

Pedestrian Scramble Crossings – A Tale of Two Cities

by

Rajnath Bissessar, City of Toronto

&

Craig Tonder, City of Calgary

ABSTRACT

Pedestrian Scramble crossings (also called “exclusive pedestrian phase” or “pedestrian criss-cross”) have been used in a number of cities around the world to enhance the safety and mobility of pedestrians at signalized intersections. A dedicated phase for pedestrians allows them to cross in any direction, including diagonally, without coming into conflict with turning vehicles. In 2008, both Calgary and Toronto implemented pedestrian scramble phases at select downtown intersections. While pedestrian safety can be enhanced, other operational problems can arise, particularly for blind and visually impaired pedestrians who use guide dogs and/or the sound of traffic as cues to cross the intersection. This paper will outline the justification and analysis prepared in advance of the installations, along with the implementation process, including stakeholder consultation, design and education. The paper will also discuss the similarities and differences in the approaches adopted by Calgary and Toronto. Finally, the paper will discuss the findings from the evaluation studies completed for each project.

1. INTRODUCTION

A pedestrian scramble phase is a traffic signal phase that provides pedestrians with exclusive access to a signalized intersection while vehicular traffic is stopped in all directions. This form of phasing is useful at intersections with heavy pedestrian traffic and vehicle turning volumes as it serves to reduce vehicle-pedestrian conflicts by providing exclusive phases for pedestrians, and sometimes, for motorists. A scramble phase is generally displayed as a red signal in all directions for vehicles in conjunction with the “Walk” display in all directions for pedestrians.

In some instances, scramble phasing has proven to be unsuccessful due to severe reductions in capacity for vehicular movements because of the longer cycle length required. In addition, there was reluctance on the part of many pedestrians to obey the “Don’t Walk” indications during the vehicle phases, which resulted in considerable confusion among both drivers and pedestrians. Since there are no pedestrian/vehicle conflict points with a pedestrian scramble phase, the presence of this phasing is associated with significantly lower pedestrian collisions, particularly for locations that have moderate-to-high pedestrian volumes.

Pedestrian scramble phasing is also commonly referred to as “exclusive pedestrian phase”, “pedestrian criss-cross”, “scramble lights”, “scatter lights”, “scramble corners” and “Barnes Dance”. The last mentioned terminology is named after Henry Barnes, the prominent traffic engineer, who is credited to be the first to use the system in Kansas City (Kansas) and Vancouver (Washington) and then later in Denver (Colorado), Baltimore (Maryland) and New York City (New York). The terminology came from an article written by a reporter who stated “Barnes had made the people so happy they’re dancing in the streets”.

Pedestrian scramble phasing is one of the enhanced pedestrian features for traffic control signals identified in Toronto’s “Steps Towards a Walkable City¹”. City Council, at its meeting on October 22 and 23, 2007 approved the introduction of “pedestrian scramble phases (Barnes’ dance) at appropriate locations on a pilot project basis²”. The intersections chosen were Bloor Street/Bay Street, Bloor Street/Yonge Street, Yonge Street/Dundas Street and Bay Street/Dundas Street – all four intersections are in the downtown core. It was decided that the Yonge Street/Dundas Street intersection would be installed first because of planned reconstruction at the other three intersections; the implementation occurred on August 28, 2008. The Yonge Street/Dundas Street intersection has a four-lane cross-section on Yonge Street and Dundas; the inner eastbound and westbound lanes on Dundas Street are occupied by streetcar tracks on which both streetcars and mixed traffic are allowed.

In Calgary, there were a number of Aldermen who were interested in pedestrian scramble phasing and wanted to bring this type of control to the city. The Transportation Department took the initiative to identify and review several candidate locations before deciding upon two locations in the Eau Claire Market area, a pedestrian-oriented shopping area that is adjacent to the city’s river pathway system. The intersections attract a high number of walkers and joggers. In pedestrian counts taken before the launch of the project, the intersections were averaging about 6,000 pedestrians each during the peak six hours of the day. On May 12, 2008, the City of Calgary implemented scramble phasing at the 3 Street /2 Avenue SW and 3 Street/3 Avenue SW intersections. Both intersections have a two-lane cross-section in the east-west and north-south directions.

2. TERMINOLOGY

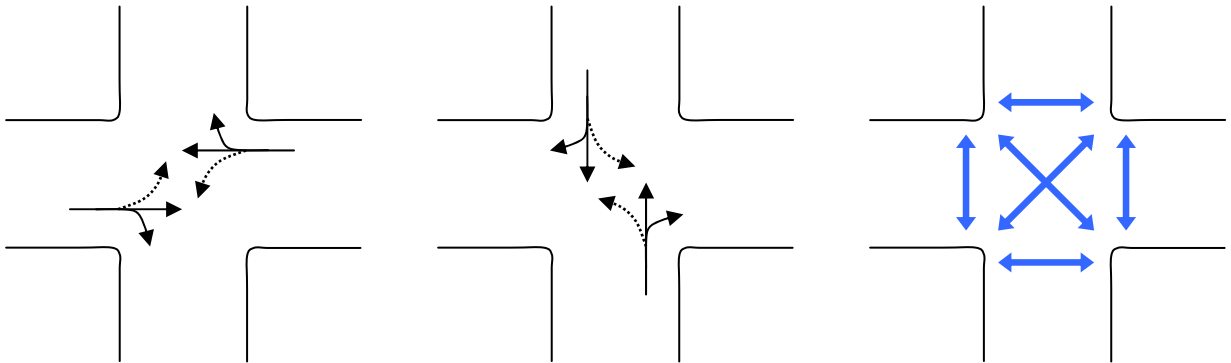
In Toronto and Calgary there was much debate on the terminology to be adopted. Toronto staff initially suggested that the feature be called “pedestrian scramble phasing” or “exclusive pedestrian phasing”.

Senior staff did not like the term “scramble” since it seemed to imply that pedestrians had to rush to get across the intersection. It was decided that a more appropriate term would be “pedestrian priority phasing” since this term conveyed the message that this intersection would be different in that pedestrians would have priority over all other users. Senior staff in Calgary wanted to provide a “brand” name for this type of control that was “exciting” and unique to the City of Calgary. After discussing a number of options, Calgary’s Transportation Department decided that “pedestrian criss-cross” would be the name used in Calgary because it provided clear indication that pedestrians were permitted to cross diagonally. For the purposes of this paper, “pedestrian priority phasing” and “pedestrian criss-cross” will be referred to by the more common name “pedestrian scramble phasing”.

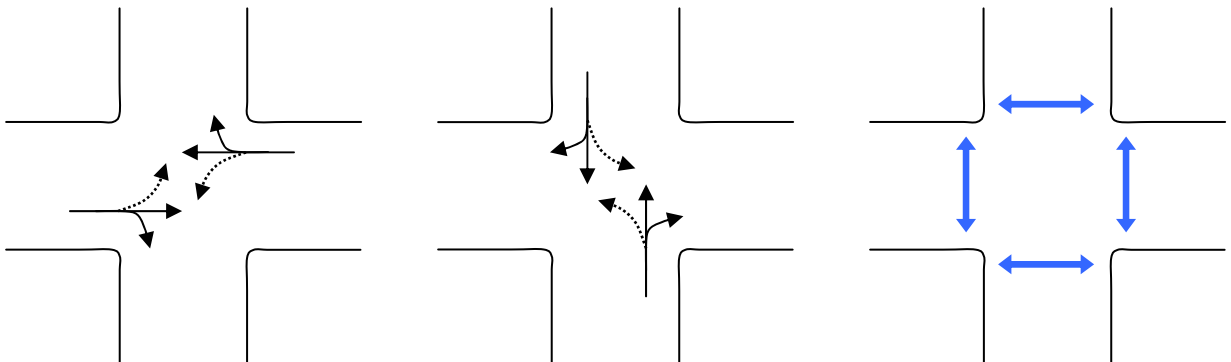
3. CHOICE OF TYPE

There are three types of pedestrian scramble phasing:

