TESTING OF INNOVATIVE PEDESTRIAN SAFETY INITIATIVES IN THE CITY OF TORONTO

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ABSTRACT

Testing of Innovative Pedestrian Safety Initiatives in the City of Toronto

The City of Toronto has been dealing with an increasing amount of concern about pedestrian safety. Over the years, a number of technologies have been suggested to remedy these concerns. In addition, new techniques and control methodologies have been considered and/or implemented in other jurisdictions to address pedestrian safety, some of which have proven to reduce pedestrian conflicts and collisions. As part of the broader “Pedestrian Safety Initiatives Program”, the City of Toronto is planning pilot installations for a number of these pedestrian safety initiatives. The objective of the pilot installations and associated analysis is to determine the effectiveness of these safety initiatives on City of Toronto roadways, which will permit the City to assess the relative merits of widespread deployment.

The six candidate Pedestrian Safety Initiatives include:

- Broad Pavement Markings;
- Pavement Level Delineation Lighting;
- Flashing WALK Display;
- Pedestrian Countdown Timer;
- Passive Pedestrian Detection; and
- Leading Pedestrian Interval.

A ‘preliminary assessment’ was undertaken by the Consultant Team to investigate previous and current evaluation studies undertaken by other jurisdictions, and the relative effectiveness of each of the above-noted initiatives. The City has finalized the study designs for six PSIs. Each study design includes a:

- Description of the PSI and anticipated benefits;
- Candidate sites and the site selection process;
- Specifications for the initiative;
- Installation requirements;
- Evaluation methodology including measures of effectiveness, recommended data collection and analysis methodologies;
- Education program requirements; and an
- Implementation plan including schedule and budget estimates.

The first half of the paper will describe the findings of the investigation into the six Pedestrian Safety Initiatives. It will describe the technologies, and the results of field testing in North America.

The second half of the paper will describe the study designs for each of the PSIs, including the resources required, community liaison approach, the type and amount of data to be collected, and the proposed method to evaluate the results.

TESTING OF INNOVATIVE PEDESTRIAN SAFETY INITIATIVES IN THE CITY OF TORONTO

INTRODUCTION

The City of Toronto has a long history of dealing with the issue of pedestrian safety within the City's roadways and intersections. Pedestrians will always be the most vulnerable component of the traffic system and must be explicitly considered in the overall objective of improving the safety of the City's streets. Concerns that the City must address on a regular basis relate to:

- The lack of understanding/compliance with the "Flashing DON'T WALK" signal display;
- Pedestrians crosswalk conspicuity; and
- Pedestrian-vehicle conflicts/collisions.

Over the years, a number of technologies have been suggested to remedy these concerns. In addition, new techniques and control methodologies have been considered and/or implemented in other jurisdictions to address pedestrian safety, some of which have proven to reduce pedestrian conflicts and collisions. As part of the broader "Pedestrian Safety Initiatives Program", the City of Toronto is planning to implement pilot installations for a number of these pedestrian safety initiatives. The objective of the pilot installations and associated analysis is to determine the effectiveness of these safety initiatives on City of Toronto roadways, which will permit the City to assess the relative merits of widespread deployment.

The initial Pedestrian Safety Initiatives (PSI) list was developed by City staff, and reflected safety initiatives that have been:

- Considered by City staff in the past to address recurrent complaints regarding pedestrian crossing times, pedestrian safety and misunderstanding of the pedestrian clearance interval;
- Installed within other jurisdictions with unknown or unverified success; and/or
- Requested by residents, politicians or interest groups in the past.

The six candidate Pedestrian Safety Initiatives included:

- Broad Pavement Markings;
- Pavement Level Delineation Lighting;
- Flashing WALK Display;
- Pedestrian Countdown Timer;
- Passive Pedestrian Detection; and
- Tri-Colour Pedestrian Display.

A seventh PSI, "Leading Pedestrian Interval" was added through the selection/consultation process.

PRELIMINARY ASSESSMENT OF POTENTIAL PEDESTRIAN SAFETY INITIATIVES

A 'preliminary assessment' was undertaken to investigate previous and current evaluation studies undertaken by other jurisdictions, and the relative effectiveness of each of the above-noted initiatives. The preliminary assessment activity had the primary goals:

- To aggregate previous research/analysis, document existing installations in other jurisdictions and to compile a list of potential suppliers;

- To determine if sufficient statistically valid evidence has been undertaken by others, which would negate the need for the City to undertake its own independent review of a particular PSI; and
- To determine if sufficient statistically valid evidence has been undertaken by others to demonstrate that one or more of the Pedestrian Safety Initiatives does not provide substantial pedestrian safety benefits.

