literature as to where they are being used. One possible explanation is the number of false calls to be expected.

*Microwave*

Microwave devices are derived from similar families of vehicle detectors. These detectors are at the heart of Britain's Puffin Crossings (see 3.6 below) and go a step beyond infrared technology. In a similar fashion to their vehicular use, they have the capacity to monitor a pedestrian's presence and progress in a crossing and extend the pedestrian phase accordingly (although this may interfere with the operation of a pedestrian countdown timer – see 3.3). Precaution should be used if a microwave detector is used to replace a pedestrian pushbutton; in vehicular applications, microwave detectors are know to "forget" a vehicle that is not moving at a stop bar. With vehicles, a minimum recall is used to circumnavigate this issue (the device being used to extend that minimum green time), but with pedestrian phases there is no such thing as a minimum recall.

Video

Video-based detection at intersections is the latest ITS tool directed at pedestrians. Just like with video vehicle detectors, virtual zones are set that will trigger a phase or action by the traffic controller. Outside of the roadway, however, the traditional limits of the technology are more readily apparent: moving shadows may trigger a call, or pedestrians standing in the shade may not trigger a call. Contrast is the issue, since video detection "reads" changes in pixels. Pedestrians don't have headlights, either, so night time detection relies on proper lighting of the detection area at the curb. Often, specific lighting is required when pedestrian video detection is used. Lately, products came to the market with specific engineering and design targeted at pedestrian detection.

While truly passive, this type of actuation is a very expensive alternative to pushbuttons.

### 3.2.2 Automatic pedestrian recall

Automatic recall of a pedestrian phase is just that – a pedestrian phase that is always serviced with no action or presence required by a pedestrian. Easily justified in dense urban areas, recalled pedestrian phases meet the expectations of citizens, and are the best representations of road safety manuals: pedestrians have priority, period.

This method doesn't have to be used at the expense of vehicular level of service. In many cases, the pedestrian phase can be concurrent to vehicular phases that run in parallel or outside of any potential conflicts.

Modern traffic controllers also allow custom parameters for pedestrian phase actuation. For example, a phase could be put in automatic recall during school hours, and then pushbutton-actuated in off hours if the area doesn't see regular pedestrian traffic.

Automatic recall of pedestrian phases is simple, does not require any expensive or maintenance-heavy devices and can be executed by any traffic controller, even old electro-mechanical units. It is at the same time the most basic and ultimate device in the practitioner's toolbox when pedestrians are the priority.

## 3.3 Pedestrian Countdown Timers

We have seen in Chapter 2 that the pedestrian signal head has retained the same basic concept for decades. The advent of the Pedestrian Countdown Timer (PCT) in the 1990's was the single, most important change to the "message" shown to pedestrians at traffic signals. Figure 3.1 shows a PCT in operation in Montreal.

**FIGURE 3.1: PEDESTRIAN COUNTDOWN TIMER IN MONTREAL (SOURCE: VILLE DE MONTRÉAL)**

We have already mentioned that the flashing red hand is the single most misunderstood traffic signal with the general population. The addition of the countdown helps in understanding that the flashing hand (or flashing "Don't Walk") indicates the time needed or remaining to cross the intersection. There is a tremendous added value in the PCT for the pedestrian: it gives him more information before he decides on making a crossing. For wide intersections, the PCT has an undeniable safety benefit (as mentioned in many studies, like Markowitz et al, 2006). Without it, the pedestrian has no indication regarding the amount of time he has to complete the crossing, either before engaging or during the crossing. With the PCT, the pedestrian is able to assess the situation and decide on making the crossing during the current FDW pedestrian phase, or to wait for the next Walk signal.

The first PCT was installed in Montreal following a tragic accident in the late ‘90s. A pedestrian failed to complete a wide crossing at a “T” intersection. Vehicles waited on the green signal for the pedestrian to finish the crossing, but due to vehicle occlusion at this four-lane approach, a driver proceeded through from the empty rightmost lane and fatally hit the pedestrian. Even though this intersection met all current standards at the time, its design did not forgive for such an occurrence.

As more installations were made in the field, PCTs proved to be very popular with the public. Their advantage is such that they were made mandatory for use at all pedestrian traffic signals in Quebec as per the provincial standards. The United States has now followed in the same lead, the 2009 edition of the MUTCD making the device mandatory for new signals or when refurbishing existing ones, while allowing a ten year conversion period.