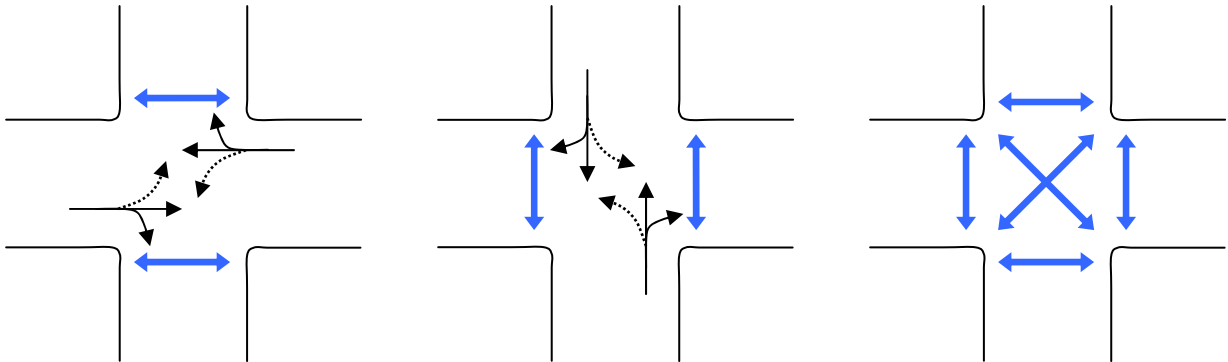
- Type A: Pedestrians are provided with exclusive access to a signalized intersection by allowing conventional (north-south & east-west) as well as diagonal crossing across the intersection while vehicular traffic is stopped on all approaches. After the pedestrians cross, vehicle traffic in one direction will get a green light, while all four pedestrian signals will show the “Do Not Walk” signal. Finally, in the third phase traffic in the other direction will be given a green light with the pedestrian signals still showing “Do Not Walk”.



- Type B: Pedestrians are not allowed to cross diagonally; they are only allowed to cross parallel to the roadways while vehicular traffic is stopped.



- Type C: Type C is similar to type A except that pedestrians are also allowed to cross concurrent with parallel traffic on the vehicle green.



Type A is the most commonly used method where pedestrian safety is paramount and there is sufficient sidewalk space to allow pedestrian circulation and also to store pedestrians waiting to cross the street. Calgary opted for this type at both its intersections.

Type B is used for intersections where there is a need to maintain current cycle lengths or to operate intersections at low cycle lengths.

Type C is used where there is a large volume of pedestrians, there is a lack of sidewalk space, pedestrians would not wait and where there are concerns for the safety of visually impaired pedestrians. The pedestrian area requirements at street corners can be calculated using the methodology in the Highway Capacity Manual (Section 18-10). Toronto adopted Type C because of storage problems on the north-west corner of the Yonge Street/Dundas Street intersection. There were concerns that pedestrians would spill over onto Dundas Street if additional opportunities were not provided for pedestrians to also move concurrent with the east-west and north-south traffic.

4. CRITERIA

Since Toronto has many intersections with very high volumes of pedestrian traffic, it was felt that pedestrian volume and crossing behaviour should dictate the type of pedestrian scramble phase that is implemented. Toronto established the following criteria:

- High pedestrian volumes average > 3,000 pedestrians per hour for an eight hour period (*Condition 1*).
- Moderate pedestrian volumes average >2000 pedestrians per hour for an eight hour period (*Condition 2*).
- High turning vehicle volumes > 35 % of total vehicular approach volume (*Condition 3*).
- High concentration of pedestrian-vehicle collisions > three left-turn and right-turn collisions where pedestrians had the right-of way over a three year period (*Condition 4*).
- There is a desire by at least 15% of pedestrians to cross diagonally (*Condition 5*).
- Unusual intersection geometry (five or more legs) that precludes normal pedestrian crossing operation (*Condition 6*).

The following sole conditions or combination of conditions would justify the installation of exclusive pedestrian phasing in Toronto:

- Condition 1.

- Conditions 2 and 3.
- Conditions 2 and 4.
- Conditions 2 and 5.
- Condition 6.

For Condition 5, a pedestrian survey will be required to determine the percentage of pedestrians that plan to cross diagonally. The installation at Yonge Street/Dundas Street in Toronto was justified based on Condition 1.

The 3 Street /2 Avenue SW and 3 Street/3 Avenue SW intersections in Calgary were selected for the following reasons:

- High volume of pedestrians (up to 2,000 pedestrians per hour during the noon peak hour).
- Low vehicle traffic volumes relative to other intersections in the downtown core.
- Narrow roadway cross-section at both intersections (two lane, two-way traffic).
- Two phase traffic signal operation.
- Both intersections were expected to operate at acceptable Levels of Service (LOS) after implementation (LOS C-D in the morning and afternoon peak periods).
- Eau Claire Market and Barclay Mall (3 Street W) are pedestrian oriented areas.

5. COMMUNICATIONS

In order to educate the public about the operation of scramble phasing in Toronto, the City took several measures to ensure that the public was informed of the new operations in the days leading up to implementation. City staff met with the Canadian National Institute for the Blind (CNIB) and the Toronto Transit Commission (TTC) several weeks before installation, since they would be the most affected by the implementation. A Briefing Note was circulated to the Mayor and City Council two weeks before implementation. A Technical Briefing was provided to the local Business Improvement Area (BIA) Committee, Toronto Police Service, Toronto Fire, Toronto Emergency Medical Services (EMS) a week prior to the installation. A News Release and a Media Advisory were issued in the week leading up to the installation and information regarding the scramble phasing was posted on the City of Toronto website. The media was invited to the opening ceremony on August 28, 2008; several members of City Council were present. On August 28 there was extensive coverage of the planned scramble phasing in the local and national media. This coverage continued on August 29 and the following week. On the opening day, Toronto arranged for police officers to be present at the four corners of the intersection from 8:00 a.m. on August 28 to 1:00 a.m. the following day to ensure that pedestrians and motorists obeyed their signals. City staff was present from 8:00 a.m. to 5:00 p.m. on August 28 as ‘ambassadors’ to answer questions from the public as well as to encourage pedestrians to cross diagonally.

Similar to Toronto, the City of Calgary distributed a technical briefing to local businesses, Alderman, and various internal and external agencies to outline the benefits of pedestrian scramble operations. The City met with various stakeholders including the Calgary Downtown Association (CDA) and CNIB to discuss the project and address any concerns. For the first three days of operation, City staff were present at both

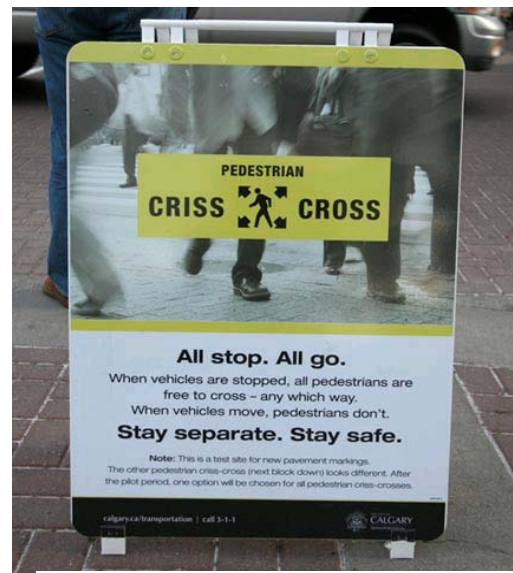


Fig. 1 – Temporary Poster Board at 3 Street/2 Avenue SW in Calgary

scramble locations during the morning, afternoon and noon peak periods. In addition to walking with pedestrians during the pedestrian phase, staff handed out brochures to pedestrians, cyclists, and motorists informing them of the change in traffic control, the rules and responsibilities, and general information about how both intersections operate. Temporary poster boards were also placed at all four corners of both intersections explaining the new signal and pedestrian phasing operations. Senior staff and local Ward Alderman were present for a ribbon cutting ceremony on opening day. Similar to Toronto, there was extensive local and national coverage on television, radio and the press on the opening day and on the day following the event. Calgary also posted the pedestrian scramble phasing brochure, pedestrian scramble video and a pedestrian scramble opening ceremony video on its website³.