The seven PSIs were subjected to a detailed review. This section provides a summary of current and past research, and the potential benefits of the seven initiatives.

BROAD PAVEMENT MARKINGS

Description and Previous Studies

Broad pavement markings refers to the use of wide longitudinal painted bars to signify a pedestrian crossing at a signalized intersection in addition to the two horizontal lines currently provided at many of the City's intersections. Essentially the each crosswalk area would resemble a horizontal ladder.

The FHWA document '*Designing Sidewalks and Trails for Access, Part 2 – Best Practice Design Guide*' (2001) indicates that research has shown broad pavement markings to be more visible for motorists (Knoblauch et al., 1988). They are also a more effective means of displaying the crossing area for people with visual impairments. In addition, the Pedestrian and Bicycle Information Center of the FHWA has just released its '*Pedestrian Facilities User Guide*' (2002) that outlines a number of recent research outcomes on a variety of pedestrian-related safety programs. This study indicates that broad pavement markings are desirable, but most effective when installed in conjunction with other improvements such as pinch-points and raised crosswalks.

There are numerous examples of broad pavement marking use in North America, including Los Angeles and Sierra Madre (California), Boulder (Colorado), and the Puget Sound area (Washington State). They are primarily used at uncontrolled locations, and in conjunction with roadside caution signs. However, there are examples where they have been used at controlled crossings, including Tucson (pelican crossings), and Seattle (intersection pedestrian signals).

The Millennium Edition of the United States' Manual of Uniform Traffic Control Devices (MUTCD) outlines two possible formats for broad pavement markings at signalized intersections. These are:

- Broad bars of pavement markings aligned perpendicular to the pedestrian direction of travel (with or without the use of the existing crosswalk lines);
- Broad bars of pavement markings aligned diagonally (at approximately 45 degrees to the pedestrian direction of travel) and used in combination with the existing crosswalk lines.

None of the research reviewed for this project provided an evaluation of the relative merits of these two pavement-marking configurations. However, the two FHWA documents noted above, both recommended the use of the pavement markings aligned perpendicular to the pedestrian direction of travel. The former document also recommends that these markings be installed with the equivalent of the existing crosswalk lines to create a 'ladder'-style installation.

Anticipated Benefits of Broad Pavement Markings

Broad pavement markings installed at traffic signal crosswalks are expected to fulfill the following purpose:

- Warn motorists to expect pedestrian crossings; and
- Indicate preferred pedestrian crossing locations.

In turn, it is expected that the following benefits will be derived:

- An increased sense of security for pedestrians;
- A more clearly delineated pedestrian crossing area;
- A potential increase in vehicle yielding; and
- A decrease in the number of vehicle-pedestrian conflicts during vehicle turning movements.

Potential Disbenefits

The use of Broad Pavement Markings will result in larger surfaces of the walking area to be covered with line marking material. When applied without any supplements to improve grip, line marking paint does not provide as firm of a walking surface as bare asphalt or concrete. This potential deficiency will be addressed by applying silica grit to the painted areas.

Broad pavement markings, specifically paint applications, may require frequent reapplication due to fading (mechanical weathering). Due to the larger painted area, broad pavement markings are more costly than a typical crosswalk application of two transverse lines.

PAVEMENT LEVEL DELINEATION LIGHTING

Description and Previous Studies

Pavement level delineation lighting is a number of pedestrian-activated pulsing lights in the pavement, at pedestrian crossover locations, that supplement the existing warning equipment.

The first installations of this system were in the City of Santa Rosa, California. This PSI was later investigated in Kirkland, Washington, and a number of other Californian cities. None of the studies measured motor vehicle-pedestrian conflicts. This is an important limitation of these studies because it is possible for yielding and braking to increase with little or no change in conflicts. It is even possible for increased yielding to be associated with an increase in multiple threat crashes. The City of Santa Rosa removed the three systems within a year after the test of an uncontrolled site, and decided to install overhead flashing signs.

The study reporting the most significant results is the one conducted in Kirkland, Washington. Driver yielding rates were reported to improve on one street from 61% to 93% during the day and from 22% to 99% during the night and on the second street from 51% to 89% during the day and from 57% to 95% during the night.

It is interesting to note that only a third of pedestrians pushed the button. Because post PSI installation data were only collected when the lights were activated, it is possible that those who pressed the button crossed differently from those who did not. Specifically, this self-selection process may have lead to post PSI installation data being collected on people who were better at getting motorists to yield.