Major Canadian cities like Ottawa or Toronto are also converting their pedestrian signal heads to PCT units, even though they are not mandatory. Surprisingly, they are still not that common elsewhere: New-York City got its first in 2006, while the United Kingdom only had its first installation in 2010.

Notwithstanding a practitioner’s preference for pedestrian phase actuation, the use of PCT is universal to any actuation method and is definitely a way to deliver walking-friendly infrastructures.

### 3.4 Animated Eyes Display

The first thing we are taught when introduced to the world of traffic is to look both ways before crossing the street. Apparently, as adults we still need a reminder to do so. In some intersections, the phasing will display an unprotected Walk indication, while pedestrians often think that they can cross unencumbered during that phase. Enter the Animated Eyes Display, as seen in Figure 3.2:

**Figure 3.2: Animated Eyes Display (source: www.walkinfo.org)**

This animated device was created exactly for that situation: the roving eyes above the Walk indication remind the pedestrian that he is not on a protected phase and that his path may be crossed by vehicles.

This device was the subject of an in-depth study by the Florida DOT (Department Of Transportation), conducted at eight intersections. The conclusions of the field tests were very supportive of the device, with conflict reduced to only 1 per 400 pedestrians from a total of 8.5 in the pre-test survey. These results are very significant, as Florida has some of the worst records of pedestrian crashes in the US.

Interestingly, this device can also be used to protect pedestrians by displaying it to motorists. A study by Van Houten et al has found that 14% of reported pedestrian crashes happen in private facilities. The Animated Eyes Display can be used at the exit of parking garages to remind drivers that pedestrians are present on both sides of the exit (Van Houten et al, 1999).

### 3.5 Scramble Crossing

Who is Mr. Barnes, and why is he dancing?

The Scramble Crossing, also know as a Diagonal or “X” crossing, is a pedestrian-only phase that also allows walking diagonally across the intersection, in addition to using the regular crossings. It appeared in Canada and the US in the 1940’s, but generally fell out of favour in the personal car boom of the 1950’s.

Perhaps the better-know name for this phase is the “Barnes Dance”. Henry Barnes doesn’t claim to have invented the measure, but he was a strong advocate of it and introduced it massively in his hometown of Denver, CO. One newspaper of the day claimed that “pedestrians were so happy they were dancing in the streets”, and the name Barnes Dance stuck for the next 70 years. Most intersections in Denver’s downtown core featured the measure.

This approach may not be universal, but it merits consideration when:

- pedestrian flow rates are important in all directions;
- sidewalk waiting areas are limited;
- few vehicular turns are needed at the intersection;
- major pedestrian generators are nearby (transit stations, shopping centers, etc.).

Stopping all vehicular traffic may be counter-intuitive for many practitioners, but when these conditions are present, a scramble phase is an efficient and above all safe way to service pedestrian demand while reducing or even eliminating all vehicle / pedestrian conflicts.

At the same time as walking became active transportation, there as been resurgence in interest for the Barnes Dance, under its modern Canadian name of Scramble Crossing. Toronto pioneered the revival locally in August 2008 at the corner of Dundas and Yonge (Figure 3.3), while Vancouver kept the concept in operation since its inception (even before Denver, in fact). Montreal has a pilot intersection planned in 2011 near the downtown core, and many sites are also in operation in the U.K. (since 2005), Australia and New-Zealand (since 1958). Let’s not forget the famous pedestrian crossing of Shibuya, Japan, where pedestrians literally invade the street.


**FIGURE 3.3: SCRAMBLE CROSSING PHASE AT DUNDAS AND YONGE, TORONTO (SOURCE: VILLE DE MONTRÉAL)**

Ironically, the city of Denver has removed all of its scramble crossings on May 14, 2011 because of the need to juggle with increasing demand for transit vehicle service. The era of pedestrians subordinating to motorists may be over, but with increased demand by transit and cyclists, there is competition at the curb.

## 3.6 Hawks, Pelicans and Puffins

Crossings for the birds? It seems the British with their legendary form of humour have taken a twist to the old “Why did the chicken cross the road?” joke, and named innovative crosswalk operating schemes after birds. The Americans followed with a bird of prey of their own.

### 3.6.1 PELICAN and HAWK

The Pelican acronym stands for PEdestrain LIght ActivatioN crossing. It is a mid-block crossing equipped with a complete traffic signal system. However, unlike a half-signal, there are no vehicular secondary approaches, as seen in Figure 3.4. As the name implies, pedestrians activate a signal change through actuation. Vehicles on the roadway get the yellow, followed by the red, after which the Walk interval is granted to the pedestrian. If a central divider island with refuge is present, the crossing can be staged and successive actuation is needed to complete the crossings.