6. SIGNS

Instead of using the standard sign (Fig. 2) used in the United States, Toronto decided to use the “Priority Crossing” sign shown in Fig. 3. Instead of placing the signs on the posts, Toronto opted to place the “Priority Crossing” signs on the opposite ends of the diagonal crosswalks. Also, Toronto opted to place “Pedestrian Priority Crossing Ahead” warning signs (Fig. 4) on the four approaches to warn drivers of the new operations.



Fig. 2 - “Diagonal Crossing OK” Sign Used in the U.S.



Fig. 3 - “Priority Crossing” Sign used in Toronto



Fig. 4 – “Pedestrian Priority Crossing Ahead” Sign used in Toronto

Calgary developed its own signs (Fig. 5) which were installed on existing posts at the four corners of the intersections. Due to the amount of information, size, colour, and placement of these signs, Calgary has received some complaints from pedestrians who indicate that the signs are not readily noticeable. Calgary is reviewing the signage provided at the intersections and may modify the signs later this year. Calgary opted not to provide advance warning signs for motorists. However, it may consider such signage at future locations, where feasible.



Fig. 5 – Pedestrian Information Sign Used in Calgary

7. ROAD MARKINGS

After consideration of the three options shown in Appendix A, Toronto chose option 3. This option was chosen because it was felt that the overhead signs and the additional pedestrian heads would provide enough guidance and direction. Also option 3 was the cheapest.

Calgary used a variation of Option 1 (without the zebra markings and with full diagonal lines) at the 3 Street/2 Avenue SW intersection (Fig 9), and a variation of option 3 (without the zebra markings) at the 3 Street/3 Avenue SW intersection. After an evaluation of both marking schemes, Calgary concluded that the full diagonal road markings conveyed a clearer message, particularly to motorists, that there is a pedestrian scramble phase present, or at the very least, a different form of traffic control at the intersection. Also, pedestrian and motorist compliance rates appeared to be better at the intersection with the full diagonal markings.



Fig. 6 – Road Markings used in Toronto

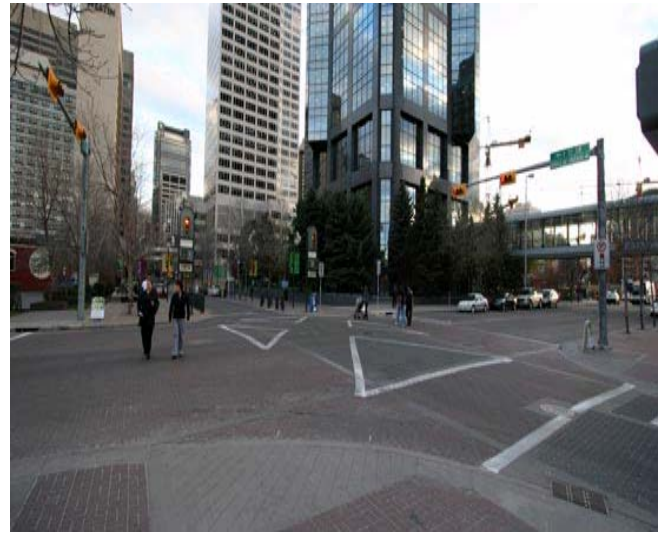


Fig. 7 – Road Markings used in Calgary at the 3 Street/2 Avenue SW intersection

8. PEDESTRIAN HEADS & COUNTDOWN TIMERS



Fig. 8 – Diagonal Pedestrian Heads & Countdown Timers in Toronto



Fig. 9 – Signal Structures on 3 Avenue SW in Calgary

Toronto decided that a pedestrian signal head (Fig 6) should face each direction of pedestrian movement to ensure pedestrian compliance with the pedestrian scramble phasing and to provide positive guidance to pedestrians who wish to cross diagonally. Therefore, four additional pedestrian signal heads were installed. As per current City policy, pedestrian countdown timers were also installed to countdown only during the “Flashing Don’t Walk (FDW)” interval. Since the FDW duration is based on the length of the crosswalk, the FDW value for the diagonal crossing is greater than the FDW value for the conventional north-south and east-west crossings.

Calgary decided that diagonal pedestrian signal heads were not required since the cross section for 3 Street was narrow enough (1 x 3.0m lane in each direction) so that the existing pedestrian heads were clearly visible from all corners. Also, the existing signal structures at Calgary’s two intersections could not be easily modified to accept additional pedestrian signal heads and pedestrian countdown timers. Since the structures are scheduled for replacement in the next few years, it was decided not to include additional pedestrian heads and countdown timers at implementation. However, based on Calgary’s experience, it is believed that countdown timers may be beneficial at pedestrian scramble phasing locations to provide a greater degree of comfort for pedestrians who cross diagonally.

9. ACCESSIBLE PEDESTRIAN SIGNALS (APS)

The CNIB and Toronto’s APS Advisory Group expressed some concerns about the installation of scramble phasing in Toronto. Their main concern was that blind and visually impaired people use the

parallel-moving sound of cars and pedestrians as a cue to keep them heading in the right direction; at a scramble intersection there is no moving noise and the sound and bodies of pedestrians moving in all directions is confusing, even to guide dogs. Further, there is concern that guide dogs may inadvertently lead visually impaired pedestrians diagonally through other intersections where there is no scramble phasing. Other concerns related to the following:

- Need for tactile way finding.
- Crowding of pedestrians around APS buttons making it difficult to access.
- Lack of distinct north-south vs. east-west tones that should be different from the tones used at a conventional intersection.

After much stakeholder discussions, the APS was set up to operate as follows:

- Phase A (scramble phase): voice message "Walk sign is on for all crossings" is repeated twice during the "Walk" interval.
- Phase B (north-south phase): "Cuckoo" APS tone is on during north-south "Walk" interval.
- Phase C (east-west phase): "Chirp" APS tone is on during east-west "Walk" interval.

Calgary did not provide any verbal messaging during the pedestrian scramble phase. Instead, Calgary provided a "chirp" tone during the pedestrian scramble phase for the east-west pedestrian crossing in one cycle and then provided a "cuckoo" tone during the pedestrian scramble phase for the north-south crossing during the subsequent cycle. In addition to the similar concerns received by Toronto, Calgary received inquiries from visually impaired pedestrians who expressed concern about the following:

- Visually impaired pedestrians who do not want to cross diagonally are required to cross over two cycles.
- Audible signals were not loud enough.
- There is no notification for the visually impaired as they approach these intersections to indicate that these intersections operate differently than other intersections in Calgary. Visually impaired continue to cross on green with vehicle traffic.

Toronto's APS operate fixed (comes up every cycle) on a 24/7 basis and adjusts to ambient sound levels. Initially, Calgary operated its APS similar to Toronto. However, in response to concerns from a nearby hotel about the APS tones affecting its guests at night, the APS signals at the 3 Street/2 Avenue intersection of were turned off from 11:00 pm to 6:00 am every day.

10. SIGNAL TIMING CHANGES

On implementation of scramble phasing in Toronto, the cycle length at the Yonge Street/Dundas Street intersection was increased from 70 to 85 seconds in the morning and afternoon peak periods and from 60 to 85 seconds in the off-peak period to accommodate the longer crossing time required for the diagonal crossing. The diagonal FDW was 20 seconds and is based on the city's new pedestrian timing practice whereby the FDW is based on the full crossing at a walk speed of 1.2 m/s. The previous north-south and east-west FDW were 13 seconds. Soon after implementation of the pedestrian scramble phasing, Toronto increased the afternoon peak cycle length from 85 to 90 seconds in reaction to complaints of eastbound congestion in the weekday afternoon peak period. The additional five seconds was allocated to the east-west green phase.

Table 1 – Change in vehicle green time per hour

Period	CL (secs)		N-S Vehicle Green Before/After				E-W Vehicle Green Before/After				Total N-S & E-W Veh Green Before/After			
			per cycle (secs)		% per hour		per cycle (secs)		% per hour		per cycle (secs)		% per hour	
	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
AM	70	85	29	21	41	25	29	21	41	25	58	42	82	50
OFF	60	85	25	21	42	25	23	21	38	25	48	42	80	50
PM	70	90	22	21	31	23	36	26	51	29	58	47	82	52

The amount of green time provided for vehicles per hour at this intersection has decreased substantially with the installation of pedestrian scramble phasing. Table 1 shows the percentage of vehicle green time per hour was reduced from approximately 80% before the installation to about 50% after the installation.