A more comprehensive study was carried out by Whitlock & Weinberger Transportation, Inc. (1998) and was funded by the State of California Office of Traffic Safety and FHWA. The Whitlock & Weinberger data included many other sites besides the two in Kirkland Washington. In general, the Kirkland sites showed larger increases in daytime yielding than most of the other sites (an increase of 36 percent more motorists yielding vs. an average increase of 23.5 percent at the other sites). Follow up data at the two Santa Rosa sites showed a decline from the original 36 percent in vehicles yielding, to 22 percent.

The study also found that the effects of the Pavement Level Delineation Lighting degrade somewhat in daylight conditions.

Anticipated Benefits of Pavement Level Delineation Lighting

Pavement Level Delineation Lighting is expected to increase driver awareness of the pedestrian crossover, thereby increasing the frequency of driver yielding and decreasing the number of vehicle-pedestrian conflicts.

Potential Disbenefits

The following issues were raised with respect to previous Pavement Level Delineation Lighting installations:

- After the installation of the lighting, some pedestrians continued to proceed across the crosswalk without pushing the button;
- The effects of the Pavement Level Delineation Lighting degrade somewhat in daylight conditions; and
- Street lighting should be present at crosswalks where the system is applied, to increase the visibility of pedestrians at night, and to wash out the glow of the lighting devices so they do not distract the pedestrians while the pedestrians are crossing the roadway.

FLASHING "WALK" DISPLAY

Description and Previous Studies

Flashing WALK display is an operational change that would display a flashing white "walking man" to indicate the pedestrian clearance interval in place of the flashing "don't walk" (i.e. flashing "orange hand") currently employed at many of the City's intersections.

While this PSI is in regular use abroad, research concerning the domestic use of a Flashing WALK for the pedestrian clearance interval was not readily available. Through the course of the scoping exercise some Australian studies were identified and reviewed, but safety improvements were not determined.

Australia has experienced some of the same concerns as Canadian jurisdictions regarding the poor understanding of the Flashing DON'T WALK. Australian pedestrian displays employ a steady green walking person for WALK, a Flashing red standing person for the clearance, and a steady red standing person for the DON'T WALK.

A study conducted by Cairney (1988) indicated that changing the clearance display to a Flashing green walking person did not improve pedestrian comprehension of the display. Using a combination of site observation and interviews, Catchpole et al (1996) similarly determined that a Flashing amber walking person did not improve pedestrian comprehension of the display.

The City of Washington, D.C. uses the Flashing WALK at most signalized intersections, but for a different purpose. The Flashing WALK is used wherever there is a potentially conflicting vehicular movement. Therefore, the Flashing WALK is displayed concurrent with the solid Green ball for vehicular movements. The pedestrian signal display sequence then continues to a Flashing DON'T WALK display for pedestrian clearance. The WALK is not displayed in flash mode if there is no conflicting vehicular movement (eg. one-way intersections, or separate pedestrian phase).

Anticipated Benefits of Flashing WALK Displays

The Flashing WALK pedestrian clearance display is expected to fulfill the following purpose:

- Increase pedestrian comprehension of the pedestrian clearance interval period;
- Decrease the percentage of pedestrians who start to cross during the clearance interval;
- Decrease the percentage of pedestrians in the intersection at the start of the DON'T WALK phase;
- Decrease the percentage of pedestrians who start to cross during the WALK phase but turn around during the clearance phase.

In turn, it is expected that the following benefits will be derived:

- An increased sense of security for pedestrians;
- Reduced average pedestrian delay;
- A decrease in the number of vehicle-pedestrian conflicts.

Potential Disbenefits

Since the Flashing WALK is a significant deviation from the typical pedestrian displays, there are a number of issues that should be considered:

- A flashing green ball has been used in Toronto to inform drivers that a protected left turn phase is in effect. Since most pedestrians also drive vehicles, it is possible that some pedestrians might conclude that they have a protected crossing phase, and therefore would not cross in a prudent manner; and/or
- Many pedestrians do currently realize that the Flashing DON'T WALK indication is a common display to indicate the end of the imminent end of the pedestrian right-of-way (even if they are not aware of how it is timed). These pedestrians might think that a Flashing DON'T WALK phase will follow the Flashing WALK phase and therefore, might step off the curb near the end of the clearance interval.

Human factors testing would be used to understand these issues prior to proceeding with a pilot test.

FAR SIDE PEDESTRIAN COUNTDOWN TIMER

Description and Previous Research

A countdown timer is a device mounted in the same location as a standard pedestrian head on the far side of an intersection to indicate the time left until the DON'T WALK display. This initiative supplements the existing pedestrian displays.