In the U.K., where the “Pelican” acronym is actively used, vehicles get a flashing amber signal during the pedestrian clearance, allowing them to proceed safely if pedestrians aren’t present in the crossing. By British law, a Pelican crossing must be completed in a single stage, even if there is a central divider island. Depending on pedestrian volume, more variations on the Pelican can be found. Montreal, for example, is operating single-stage crossings on automatic recall that don’t create any delays since they are synchronised with the traffic light network. Regular Pelicans can be synchronised or free depending on location. They minimize delay for pedestrians and offer the recognized safety of regular traffic lights.

FIGURE 3.4: PELICAN CROSSING IN BOUCHERVILLE QC (SOURCE : GOOGLE MAPS STREET VIEW)

The HAWK (High intensity Activated crossWalK) is similar in function, if not in hardware. The regular traffic signals are replaced with dual yellows and a red. Upon pedestrian actuation, the yellows flash, followed by an indication advising motorists to stop. The signal changes to solid red when pedestrians are shown their Walk signal. The red begins to flash when vehicles are allowed to move again. This device is mostly seen in the southern part of the US where it was invented, and has mixed reviews from its unconventional approach to signals.

### 3.6.2 PUFFIN

The Pedestrian User Friendly Intelligent Crossing (known by its acronym "PUFFIN") is Britain's most popular crossing treatment. Its basic idea is to extend the pedestrian signal when pedestrians are present in the street. The Puffin is actuated via a pushbutton, but on-crossing pedestrian detectors are used to monitor pedestrians in the crossing, and stop the phase once the crossing has been cleared. Therefore, it has no preset value set for the crossing time, and as such does not use a conventional pedestrian signal head. Instead, they feature a smaller pedestrian signal installed nearside over the pushbutton, as seen in Figure 3.5. It displays green man and red man pictograms that are standardized in the United Kingdom.


FIGURE 3.5: PUFFIN CROSSING SIGNAL HEAD AND PUSHBUTTON
(SOURCE: WWW.WIKIPEDIA.ORG)

The nearside pedestrian signal heads and the regular operation of the vehicular tri-color signals are the main differences between Puffins and Pelicans, on top of the in-crossing detection.

An American variation called the “baby Puffin” consists of handing remote control of the traffic signals to school crossing guards, freezing the traffic lights when children are crossing the street. By its nature, the Puffin is not compatible with synchronized traffic light networks as holding a phase removes any notion of fixed cycles and offsets. Limited to the United Kingdom, the Puffin doesn’t conform to North-American standards and also now faces a threat for its survival in the form of the pedestrian countdown timer. Indeed, the popular PCT is not able to work without a fixed operating time, as it displays a time computed from the previous phase. If that phase varies in time, the countdown display will be erratic, blank or fixed at “00”.

### 3.7 Through Arrow Leading Walk Interval (“Montreal Ped Advance”)

The theme of TAC’s 2011 Annual Conference is “*Transportation Successes: Let’s Build on Them*”, and for Montreal the Through Arrow Leading Walk Interval (TALWI) is most definitely a great operating success.

*Safety issue*

Motorists in Quebec aren’t known for their patience, and in a bustling metropolis like Montreal, many transportation modes are in competition or conflict, with tremendous movements being generated at all times. The city’s tight historical street grid, combined with on-street parking and delivery zones does little to help traffic flow. This climate led to an increase of disrespect for pedestrian priority at traffic signals. When pedestrians are curbed by heavy turning traffic flow, they tend to jaywalk to compensate for the lost crossing opportunities. By the middle of the1980’s, pedestrian accidents had reached an unacceptable level.

*Making pedestrian priority active*

Elected officials demanded that the city’s traffic department find a way to induce pedestrian priority at intersections while not stalling traffic (like exclusive phases do). Pedestrian priority is a law, but a law is only a passive measure if it not enforced and respected. What the engineers did was turn the passive “yield to pedestrian” law into an active measure by holding turning traffic while allowing through movements. At most intersections, the through movements are the most important, and they are not in conflict with parallel pedestrian crossings. The idea was to give pedestrians a head start on turning traffic. The TALWI, or what suppliers are now calling the “Montreal Ped Advance”, was born.

*How it is done*

The TALWI needs to display a through arrow in addition to the regular green signals that are present at the intersection. If a green ball is used, then a through arrow lens of the same diameter is installed below the green ball, as in Figure 3.6, or to its right in the case of horizontal signal heads. The balls and the arrows have to be wired separately so that they can be controlled by specific phases. When using only arrowheads in a signal head, then the through arrow needs to be wired distinctly so that it can be operated apart from the right-turn arrow.