Before the implementation of scramble phasing at the Yonge Street/Dundas Street intersection, signals on Yonge Street were coordinated from College Street to Front Street at 70 seconds cycle length in the morning and afternoon peak periods and at 60 seconds in the off-peak period. With the implementation of scramble phasing, it was decided that Yonge Street/Dundas Street intersection would operate in isolation, thereby breaking up the previous control area into two control areas – one to the north with three signals and the other to the south with eight signals. Before the implementation of scramble phasing, the Yonge Street/Dundas Street intersection was always coordinated with the Dundas Street/Victoria Street intersection because this signal is only 100 metres away. With the implementation of scramble phasing, the Dundas Street/Victoria Street intersection was no longer coordinated with the Yonge Street/Dundas Street intersection. However, in response to driver complaints, the cycle length at the Dundas Street/Victoria Street intersection was increased to match the cycle at Yonge Street/Dundas Street intersection in all periods and coordinated with the Yonge Street/Dundas Street intersection.

Although the two locations in downtown Calgary were coordinated with the rest of the downtown signals prior to implementing scramble control, the decision was made to reduce the cycle lengths at the scramble locations to minimize pedestrian and vehicle delay. Therefore the two signals were taken out of coordination with the rest of downtown signals. This was not a serious concern, however, as the two intersections have lower daily traffic volumes relative to other intersections in the core, and are not located along a corridor where coordination is important. It was felt that minimizing delay for pedestrians was more important than providing coordination through these intersections. While other downtown signals operate with a 90 second cycle length at all times of day, the scramble locations operate with a 75 second cycle length in the morning peak period, 65 second cycle length in the off peak period, and a 90 second cycle length in the afternoon peak period.

Staff, at a hotel located on the northwest corner of the 3 Street/2 Avenue SW intersection, contacted Calgary staff to express concern that the pedestrian scramble phasing had created additional delays to eastbound and westbound motorists and was having a negative impact on the hotel’s valet parking service. In an effort to address this concern, Calgary increased the cycle length from 65 to 70 seconds at the 3 Street /2 Avenue SW intersection on weekends and allocated the additional five seconds to east-west green.

11. DATA COLLECTION AND EVALUATION

Below is a brief summary of the data collected and analyses performed for the Yonge Street/Dundas Street intersection:

- Vehicle, pedestrian, and transit volumes were recorded during the morning peak, afternoon peak, and noon periods before and after implementation.
- A micro-simulation analysis using Synchro 7.0 was performed to identify operational impacts.
- Pedestrians crossing diagonally were recorded after implementation.
- Pedestrian violations were recorded before and after implementation.
- City staff conducted pedestrian surveys on site three months after implementation to gauge public reaction to the scramble control. The three month period was chosen because pedestrians and drivers would be familiar with the operation and the survey results would be more reflective of normal pedestrian/driver behaviour.
- Transit delay was measured before and after pedestrian scramble phasing implementation.
- Survey of pedestrians at the Yonge Street/Dundas Street after implementation.
- Survey of responses on Internet sites after implementation.

Below is a brief summary of the data collected and analyses performed on both intersections in Calgary:

- Vehicle, pedestrian, and cyclist traffic volumes were recorded during the morning peak, afternoon peak and noon peak periods before and after implementation.
- A micro-simulation analysis using Synchro 7.0 was performed on both intersections to identify operational impacts.
- Pedestrians crossing two legs of an intersection were recorded before implementation, and pedestrians crossing diagonally were recorded after implementation.
- Pedestrian, vehicle and cyclist violations were recorded before and after implementation.
- University of Calgary students conducted pedestrian surveys one month after implementation at both locations and online to gauge public reaction.
- Complaints to the 311 Call Centre were reviewed and categorised.

11.1 Vehicle Counts

Vehicle volumes were measured on the approaches to the Yonge Street/Dundas Street intersection using automatic traffic counting equipment for a three day period before and after implementation of the pedestrian scramble phasing. The “before” 24 hour vehicle volumes were conducted in the August 19 -21, 2008 period and the “after” counts were done in the September 16-18, 2008 period. Due to the presence of streetcar tracks on Dundas Street, the tubes were only placed on the curb lane as tubes would be damaged if installed across the streetcar tracks. Hence, only one of the two lanes of traffic was captured in the eastbound and westbound directions. Therefore, streetcars and other vehicles travelling in the streetcar lanes are not included in this count for the “before” and “after” scenarios. The volume data does not indicate any shift in traffic volume from Yonge Street and Dundas Street to nearby parallel streets, probably because the parallel streets may be just as congested.

Six hour turning movement traffic counts, including vehicles, pedestrians, and cyclists were conducted at both intersections in Calgary prior to implementation in May 2008. A total of 4,453 vehicles entered the 3 Street SW/2 Avenue SW intersection and a total of 4,875 vehicles entered the 3 Avenue SW/3 Street SW intersection. Although pedestrian, cyclist, and violation data was collected after implementation, vehicle counts were not conducted. However, based on field observations, there does not appear to be any shift in traffic from 3 Avenue SW, 3 Street SW and 2 Avenue SW to adjacent streets.

11.2 Synchro Analysis

Synchro analyses were conducted for the three intersections to determine intersection delays and LOS before and after the installation of pedestrian scramble phasing. As shown in Table 2, the three intersections had an increase in intersection delay and deterioration in the intersection LOS. The Yonge Street/Dundas Street intersection was the most affected – intersection delay more than doubled in the morning and afternoon peak periods and the intersection LOS changed from B to D in both periods. There was a significant increase in delays to transit and mixed traffic in Toronto; from a policy implementation perspective, this trade-off was acceptable given that there are over 50,000 pedestrians at the Toronto intersection in a typical 24 hour period compared to 36,000 vehicles.

Table 2 – Intersection Delay and Level of Service

Period		Yonge St & Dundas St			2 Av - 3 St SW			3 Av - 3 St SW		
		Before	After	% Inc.	Before	After	% Inc.	Before	After	% Inc.
AM Peak	Intn delay	15.6	37.6	141	17.8	31.2	75	12.8	27.3	113
	Intn LOS	B	D		B	C		B	C	
PM Peak	Intn delay	17.1	47.0	175	18.6	31.2	68	19.7	27.6	40
	Intn LOS	B	D		B	C		B	C	

The intersection delay at the 3 Street/2 Avenue intersection increased by 75 percent in the morning peak period and by 68 percent in the afternoon peak period. The intersection delay at the 3 Street/3 Avenue intersection increased by 113 percent in the morning peak period and by 40 percent in the afternoon peak period. The LOS changed from B to C in both periods at both Calgary intersections. Although the percent increase in delay is high at both Calgary locations, the increase in actual delay per vehicle is minor and the intersections continue to operate at an acceptable LOS.

11.3 Transit Delays

Streetcar delays at the Yonge Street/Dundas Street intersection were measured before and after the implementation of the pedestrian scramble phasing. Appendix B shows the average delay, standard deviation, minimum and maximum delays incurred by eastbound and westbound streetcars in the morning, off-peak and afternoon peak periods. Delays were measured using the following formula:

$$\text{Delays} = \{\text{Time Cleared Intersection}\} - \{\text{Arrival Time (end of queue)}\} - \{\text{Service Time}\}$$

$$\text{Service Time} = \{\text{Time Doors Closed}\} - \{\text{Time Doors Open}\}$$

This data was collected on a typical Wednesday before and after the implementation of pedestrian scramble phasing during the following periods:

- Morning peak period: 7:30 a.m. to 9:30 a.m.
- Off-peak periods: 10:00 a.m. to 12:00 noon and 1:00 p.m. to 3:00 p.m.
- Afternoon peak period: 4:00 p.m. to 6:00 p.m.