The intended purpose of these Countdown Timers is to enhance pedestrian comprehension of the pedestrian clearance display, thereby improving pedestrian compliance with the clearance display, and reducing the frequency of vehicle-pedestrian conflicts.

Belanger-Bonneau, Lamothe, Rannou, Joly, Bergeron, Breton, Laberge, Nadeau, & Maug (1994) determined that the use of an LED countdown timer that displays the number of seconds left for the pedestrian to cross can increase the comprehension of the clearance phase. In this study, digital count down pedestrian heads were installed along with a standard pedestrian head with the DON'T WALK indication associated with a steadily illuminated orange hand, the clearance interval associated with a flashing orange hand, and a WALK phase with a white silhouette of a pedestrian. The authors measured pedestrian head turning, vehicle-pedestrians conflicts, and whether pedestrians started to cross during the clearance phase at two experimental, and at two control intersections, in the city of Saint-Laurent, Quebec.

The digital countdown device, according to the survey, increased the feeling of safety and security of pedestrians using the crosswalks. This feeling of security was greater for persons under 17 years of age, and more than 65 years of age. The digital count down device was associated with a small increase in the level of compliance to the crossing signals at one treatment site, and a small decrease at the other site. A decrease in motor vehicle pedestrian conflicts was observed at the treatment site, but a similar reduction in conflicts was also observed at the control site. The authors did not report on the data they collected on pedestrian observing behaviour. The use of the countdown timer did not lead to an improvement in pedestrian safety.

These finding are consistent with those discussed by Baass (1990) who reported the results of a study conducted by Druilhe in Toulouse, France that found no significant change in pedestrian behaviour following the installation of count down pedestrian signals.

Huang and Zegeer (1999; 2000) conducted a comprehensive study of countdown timers in Sacramento County, California and Lake Buena Vista Florida. They found that the countdown timers reduced pedestrian compliance with the WALK sign at crosswalks in California and Florida, and increased the number of pedestrians still crossing after the steady DON'T WALK in California, and Florida. However, the increase in the number of pedestrians still crossing after the DON'T WALK was only statistically significant in California. Based on these results, and those of other studies, countdown timers were not recommended for use at standard intersections in Florida.

Another concern expressed by the research team was the documented increase in red light running when countdown signals were investigated as part of traffic signals. Motorists noting the time remaining on the pedestrian countdown display may also be more inclined to run the traffic signal or attempt to jump the signal.

Taken together the results of these studies show that Far Side Pedestrian Countdown Timers have not been demonstrated to provide a clear safety benefit to the pedestrian.

Anticipated Benefits of Far Side Pedestrian Countdown Timers

Far Side Pedestrian Countdown Timer displays are expected to fulfill the following purpose:

- Increase pedestrian comprehension of the pedestrian clearance interval period.
- Decrease the percentage of pedestrians who start to cross during the clearance interval.
- Decrease the percentage of pedestrians in the intersection at the start of the DON'T WALK phase.
- Decrease the percentage of pedestrians who start to cross during the WALK phase, but turn around and return to the curb during the clearance phase.

In turn, it is expected that the following benefits will be derived:

- An increased sense of security for pedestrians;
- Reduced pedestrian delay; and/or
- A decrease in the number of vehicle-pedestrian conflicts.

Potential Disbenefits

The following issues were raised with respect to previous Countdown Timer installations:

- A number of previous studies indicated that no significant changes in pedestrian behaviour were observed following the installation of countdown pedestrian signals; and
- There is a potential for an increase in red light running as motorists may use the time remaining on the pedestrian countdown display as a tool in the decision to run the traffic signal or attempt to jump the signal.

PASSIVE PEDESTRIAN DETECTION

Description and Previous Studies

Microwave detection is used to detect the presence of pedestrians in a crosswalk during the "flashing don't walk" phase, extend the crossing time, and to delay the onset of the conflicting vehicle movement. The intended purpose of these Passive Pedestrian Detectors is to enhance pedestrian safety by reducing the probability of having pedestrians within the crosswalk at the beginning of an cross-street vehicular through movement. It is anticipated that this will, in turn, reduce the frequency of vehicle-pedestrian conflicts.

Automatic detection has been used in the United Kingdom, the Netherlands, Sweden, Australia, and France. For the most part, research has focussed on curbside detection. It has been found that systems that use automated curbside detection reduced the percentage of pedestrians crossing during the DON'T WALK phase in Australia and Sweden (Catchpole, 1996; Ekman & Draskocsky, 1992).