The through arrow lenses have to be installed in every signal head that service through movements, shared or not. Complete pedestrian signal heads are needed. The through arrows are operated during the Walk interval, for part or all of its length, as desired. The signal heads that operate turning movements remain on the red ball for the duration of the TALWI. Typical use in Montreal is to have a 9s TALWI before turning movements are allowed. When protected left turns are used, they need to be lagging instead of leading, so caution needs to be used to avoid “yellow-trap” type conflicts.

*Controller hardware needed*

You don’t need a state-of-the-art traffic controller to operate a TALWI intersection. In fact, Montreal developed the measure while it still had over a thousand electro-mechanical traffic controllers in the field. Most modern NEMA TS1, TS2 and ATC controllers are able to operate the measure. The TALWI is operated on Montreal’s Econolite and PEEK controllers, but past experience has shown that some suppliers (Eagle / Siemens) have difficulty operating it, since the measure is not standard NEMA protocol. Software development may be needed with CALTRANS controllers.


**FIGURE 3.6: TALWI DISPLAYED IN DOWNTOWN MONTREAL (SOURCE: VILLE DE MONTRÉAL)**

*TALWI and actuation*

When pedestrian actuation is used, the TALWI won’t be displayed unless the pedestrian phase has been actuated (only the green ball will show). Vehicular detection does not affect the TALWI either: if vehicle detection is used to call a phase, then pedestrian actuation is also present at the intersection. Another option is to use pedestrian recall, but through detection extend the green ball beyond the minimal pedestrian time. Thus, the measure does not limit flexibility for practitioners when they design an intersection program.

*Intersection layout*

Some layouts are more compatible with a TALWI than others. For example, a one-lane approach that allows turns will be more impacted by the measure than a wide approach with turning lanes (in that case, a leading Walk interval might be a better choice). In Montreal, the typical approach has prohibited left turns during the day, at least one through lane and a nearside bus stop that forms a 30m right turn lane. This made for a smooth integration of TALWI at all intersections.

*Giving an Edge to Pedestrians*

With TALWI, the pedestrian takes precedence over adjacent turning traffic, giving him a clear priority through the crossing. The lead time is usually sufficient to enable the pedestrian to clear the conflict zone from nearby right turns and conflicting permissive left turns (if any). For the pedestrian walking counter-traffic, the TALWI leads him into the field of view of upcoming turning vehicles, helping conspicuity and eye contact, both beneficial to safety.

*Results that speak*

Following a vast implementation of TALWI throughout its traffic-light controlled intersections, Montreal saw a reduction of 50% for pedestrian accidents at traffic signals (from internal unpublished data, circa 1990). The measure also got good reviews from associations representing the visually impaired, as their members are able to guide themselves with the sound of parallel traffic moving during the “through” phase. In addition to Montreal, the TALWI can be seen in action in Ottawa, Toronto, Burlington and Calgary.

### 3.7 Leading Pedestrian Interval (“Red Advance”)

The Leading Pedestrian Interval (LPI) is a simple treatment that achieves part of the goals targeted with the more complex TALWI. The LPI is a delay applied to the vehicular green upon starting the Walk phase. It addresses the same age-old issue as the TALWI: conflicts between turning vehicles and pedestrians. It is sometimes called a “red advance” as pedestrians can move on the red signal.

*Making pedestrian priority active*

The LPI allows pedestrians to take to the street before vehicles do. While all vehicular traffic sits on the red signal, the Walk interval is shown and pedestrians begin their crossing without any conflicts during its activation. The measure clearly offers a pedestrian priority.

*How it is done*

A simple programmed phase or function (depending on controller hardware) is used to “hold” the green signal during part or all of the pedestrian Walk interval. No special signal heads are needed, other than standard pedestrian signals. Pedestrian actuation of the measure is possible. The typical delay used in a LPI measure is three to four seconds, while some jurisdictions like Montreal have used a standardized value of nine seconds for many years. Practitioners have to select the proper delay to use according to conditions.

*Controller hardware needed and actuation*

Nothing special is needed as the LPI is a standard NEMA function. It is also compatible with older electro-mechanical controllers. Software development may be needed with CALTRANS controllers. When pedestrian actuation is present, no delay is given when servicing the green phase.