There were substantial increases in transit delay in all periods. The average increase in eastbound transit delay was 84, 65 and 413 percent in the morning peak period, off-peak period and afternoon peak period respectively. The average increase in westbound transit delay was 215, 122 and 319 percent in the morning peak period, off-peak period and afternoon peak period respectively.

In Calgary, there is no transit service on 3 Street or 2 Avenue at the scramble phase intersections. There are only two transit routes that serve 2 Avenue. Buses on route 403 run at a 40 minute frequency during the peak periods and buses on route 419 run at a 30 minute frequency during the peak periods. Given the

frequency of service and the minimal increase in intersection delay, the impacts on transit would be minimal and were not reviewed before and after implementation.

11.4 Pedestrian Utilization of Pedestrian Scramble Phasing

Appendices C and D provide a summary of the total number of pedestrians crossing at the intersections during the morning, afternoon and noon peak periods for the two intersections in Calgary for the “before” and “after” scenarios. Appendix E provides corresponding data for the Toronto intersection for the “after” situation only.

Results indicate that the total number of pedestrians crossing diagonally has gone up at both Calgary intersections since pedestrian scramble phasing was implemented. Diagonal crossings accounted for 21% of all pedestrian crossings at the 3 Street/2 Avenue SW intersection, up from 19% before pedestrian scramble phasing was implemented. Diagonal crossings went up even further at the intersection of 3 Street and 3 Avenue, from 15% to 22% of all pedestrian crossings. The number of pedestrians crossing diagonally has grown by the greatest amount during the morning and afternoon peak periods.

Reasons for the increase in the number of pedestrians crossing diagonally at both intersections may include the following:

- Crossing diagonally during the pedestrian scramble phase is more efficient than crossing two legs of an intersection over two phases. This may account for the noticeable increase in diagonal crossings during the morning and afternoon peak periods when pedestrians are trying to minimize travel time to and from work.
- Since the “after” studies were conducted a month after implementation, there may still be a high number of pedestrians still trying out the new form of pedestrian control.

Toronto’s results show that only ten per cent of pedestrians used the scramble phase; this figure may be low because it does not take into account pedestrians who use the opportunities to cross during the vehicle green phases. There are 4,825 pedestrians using the scramble in a weekday six-hour period in Toronto compared to 1,129 at 3 Street/2 Avenue intersection and 1,458 at the 3 Street/3 Avenue intersection. The corresponding weekend figures are 3,825 in Toronto and 141 in Calgary.

11.5 Pedestrian Violations

Table 3 provides a summary of the pedestrian violations recorded at the Toronto and Calgary intersections before and after pedestrian scramble phasing was introduced. Pedestrian violations in Calgary include “Against Light” violations consisting of pedestrians who started crossing after the FDW interval began and pedestrians who crossed during a red interval. Pedestrian violations recorded after implementation of pedestrian scramble phasing also included pedestrians who crossed with vehicles during the vehicle green phases.

Since vehicles are not allowed to turn right or left at the Yonge Street/Dundas Street intersection, Toronto considered violations to be the following:

- 1) Pedestrians who started in FDW and ended in “Do Not Walk”.
- 2) Pedestrians who started in “Do Not Walk” but were able to complete their crossing in the “Do Not Walk” interval.
- 3) Pedestrians who started in “Do Not Walk” but completed their crossing in a subsequent “Walk” or “Do Not Walk” interval.

Table 3 - Total Pedestrian Violations Before/After Implementation of Scramble Phasing

<i>3 Street and 3 Avenue SW, Calgary</i>			
	Pedestrian Violations	Total Pedestrians	% Pedestrian Violations
Before	341	6,170	5.6%
After	805	5,798	13.9%
<i>3 Street and 2 Avenue SW, Calgary</i>			
	Pedestrian Violations	Total Pedestrians	% Pedestrian Violations
Before	503	5,785	8.7%
After	458	5,495	8.3%
<i>Yonge Street & Dundas Street, Toronto</i>			
	Pedestrian Violations	Total Pedestrians	% Pedestrian Violations
Before	4,760	59,060	8.1%
After	5,602	56,666	9.9 %

Notes: Calgary – one day 6 hour count at both intersections

Toronto – two day 8 hour count (average of both days shown in table)

At the 3 Street/2 Avenue SW intersection, pedestrian violations remained almost constant before and after pedestrian scramble phasing was implemented. However, the total number of pedestrian violations increased sharply at the 3 Street/3 Avenue SW intersection after implementation. In Toronto, there was a slight increase.

The percent increase in pedestrian violations at the 3 Street/3 Avenue intersection relative to of 3 Street/2 Avenue intersection may be partially attributed to the different road marking schemes that were implemented at both intersections. Diagonal crosswalks were marked at the intersection of 3 Street and 2 Avenue from corner to corner, whereas at 3 Street and 3 Avenue only partial diagonal crosswalks were marked.

Table 5 provides a more detailed break down of the type of pedestrian violations that occurred at the 3 Street/3 Avenue intersection during each period. “Against Light” violations accounted for nearly 80% of all pedestrian violations. Most of the “Against Light” violations observed were pedestrians who started crossing after the FDW interval began. Installation of pedestrian countdown timers may help reduce the incidences of pedestrians crossing at the start of the FDW interval. A high number of pedestrians crossing on the red interval was observed before and after implementation of pedestrian scramble phasing at both intersections. This is likely due to the narrow cross-section of 3 Street at both intersections with pedestrians being able to cross within the clearances and the increase in wait time.

Pedestrians crossing illegally on green continues to be a problem and was a primary concern for motorists who called the 311 Call Centre to complain about the new operations. This behaviour also places pedestrians at risk of being struck by turning motorists. Based on field observations, it appeared that most pedestrians who cross on green are those who are not familiar with the new operation. Considering that the Eau Claire Market has a high concentration of tourists who would not be familiar with pedestrian scramble phasing, this may be a chronic problem at both locations.

Table 4 - Type of Pedestrian Violations at 3 Street /3 Avenue after Scramble Phase Implementation

Time Period	Against Light	Cross With N/S Vehicle Phase	Cross With E/W Vehicle Phase	Total Non-Compliance*
AM Peak	117	11	20	148
Off Peak	282	23	40	345
PM Peak	158	34	37	229
Total	557	68	97	722*
% of Total	77.1%	9.4%	13.4%	

* Pedestrian violations from the SW corner of the intersection were not recorded due to technical problems experienced during the data collection process.

In Toronto there was a slight increase in the percentage of pedestrians who started in FDW and ended in “Do Not Walk” and a decrease in the percentage of pedestrians who started in “Do Not Walk” but were still able to complete their crossing in “Do Not Walk”. Since the “Do Not Walk” interval is four seconds for the pedestrian scramble phase and six seconds for the east-west and north-south phases, these pedestrians would have to be running across the intersection, rather than walking. From Toronto’s perspective, the area of concern would be (2) and (3) above. (3) would be of greater concern if the pedestrian started in “Do Not Walk” and ended in the “Do Not Walk” of the next vehicle phase.

Table 5 - Type of Pedestrian Violations at Yonge Street & Dundas Street Before/After Scramble Phase Implementation

	Date	Day of Week	Start in FDW, end in DW		Start in DW, end in DW		Start in DW, end in Walk/DW		Total Pedestrian Violations
			Total	%	Total	%	Total	%	
Before	Aug 21, 2008	Thurs	4,314	83.7	647	12.6	192	3.7	5,153
	Aug 23, 2008	Sat	3,566	81.6	699	16.0	101	2.3	4,366
After	Oct 20, 2008	Mon	5,375	88.7	517	8.5	169	2.8	6,061
	Sept 20, 2008	Sat	4,474	87.0	551	10.7	118	2.3	5,143

The violations that start in “Do Not Walk” decreased after the installation of scramble phasing which is most likely due to the increased opportunities provided for pedestrians to cross the intersection within a given cycle.

11.6 Vehicle Violations

Table 7 and Table 8 provide a summary of the vehicle violations recorded at both Calgary intersections after pedestrian scramble phasing was implemented. Vehicle violations observed include Straight Through on Red (ST on Red), Right Turn on Red during the pedestrian scramble phasing (RT on RD Ped Phase), and Right Turn on Red during the opposing vehicle green phase (RT on Red Veh Phase).