Hughes, Huang, Zegeer, & Cynecki (2000) studied the use of automatic detection in conjunction with push buttons at signalized intersections, to detect pedestrians who did not push the button, and to extend the clearance interval to let slower pedestrians finish crossing. The measurement system and methodology employed in this research met the highest standards. Data were collected at intersections in Los Angeles, CA., Phoenix, AZ, and Rochester, NY. If pedestrians were detected as still crossing at the end of the clearance phase at the Los Angeles sites, the clearance phase was extended by 0.2- second increments up to a maximum of an additional 6 seconds, which corresponded to a walking speed of 0.9 m/sec, compared with the customary speed of 1.2 m/sec.

The results of this study indicated several significant benefits of the automated detection system. In particular, selectively extending the crossing time at the two Los Angeles sites using automated detection was associated with a reduction in the percentage of pedestrians who finished crossing after the signal for cross-street traffic had turned Green from 16 percent to 7 percent. These data showed that the extension capability increased the protected time for pedestrians. The number of motor vehicle-pedestrian conflicts also showed a marked decline after the introduction of automated detection with conflicts encountered by pedestrians in the first half of the crossing declining by 89 percent, and conflicts occurring during the second half of the crossing declining by 42 percent. The correlation between conflicts and collisions indicates that the system had a clear safety benefit for pedestrians. The authors concluded that automated pedestrian detectors could provide significant safety benefits when installed in conjunction with traditional push buttons at actuated traffic signals.

Anticipated Benefits of Passive Pedestrian Detection

Passive Pedestrian Detection systems, used to detect pedestrians within the crosswalk, are expected to decrease the percentage of pedestrians remaining within the intersection at the end of the intergreen period (i.e. the start of the cross-street vehicular through movement). This should, in turn, decrease in the number of vehicle-pedestrian conflicts.

Potential Disbenefits

The primary disbenefits associated with a passive detection system are the potential for "missed" or "false" calls. With respect to the technology used, the microwave detectors performed reasonably well. Heavy rain can produce false calls. In Los Angeles in rainy weather the false call rate was 3.5 percent. Through traffic in the curb lane and right-turning traffic occasionally triggered false calls. The missed call rate was 1.5 percent. Pedestrians who crossed very close to the sensor pole accounted for the missed calls.

TRI-COLOURED PEDESTRIAN HEAD

Description and Previous Studies

The tri-coloured pedestrians signal head consisted of one symbol, a silhouette of a walking pedestrian, combined with the use of a red, yellow, and green pedestrian icon in a vertical configuration similar that used with standard red, yellow, and green traffic signals. A green silhouette light of a walking pedestrian is used for the walk phase, a yellow-silhouetted light is used for the pedestrian clearance phase (to replace the flashing orange hand) and a red-silhouetted light is used for the DON'T WALK phase (to replace the orange hand).

Gourvil, Pellerin, & Hassan (1994) evaluated whether a tri-coloured pedestrian heads would be better understood by pedestrians and lead to better compliance during the pedestrian clearance phase than the standard two coloured pedestrian signal head (white silhouette of a pedestrian and the orange hand).

Eight intersections in six Quebec municipalities were selected for this study. The tri-coloured pedestrian heads were installed and an 11-question survey was administered to 1,917 pedestrians before and after the new pedestrian heads were installed. Pedestrian's behaviour at these crosswalks was also observed before and after the new signals were installed to determine the level of compliance to the standard and tri-coloured pedestrian heads.

The results of the pedestrian survey indicated that the tri-coloured pedestrian head was better understood than the standard pedestrian head. There was no difference in pedestrian understanding between the standard pedestrian heads and the tri-coloured heads for the WALK and DON'T WALK indications; however, there was an increase in the understanding of the yellow silhouetted pedestrian when compared to the flashing orange hand to prompt pedestrians not to begin to cross (78% vs. 58%).

Observations of pedestrian behaviour at crosswalks indicated that the tri-coloured pedestrian heads did not increase pedestrian compliance at crosswalks. The authors concluded that pedestrians better understood the clearance phase when the tri-coloured heads were used. However, pedestrians did not show any better compliance with the tri-coloured pedestrian signal heads. The authors also report no safety benefits in installing the tri-coloured signal heads. After weighing the costs against the benefits the experimenters concluded that the use of tri-coloured pedestrian heads was not justified.

Anticipated Benefits of Tri-Coloured Pedestrian Heads

The primary objective of the tri-colored pedestrian display is to reduce motor vehicle-pedestrian conflicts by decreasing the percentage of pedestrians who start to cross during the clearance interval and the percentage of pedestrians in the intersection during the DON'T WALK phase.

Potential Disbenefits

Although there appeared to be a better understanding of the clearance phase when the tri-coloured heads were used, previous studies did not demonstrate improved pedestrian compliance or safety benefits.