*Intersection layout*

The LPI is favoured over the TALWI when most vehicular movements are of the turning kind. The leg of a "T" intersection is the most frequent application of an LPI phase, because all vehicular movements are in conflict with pedestrians. It can also be a beneficial treatment at unconventional intersections where pedestrians are partly obscured from view.

*Giving an Edge to Pedestrians*

The LPI is a lighter form of TALWI, easily implemented with the hardware most jurisdictions already have in the street, and at no cost as a bonus. It is perhaps the first step in offering active pedestrian priority, a "soft" measure that takes away very little from motorists, basically using the displays to enforce pedestrian priority.

Not ideal in all situations, the LPI might not be the best choice if through movements are as strong as turning movements, or if visually impaired pedestrians are using the crossing. With the LPI, no vehicular sounds are available to guide these vulnerable pedestrians.

## 3.8 Walk Phase Extension

When pedestrian phases are put on automatic recall, what often happens is that once the Don't Walk phase is serviced, the remaining green time is wasted for pedestrians as only the fixed red hand (or Don't Walk) is displayed. All too common, this operating mode is a source of frustration for pedestrians, sending the message that once minimum pedestrian time is serviced, vehicles have the priority.

With modern traffic controllers, it is possible to extend the pedestrian phase to the entire length of the green signal.

*How it works*

The FDW phase needs to use a fixed time, as it is used to display the time needed to physically cross the street. However, the Walk phase has no fixed duration, only minimums that need to be respected. The Walk Phase Extension, in non-actuated signals, will compute the amount of extra green time that exists between the minimum pedestrian time and the beginning of the yellow change interval. It will automatically add these seconds to the Walk phase, beyond the minimum time programmed for that phase. The function will adapt to all split combinations that are called by the different schedules programmed into the controller.

*Will it work with a PCT?*

Yes, if the countdown is operated as per the TAC standard. With the countdown only displaying the fixed portion of the crossing time (the FDW phase), it is not affected by an extension of the Walk phase as it is blank at that moment.

*Will it work with actuation?*

No. When vehicular actuation is present, the total green time can't be predicted by the traffic controller. Also, when pedestrian actuation is used, it often means that there is a low volume of pedestrians, and / or an actuated vehicular phase in parallel. As such, there is no need for a Walk phase extension.

*What are the main benefits?*

Removing the combination of a green signal and a fixed "Don't Walk" gives the pedestrian a clear message that he is welcomed at this crossing, that priority is actively displayed by the "Walk" indication, and finally that the jurisdiction cares for pedestrians. Giving pedestrians the fixed "Don't Walk" signal while the motorists are getting a full green is a source of frustration, and that may induce jaywalking.

Practitioners often use minimum pedestrian time for settings with no second thought, but in this age of sustainable transportation, extending the Walk interval really gives pedestrian a perceived and very real advantage at intersections. Best of all: this measure is free, only requiring the activation of the required functions if the traffic controller offers them.

## Conclusions

We have learned from history that the very first traffic signal was designed in great part to protect pedestrians from horse-drawn vehicle traffic. As traffic control methods evolved from that point up to the onset of World War Two, practitioners and suppliers converged towards a pedestrian signal displaying the now common Walk and Don't Walk phases. The following decades were marked by an automobile boom where little progress was made regarding pedestrian traffic control. Once electronic traffic control became the standard, more pedestrian-friendly measures appeared in the practitioner's toolbox.

From a global planning perspective, transit projects are taking a big share of the limelight these days, and the promotion of active transportation by big cities adds commuting cyclists to the mix on the roadway. For the traffic practitioner, the expression "urban jungle" fully applies. With all the sustainable competition for transportation infrastructures, pedestrians are often left on the sidewalk with a small share of the transportation pie.

The measures presented in this paper all help in making walking a safe and efficient transportation mode. They send a message to pedestrians that they are an important part of the equation when decisions are made on the design of a traffic signal. Some measures like the Leading Pedestrian Interval and the Walk Phase Extension are simple to implement at virtually no cost for the jurisdictions. Others like the Through Arrow Leading Walk Interval send a clear message that walking is a priority, and not just from a passive legal point of view.

Walking into the future, ITS devices will render the pedestrian pushbutton obsolete and intersections will "see" walkers as they approach a crossing, grant them their phase and extend it as needed. In the traffic engineering field, getting the basics right results in timeless solutions to recurring problems. The triumphant return of the Scramble Phase, first displayed in Dr. Harriss' 1934 prototype display and perfected by Henry Barnes in 1940, illustrates that principle in most sustainable way.

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