Table 6 - Vehicle Violations at the 3 Street /3 Avenue SW Intersection

Period	Vehicle Violations				Traffic Volumes	
	ST on Red	RT on RD Ped. Phase	RT on Red Veh. Phase	Total	Total Veh. Traffic	Total Ped. Traffic
AM Peak (07:00-09:00)	9	6	34	49	1680	1045
OFF Peak (11:00-13:00)	4	11	16	31	1451	3025
PM Peak (16:00-18:00)	5	11	12	28	1744	1728
Total	18	28	62	108	4875	5798

Of the 30 straight through violations on red recorded at both intersections, 90% originated from the north or south approaches of the intersections. The cause for this type of violation may be due in part to the fact that there are no overhead traffic signals on the north and south approaches of both intersections. The traffic signal indications are located in side-mount structures, as shown in Figure 9. Also, during the time that vehicle violation data was recorded at both intersections, the pedestrian scramble phase followed the east-west vehicle phase. With no direct overhead traffic signals, some north-south motorists likely assumed that their green phase would immediately follow the east-west vehicle phase and proceeded through the intersection without visual confirmation that the traffic signals had actually turned green. As a result, some north-south vehicles crossed during the pedestrian scramble phase.

Since the vehicle violation data was collected in June 2008, the traffic signal phase order was changed at both intersections so that the north-south vehicle phase followed the east-west vehicle phase. The east/west signal structures have overhead signal indications whereas the north/south structures have side mounted signal indications. Changing the phasing order to allow the pedestrian scramble phase to follow the north-south vehicle phase reduced straight through on red violations by a significant amount.

Table 7 - Vehicle Violations at the 3 Street /2 Avenue SW Intersection

Period	Vehicle Violations				Traffic Volumes	
	ST on Red	RT on RD Ped Phase	RT on Red Veh Phase	Total	Total Veh Traffic	Total Ped Traffic
AM Peak (07:00-09:00)	2	6	7	15	1442	817
OFF Peak (11:00-13:00)	6	8	17	31	1258	3161
PM Peak (16:00-18:00)	4	1	12	17	1753	1517
Total	12	15	36	63	4453	5495

Right turns on red continue to be a problem at both locations and places pedestrians at risk of being struck by a turning vehicle. Two “No Right Turn on Red” signs have been installed on all approaches at both intersections and are clearly visible. Based on field observations, right turn on red violations appear to be more problematic during the off peak hours when there are fewer pedestrians crossing at the intersections. However, there was a fair number of right turn on red violations observed during the peak pedestrian

hours as well. Enforcement of the right turn on red restriction is recommended, particularly during the peak hours.

A study of vehicle violations was not conducted in Toronto.

11.7 Bicycle Violations

Tables 8 and 9 provide a summary of the bicycle violations recorded at the 3 Street/3 Avenue SW and 3 Street/2 Avenue SW intersections after pedestrian scramble phasing was implemented. Bicycle violations include Straight Through on Red (ST on Red), Right Turn on Red during the pedestrian scramble phasing (RT on RD Ped Phase), and Right Turn on Red during the opposing vehicle green phase (RT on Red Veh Phase).

Table 8 - Bicycle Violations at the 3 Street/3 Avenue SW Intersection

Period	Bicycle Violations				Traffic Volumes	
	ST on Red	RT on RD Ped Phase	RT on Red Veh Phase	Total	Total Bicycles	Total Pedestrians
AM Peak (07:00-09:00)	32	8	10	50	209	1045
OFF Peak (11:00-13:00)	28	5	2	35	92	3025
PM Peak (16:00-18:00)	48	7	3	58	150	1728
Total	108	20	15	143	451	5798

Table 9 - Bicycle Violations at the 3 Street/2 Avenue SW Intersection

Time Period	Bicycle Violations				Traffic Volumes	
	ST on Red	RT on RD Ped Phase	RT on Red Veh Phase	Total	Total Bicycles	Total Pedestrians
AM Peak (07:00-09:00)	53	5	7	65	132	817
OFF Peak (11:00-13:00)	20	0	5	25	50	3161
PM Peak (16:00-18:00)	59	2	1	62	78	1517
Total	132	7	13	152	260	5495

240 violations out of the 295 bicycle violations at both intersections were straight through on red violations. 3 Street is a popular route for cyclists, and 88% of the 240 straight through on red violations originated from the north and south approaches of both intersections. Many of the 240 straight through on red violations were cyclists who came to a complete stop during the vehicle red phase, and then proceeded to ride through the pedestrian scramble phase. Cyclists should dismount and walk their bikes across the intersection during the scramble phase. Further investigation is required to identify measures that will address these types of violations

Toronto did not conduct any bicycle violation studies because there are few bicycles using its intersection.

11. 8 Public Response via Field survey

In Toronto, City staff surveyed 462 pedestrians three months later over a two-day period at the Yonge Street/Dundas Street intersection to assess their reaction to the pedestrian scramble operations. Since the survey was conducted in November, the surveyors were able to get a well distributed sample of pedestrians comprising of office workers, students (Ryerson University) and recreational walkers. Appendix F illustrates the pedestrian perception questionnaire that was designed for this study. Results from the survey show 89% of pedestrians thought it was a good idea to have this type of operation at the Yonge Street/Dundas Street intersection. Figure 10 illustrates the level of support for pedestrian scramble phasing by various age groups and gender.

When asked what the purpose of the walking trip was, 32% of the pedestrians surveyed indicated that they were travelling to/from work and 31% were travelling to/from school. 57% of the pedestrians surveyed indicated that they cross this intersection more than once a day. 78% indicated that they have crossed this intersection diagonally. Approximately two thirds of the pedestrians believe that this type of operation would not have a negative impact on traffic flow and streetcar operations.

Table 10 - Level of Support by gender and various age groups

Age Group	Toronto		Calgary	
	Male	Female	Male	Female
Under 18	100	100	NA	NA
18 – 25	96	95	72	74
26 – 45	86	81	88	80
46 – 55	91	82	92	58
55 +	89	89	81	71

In Calgary, University of Calgary students surveyed approximately 140 pedestrians five weeks after implementation at both intersections to assess their reaction to the pedestrian scramble phasing. Results from the survey indicated that 79% approved of the pedestrian scramble phasing. Approximately 70% of pedestrians commented that they believed pedestrian scramble phasing will improve intersection safety, relative to the traditional form of pedestrian crossing (lateral crossings on green). Table 10 illustrates the level of support for pedestrian scramble phasing among various age groups.

A comparison of the Toronto and Calgary results shows that the level of support in Toronto was higher than Calgary across almost all age groups. The highest variation of 9 per cent between male and female respondents in Toronto occurred in the 46-55 age group. The same situation occurred in Calgary but the variation was much higher at 34 per cent.

A comprehensive summary of the results obtained from the survey can be found in Appendix E.

11.9 Public Response via 311 and Internet

Calgary's 311 Call Centre monitored calls after pedestrian scramble phasing was implemented on May 12, 2008. In total, 178 inquiries were received as of November 10, 2008. 106 calls were "information calls" only, with the remaining 72 callers providing feedback on the pedestrian scramble phasing implementation. Unnecessary delay to motorists, congestion in the peak hours, and pedestrians crossing on green were the most common issues raised by motorists. Reaction from pedestrians who called 311

was mixed with a slim majority of pedestrians indicating they do not support pedestrian scramble phasing. Motorists turning right on red, and bicyclists straight through on red were the most common concerns expressed by pedestrians.

Information from Access Toronto (Toronto's current equivalent to Calgary's 311) was not available. However, monitoring of online forums on the *Toronto Star*, *blog.TO*, *spacing Toronto*, *Canadian Broadcasting Corporation* and *Globe and Mail* websites showed that 186 responses were posted soon after the implementation. 91 responses were general in nature. Of the remaining 95 responses, 74 per cent were in favour and 26 per cent were against the implementation. Those who were in favour cited the following:

- Safer conditions for pedestrians.
- Another step in making Toronto a greener walkable city.
- More crossing opportunities per hour.