LEADING PEDESTRIAN INTERVAL

Description and Previous Studies

A leading pedestrian interval (LPI) will provide pedestrians with a 'head-start' to access the crosswalk before potentially conflicting vehicles are permitted to proceed. Drivers are more likely to yield the right-of-way to pedestrians who are already in the crosswalk, versus those leaving the curb. This is a function of the pedestrian's visibility within the crosswalk for drivers waiting for the light to change. It is also possible that the presence of pedestrians in the crosswalk might decrease the incidence of drivers hurrying in an attempt to turn before pedestrians enter the intersection.

The FHWA document '*Designing Sidewalks and Trails for Access, Part 2 – Best Practice Design Guide*' (2001) advocates the use of leading pedestrian intervals to generally improve pedestrian conditions at signalized crossings.

Also, the Pedestrian and Bicycle Information Center of the FHWA has just released its '*Pedestrian Facilities User Guide'* (2002) that outlines a number of recent research outcomes on a variety of pedestrian-related safety programs. The Guide is a strong advocate of the exclusive pedestrian phasing, and argues that leading pedestrian intervals of three to six seconds in duration are effective in making pedestrians more visible for motorists.

The LPI has been implemented in a number of North American cities and successfully operated over a number of years. In particular, New York City has operated such an advanced feature for pedestrians for almost 20 years. The Guide indicates that studies conducted in New York have shown that LPIs reduce conflicts for pedestrians.

Anticipated Benefits of Leading Pedestrian Intervals

The use of leading pedestrian intervals at traffic control signals will provide pedestrians with a WALK indication prior to the vehicle Green in the same direction. This is expected to provide the following benefits:

- An increased sense of security for pedestrians;
- An improved conspicuity for the pedestrians in the crosswalk;
- A potential increase in vehicle yielding; and
- A decrease in the number of vehicle-pedestrian conflicts during vehicle turning movements.

Potential Disbenefits

The leading pedestrian phase will be concurrent with a red ball display for vehicles. Vehicles attempting to make a right-turn-on-red during the leading pedestrian interval, may not observe this right-of-way, as their attention may be focussed on their signal display, and vehicles approaching from their left. The potential for an increase in pedestrian-vehicular collisions of this type may increase, in this regard.

SELECTION OF PEDESTRIAN INITIATIVES

The Toronto Pedestrian Committee was consulted and provided input into the pedestrian safety initiatives to be included in the scooping study. It was determined that the six Pedestrian Safety Initiatives to be carried forward in the study were:

- Broad Pavement Markings;
- Pavement Level Delineation Lighting;
- Flashing WALK display;
- Far side Pedestrian Countdown Timer;
- Passive Pedestrian Detection; and
- Leading Pedestrian Interval.

STUDY DESIGNS

The next step in the process was to develop study designs for the six PSIs. Each study design included a:

- Description of the PSI and anticipated benefits;
- Candidate sites and the site selection process;
- Specifications for the initiative;
- Installation requirements;
- Evaluation methodology including measures of effectiveness, recommended data collection and analysis methodologies;
- Education program requirements;
- Implementation plan including schedule and budget estimates; and
- Deliverable format.

The following sections describe some of the components of the study designs.

GENERAL SPECIFICATIONS

General specifications were prepared for each of the PSI's. The specifications included a general description, the functional requirements, and contact information for potential suppliers. It also provided:

Material Requirements

The specifications were performance-based to allow for a maximum degree of flexibility in choosing commercially available, off-the-shelf products. This flexibility was desirable to meet the requirements of the City's Purchasing policies.

Installation Requirements

The Installation Requirements identified where the proposed technologies should be installed, how they would be mounted, and how they were to be connected and integrated into the associated systems. These specifications included special provisions to ensure that the contractor works within the standards required for City of Toronto traffic systems installations. Specifically, the installations must (a) be compatible with Toronto methodologies, (b) accommodate associated Toronto devices and infrastructure, (c) be completed with the necessary City (and other) approvals, and (d) demonstrate that the workmanship is up to City standards. They also included typical installation drawings for each PSI.

EVALUATION METHODOLOGY

The main goal of the this task was to establish an evaluation methodology for each initiative that:

- Minimizes the time and data collection activities/cost while producing a statistically valid, reproducible and defendable product;
- Is easily understood and applied in the PSI Project;
- Includes control groups or "baseline" levels of safety to reduce the likelihood of unforeseen biases such as changes in enforcement activities, changes in driver or pedestrian characteristics, weather, season, etc.; and
- Concrete data collection procedures.
- Recognizing that the appropriate evaluation methodology for one form of pedestrian treatment may or may not be the most suitable for another treatment, it is proposed that the merits of various evaluation procedures and their components were weighed against to the needs of each field test initiative.