Concerns expressed by those opposed to the implementation include:

- The risk of being stranded in the intersection.
- Pedestrians jaywalking.
- The risk of a motorist (who is not familiar with the operation) proceeding through the intersection on a red light
- Longer wait time for vehicles
- Traffic signals at Yonge Street/Dundas Street not synchronized with nearby signalized intersections.

12. COSTS

The cost of Toronto's pedestrian scramble phasing was approximately \$80,000.00. The cost includes pedestrian signal heads, pedestrian countdown timers, advance warning signs, overhead "priority crossing" signs, mast arms, pole relocations, underground work (due to the presence of hydro chambers), curb cuts to accommodate the diagonal crossings, paid duty police, zebra markings and programming the signal controller. The cost does not include staff time spent on planning, implementing and evaluating the pedestrian scramble phasing. The cost of installing accessible pedestrian signals was covered under the Accessible Pedestrian Signals Project – under this project approximately 30 existing signalised intersections are retrofitted with accessible pedestrian signals each year.

Both Calgary's intersections cost a total of approximately \$30,000. The cost did not include staff time spent on planning, implementing and evaluating the pedestrian scramble phasing. The main costs for the project involved installing new pavement markings, new "No right turns on red lights" signs, and communication materials. Additional pedestrian heads were not installed. APS was already present. No modifications were required for the wheel chair ramps at the two intersections. If Calgary proceeds with scramble phasing at additional locations, where there are two or more lanes per direction, then additional pedestrian heads and countdown timers would be considered at these locations.

13. CONCLUSIONS & RECOMMENDATIONS

Although staff has identified additional locations that may be appropriate for scramble control, the City of Calgary has no intention of expanding the number of scramble locations at this time. Toronto will be proceeding with the installation of pedestrian scramble phasing at three more intersections in the downtown core in 2009. These three intersections comply with Condition 1 of the criteria established for Toronto. Using Condition 1 only, there would be about 20 intersections that would be candidates for installation of pedestrian scramble phasing.

Toronto's criteria may be perceived as being rather stringent since they take into account the high volumes of pedestrians that are present in Toronto's downtown core. Although Toronto's criteria are stringent, it is important to note that pedestrian scramble control is not appropriate at all locations. Pedestrian scramble control should be reserved for locations where there are a large number of pedestrians crossing in all directions at all times of day. Locations that have low pedestrian volumes during certain times of day may experience motorist non-compliance issues, particularly at locations where right turns on red are banned. Calgary has experienced such issues during the off peak hours. However when pedestrian volumes are high, during the lunch hour for example, the Calgary intersections operate well with a high degree of compliance from motorists and pedestrians. Jurisdictions must also be prepared to tolerate a potentially large increase in vehicle delay that can have a negative impact on transit service in the area.

Consideration should be given to maintaining consistency of operations in a City. It would be confusing to pedestrians and motorists to implement different types of pedestrian scramble phasing or to operate some by time of day and others on a 24/7 basis. Similarly, if restricting movements is required, such as banning right turns on red, these restrictions should remain in effect 24/7 to minimize driver confusion and to enhance safety.

Communications with stakeholders is a key component in achieving success. Discussions must be held with the police, transit authority, advocates for the blind and disabled, emergency medical services and nearby businesses. Since the blind and visually challenged are affected the most, steps must be taken to resolve their concerns. Unique signage at the intersection should advise pedestrians that the intersection operation has changed. Consideration should be also be given to the installation of advance warning signs, at least on a temporary basis. Special road-markings should supplement the signage.

It is recognized that the implementation of pedestrian scramble would increase vehicle delays. There was a significant increase in delays to mixed traffic in Toronto; from a policy implementation perspective, this tradeoff was acceptable given that there are over 50,000 pedestrians at the Toronto intersection in a typical 24 hour period compared to 36,000 vehicles. The increase in delay to transit vehicles is a concern – while a better level of service is being provided to pedestrians at the Toronto intersection, these same pedestrians are subject to additional delays when they ride on the streetcars. Similarly in Calgary the expected increase in vehicle delay was considered acceptable given the safety and operational benefits for pedestrians that scramble control provides. Implementation of scramble control in Toronto and Calgary demonstrates both cities' commitment to creating more walkable cities. Based on the high number of pedestrians observed crossing diagonally at the three locations, it does appear that the pedestrian scramble phasing is being well used by pedestrians in Toronto and Calgary.

ACKNOWLEDGEMENTS

The authors would like to thank Linda Lee, Natasha Gomes and Tee Say of the City of Toronto's Traffic Management Centre, Jim Sinikas of the TTC and Ryan Vanderputten of Calgary's Transportation Optimisation Division for their assistance in providing material for this paper.

REFERENCES

1. City of Toronto, "Steps Towards A Walkable City – Proposed Framework For A Toronto Walking Strategy." Accessible via http://www.toronto.ca/transportation/walking/pdf/walkable_city.pdf

2. City of Toronto, “City Council Decision Document – Meeting No 13 (October 22 and 23, 2007)”, Accessible via <http://www.toronto.ca/legdocs/mmis/2007/cc/decisions/2007-10-22-cc13-dd.pdf>
3. City of Calgary, “Pedestrian Criss-Cross Pilot Project”, Accessible via http://www.calgary.ca/portal/server.pt/gateway/PTARGS_0_2_572022_0_0_18/Pedestrian+Criss+Cross+Pilot+Project

AUTHORS INFORMATION

Rajnath Bissessar, P.Eng. is a Senior Engineer with the Urban Traffic Control Systems unit in the City of Toronto’s Traffic Management Centre. He is responsible for the day-to-day operations of the Traffic Signals Operations Group including the multi-year traffic control system replacement project. He received a BSc. (Civil Engineering) degree from the University of the West Indies, Trinidad; a MSc. (Highway & Traffic Engineering) degree from the University of Birmingham, United Kingdom; and a Diploma (Highway Engineering) from the University of New South Wales, Australia. Rajnath is a member of ITE.

Mailing Address: Traffic Management Centre
Urban Traffic Control Systems
703 Don Mills Road, 5th Floor
Toronto, ON M3C 3N3

Phone: 416 397 5769

Fax: 416 397 5777

Email: rajnath_bissessar@toronto.ca

Website: www.toronto.ca

Craig Tonder, A.Sc.T, is a Transportation Systems Management Specialist in the City of Calgary’s Transportation Planning Department. He received a B.A. in Urban Planning from the University of Saskatchewan, Saskatoon and a Diploma in Transportation Engineering Technology from Mohawk College, Hamilton, Ontario. Craig is a member of ITE and OACETT.

Mailing Address: Transportation Systems Management Specialist
Transportation Optimisation Division
Transportation Planning
The City of Calgary | Mail Code: 8124
P.O. Box 2100, Stn. M, Calgary, AB T2P 2M5

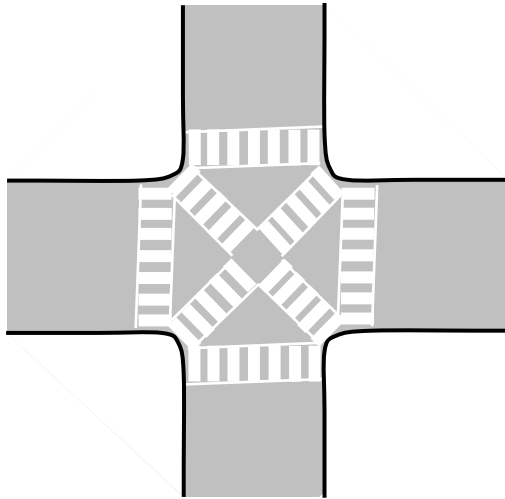
Phone: 403 268 4824

Fax: 403 268 1874

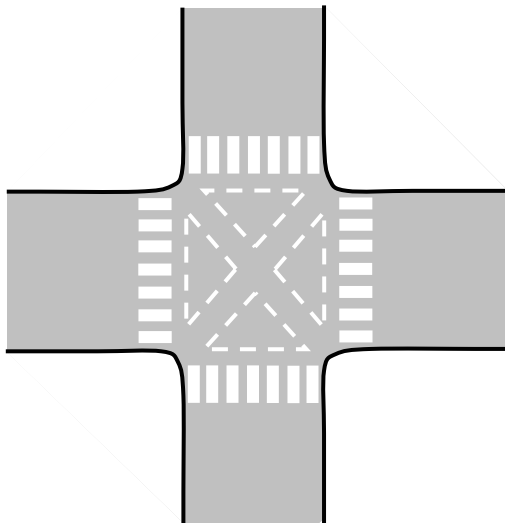
Email: ctonder@calgary.ca

Website: www.calgary.ca

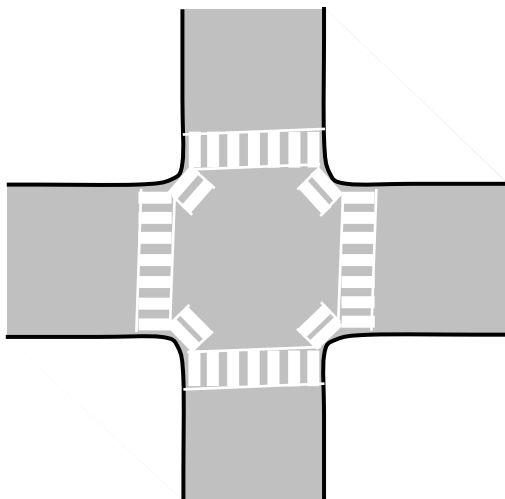
Appendix A: Pavement Marking Options



Option 1



Option 2



Option 3

Appendix B: Before and After Transit Delays at Yonge Street/Dundas Street, Toronto

Dir	(in seconds)	AM Peak Period (7:30-9:30)			Off Peak Period (10:00-12:00)			Off Peak Period (13:00-15:00)			PM Peak Period (16:00-18:00)			Total		
		Before	After	% incr	Before	After	% incr	Before	After	% incr	Before	After	% incr	Before	After	% incr
EB	Average	0:00:31	0:00:57	84%	0:00:39	0:01:09	77%	0:00:59	0:01:30	53%	0:00:39	0:03:20	413%	0:00:43	0:01:44	142%
	Standard Deviation	0:00:15	0:00:47	213%	0:00:33	0:00:55	67%	0:00:45	0:01:07	49%	0:00:23	0:01:06	187%	0:00:33	0:01:22	148%
	Minimum	0:00:07	0:00:12	71%	0:00:07	0:00:07	0%	0:00:09	0:00:11	22%	0:00:12	0:00:09	-25%	0:00:07	0:00:07	0%
	Maximum	0:00:50	0:03:04	268%	0:01:57	0:03:08	61%	0:02:42	0:04:09	54%	0:01:30	0:05:12	247%	0:02:42	0:05:12	93%
WB	Average	0:00:20	0:01:03	215%	0:00:27	0:01:20	196%	0:00:33	0:00:49	48%	0:00:21	0:01:28	319%	0:00:25	0:01:10	180%
	Standard Deviation	0:00:19	0:00:38	100%	0:00:18	0:00:52	189%	0:00:28	0:00:33	18%	0:00:12	0:01:13	508%	0:00:20	0:00:53	165%
	Minimum	0:00:04	0:00:07	75%	0:00:07	0:00:13	86%	0:00:04	0:00:08	100%	0:00:07	0:00:08	14%	0:00:04	0:00:07	75%
	Maximum	0:01:21	0:02:53	114%	0:01:18	0:02:43	109%	0:01:44	0:01:50	6%	0:00:43	0:03:58	453%	0:01:44	0:03:58	129%

Appendix C: Diagonal Counts Before/After Pedestrian Scramble Phasing Implementation at 3 Street /Avenue SW, Calgary

Before Pedestrian Scramble Phasing Installed												
	AM Peak Period (7:00-9:00)			Off Peak Period (11:00-13:00)			PM Peak Period (16:00-18:00)			Total		
Date	2 Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	Diagonal Crossing (%)
May 2	189	853	22%	627	3,166	20%	255	1,766	14%	1,071	5,785	19%
After Pedestrian Scramble Phasing Installed												
	AM Peak Period (7:00-9:00)			Off Peak Period (11:00-13:00)			PM Peak Period (16:00-18:00)			Total		
Date	Diag Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	Diagonal Crossing (%)
Jun 20	181	817	22%	672	3,161	21%	276	1,517	18%	1,129	5,495	21%

Appendix D: Diagonal Counts Before/After Pedestrian Scramble Phasing Implementation at 3 Street/3 Avenue SW, Calgary

Before Pedestrian Scramble Phasing Installed													
		AM Peak Period (7:00-9:00)			Off Peak Period (11:00-13:00)			PM Peak Period (16:00-18:00)			Total		
Date	Day of Week	Two Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	%	Two Leg Crossings	Total Peds Crossing	Two Leg Crossing (%)
May 8	Thu	155	1,131	14%	402	2,150	19%	235	1,239	19%	792	4,520	18%
May 2	Fri	189	1,331	14%	384	2,904	13%	239	1,935	12%	812	6,170	13%
May 3	Sat	7	121	6%	59	6,29	9%	75	836	9%	141	1,586	9%
TH + FRI Total		344	2,462	14%	786	5,054	16%	474	3,174	15%	1,604	10,690	15%
After Pedestrian Scramble Phasing Installed													
		AM Peak Period (7:00-9:00)			Off Peak Period (11:00-13:00)			PM Peak Period (16:00-18:00)			Total		
Date	Day of Week	Diagonal Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	%	Diagonal Crossings	Total Peds Crossing	Diagonal Crossing (%)
Jun 19, 2008	Thu	383	1,669	23%	759	3,810	20%	533	2,029	26%	1,675	7,508	22%
Jun 20, 2008	Fri	286	1,045	27%	584	3,025	19%	371	1,728	21%	1,241	5,798	21%
Thu + Fri Total		669	2,714	25%	1343	6,835	20%	904	3,757	24%	2,916	13,306	22%

Appendix E – Pedestrians Crossing the Yonge Street/Dundas Street After Implementation

Period		AM Peak (7:30-9:30)			Off Peak (11:00-13:00)			PM Peak (16:00-18:00)			Total		
Date	Day	Diagonal	Total	%	Diagonal	Total	%	Diagonal	Total	%	Diagonal	Total	%
Oct 20, 2008	Mon	313	6,440	5%	1,640	16,294	10%	2,876	23,358	12%	4,825	46,092	10%
Sept 20, 2008	Sat	136	2,457	6%	1,143	12,607	9%	2,546	23,275	11%	3,825	38,339	10%

Appendix F – Toronto’s Pedestrian Perception Questionnaire



Recorder: _____

Date: _____

Time (AM/Lunch/PM): _____

**PEDESTRIAN PERCEPTION QUESTIONNAIRE
PEDESTRIAN PRIORITY AT YONGE & DUNDAS**

- 1. Gender? Female Male
Age? Under 18 18 – 25 26 – 45 46 – 55 55+
- 2. Are you a resident of Metropolitan Toronto (Includes East York, Etobicoke, North York, Scarborough & York)?
 Yes No
- 3. What is the purpose of your walking trip today?
 Traveling to/from work Traveling to/from school Shopping
 Exercise/recreation Other _____
- 4. Do you drive regularly in downtown Toronto?
 Yes No
- 5. How often, on average, do you cross this intersection?
 More than once a day on Weekdays Once a day on Weekdays
 Less than 5 times/week Weekends Once a week

Pedestrian Priority Phase:

- 6. Have you ever seen this type of crossing before?
 Yes No if yes, where? _____
- 7. Do you think it's a good idea to have this at Yonge & Dundas?
 Yes No
- 8. When should it be operational?
 24/7 During specific periods of the day if so, when? _____
- 9. Do you cross diagonally at this intersection?
 Yes No
- 10. Do you think this has a negative impact on traffic flow?
 Yes No
- 11. Do you think this has a negative impact on streetcar operations?
 Yes No
- 12. Do you think this is safer for pedestrians than the previous crossing?
 Yes No
- 13. Do you think this is more convenient for pedestrians than the previous crossing?
 Yes No