There are several alternative statistical models that were considered to evaluate the pedestrian initiatives. They include: Observational Before-After Comparison Group (C-G) Method, Empirical Bayes (EB) Method; and The Risk Analysis Methods. Each method has strengths and weaknesses, and different needs in terms of the number and type of data entries. Therefore, it was important to establish with City of Toronto staff the acceptable length of an evaluation study, scope, and budget.

After considering the City of Toronto requirements, it was decided that a 'time series' study design would be used in place of the traditional 'before and after' study. This study design uses a baseline and replication logic to demonstrate repeatability of study results. The structure of the study has built-in controls that limit the ability of 'confounding' factors (such as unusually heavy congestion, weather, nearby roadworks, etc.) to spoil the data collected. The absence of these controls in standard 'before and after' study designs seriously limit their validity.

Time series designs all begin by obtaining 'baseline' or 'before' measures followed by the collection of data during the 'after' condition. Next the PSI are sequentially introduced at a number of additional sites that also serve as a control for other factors. This is referred to as a 'multiple baseline design'.

Data Requirements/Collection

Data was to be collected for the Measures of Effectiveness (MOEs) as identified in the evaluation methodology for each PSI. The data collection periods include:

- *Condition 1*: Baseline (existing). This is just a pre-treatment assessment to serve as a benchmark against which the treatment will be evaluated. Data is collected at two independent locations (sites).
- *Condition 2*: The PSI is implemented at one site. The purpose of this test is to perform a “before and after” type comparison at the first site. The remaining sites do not receive the treatment and therefore serve as a control for other factors such as weather, enforcement, etc.
- *Condition 3*: The PSI is implemented at the second site and remains in effect at the first site. This serves as a replication and also demonstrates that the failure of the second site to change, when the first site was treated, was not due to this site being insensitive to treatment.
- *Condition 4*: The PSI is implemented at the third site (if applicable) and remains in effect at the first and second sites. This serves as an additional replication.

Forty (40) observations per session were required. This sample size was determined by the likely accumulation of useful data from the least frequently occurring MOE.

Inter-observer Agreement

For the data collection, it was proposed that two observers (provided with the same training) would independently record vehicle-pedestrian conflicts and driver yielding behaviour during each of the above-noted sessions during each Condition. When this type of data collection process is established, inter-observer agreement is an important requirement. A measure of inter-observer agreement can be computed by dividing the number of agreements on the occurrence of each behaviour by the number of agreements on the occurrence of each behaviour plus the number of disagreements. Standard convention for agreement on occurrence of behaviour is to accept levels of agreement over 70%.

If adequate levels of inter-observer agreement are not obtained during the training session, it suggests one of the following problems.

1. There is a problem with the definition.
2. The task was too complex for the observers.
3. The observation period is too long.
4. One of the observers may be biased.

Solutions were suggested for each of the problems.

EDUCATION PROGRAM

The education program for the PSI’s generally included the following components:

- A media release outlining the broader Pedestrian Safety Initiative program and the specifics of the broad pavement markings PSI.
- A black-and-white two-page pamphlet providing background information on the proposed PSI, anticipated benefits, where they will be located, and identifying numbers to call and/or email addresses for additional information. A sufficient quantity of the pamphlets will be produced to distribute at the public meetings, to the local Councillors, and to City of Toronto staff
- Web-ready HTML pages reproducing all the content of the information pamphlet produced for the purposes of mounting the pages on the City of Toronto website.

- A conference between the Consultant, the City Project Manager, and the local City Councillors to discuss the project and to establish liaison with various community groups.
- A presentation to five (5) community groups in the immediate vicinity of each of the PSI (for a total of ten presentations) to describe the project and expected benefits. The information pamphlets noted above would be distributed at each public meeting.

To evaluate the effectiveness of the pilot program's education program, the study design included follow-up discussions with the local councillors and District Traffic Operations offices to assess feed-back on the education program and on the associated PSI (i.e. requests for information and complaints).

- Prepare and conduct a one-day on-street survey to gauge local awareness of the PSI. This survey would investigate the following:
  - How well is the use of the PSI understood?
  - The means of learning of the PSI?
  - Were there enough meetings held regarding the proposed PSI?
  - Was the information content appropriate for the audience?
  - Does the respondent suggest additional avenues of information dissemination?
- The on-street survey would be supplemented with these supplementary investigations:
  - Were the appropriate internal and external stakeholders involved?
  - Were the internal and external communications adequate for the study?

INITIATIVE SPECIFIC ISSUES

The initiative specific issues deal with the selection of evaluation sites, and the measures of effectiveness to be analyzed. These issues are summarized by PSI.

Broad Pavement Markings

Evaluation Sites - Site Location Criteria

The sites considered for the evaluation of this PSI were compared against two sets of screening criteria. Firstly, the sites must comply with certain *Basic Requirements* that are prerequisites for consideration. The *Basic Requirements* are:

- The intersection has traffic control signals;
- The traffic signal has existing transverse crosswalk lines;
- The road surface is asphalt, and there is no concrete inlay to delineate the pedestrian crosswalk (i.e. white pavement markings may not provide sufficient contrast when applied over the light grey concrete crosswalks);
- The site will not require modifications to accommodate the evaluation study (e.g. has a full complement of pedestrian heads);
- There is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study;
- The site has a sufficiently high pedestrian volume to provide one observation per cycle (i.e. more than one pedestrian crossing the desired crosswalk each cycle);
- The site has a sufficiently high vehicle turning volume to provide one observation per cycle (i.e. one or more vehicles waiting to turn right or left when a pedestrian is present on a Green display, and one or more vehicles waiting to turn right-on-red when a pedestrian is present in the crosswalk); and
- There is a visually 'busy' environment.

The second screening criteria are qualitative characteristics that will help to select the best possible location. The *Desirable Characteristics* applied to all of the PSIs. These *Desirable Characteristics* are:

- the site has a long pedestrian crossing (crossings with multiple approach lanes in one direction of travel pose a grater risk to pedestrians);
- the site has not experienced significant road modifications affecting the alignment of the crosswalk in the previous year (pedestrians are accustomed to the existing crosswalk configuration and operation);
- the site is currently free of other trials, pilot tests or other special circumstances that may alter motorist and/or pedestrian behaviour;
- the site has a convenient vantage point for observations to be collected;
- the site has as high a pedestrian crossing volume as can be selected to reduce the length of the data collection period; and
- the site has as high a vehicle through volume as can be selected to reduce the length of the data collection period.

The Broad Pavement Markings should be installed at two test sites. The sites selected would be the middle intersections within series of seven traffic control signals. This approach will 'acclimatize' motorists to the PSI treatment before they reach the subject intersections. This series of traffic control signals will ideally be situated on a relatively straight roadway with regular spacing between each location.

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of left turning, and right turning vehicles that yield or don't yield to pedestrians in the crosswalk. A vehicle has 'yielded' if the motorist waits for the pedestrian to cross even though there is a gap in traffic. Vehicles are considered to have 'not yielded' if the motorist turns though there is less than a full lane width between themselves and the pedestrian crossing in the direction of the turning vehicle.
- The percentage of vehicle-pedestrian conflicts during the WALK and pedestrian clearance intervals. A conflict is defined as any situation in which the driver does not yield appropriately and engages in abrupt braking, or either the driver or pedestrian take sudden evasive action to avoid a collision.
- The percentage of pedestrians involved in conflicts who began their crossing outside of the pedestrian crosswalk.

Pavement Level Delineation Lighting

Evaluation Sites - Site Location Criteria

The *Basic Requirements* are:

- the site has an existing pedestrian crossover;
- the PXO is a standard layout, and is not a split PXO (or SPXO)
- the site is not on a streetcar route, as this would unnecessarily escalate the costs of the pilot installation;
- there is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study (to avoid disrupting the data collection process); and
- the selected sites should be remote from each other. This approach will minimize the possibility of one site affecting the observed behaviours of the second site.

The Pavement Level Delineation Lighting should be installed at three pedestrian crossover sites

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of vehicles that yield to pedestrians in the PXO.
- The vehicle stopping distance from the PXO crossing.
- The percentage of vehicle-pedestrian conflicts.

Flashing WALK Display

Evaluation Sites - Site Location Criteria

The *Basic Requirements* are:

- the intersection has traffic control signals;
- the site will not require modifications to accommodate the evaluation study (e.g. has a full complement of pedestrian heads);
- the traffic signal currently employs a Flashing DON'T WALK display;
- there is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study;
- the site has a sufficiently high pedestrian volume to observe pedestrians beginning their crossing through the WALK indication and into the clearance period; and
- the site has a sufficiently high vehicle through and turning volume to provide vehicles turning across the subject crosswalk each cycle, and conflicting through vehicles waiting to proceed across the crosswalk at the end of the pedestrian right-of-way (i.e. at the next cross-street Green display).

The Flashing WALK pedestrian clearance display should be installed at three sites.

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of pedestrians who begin to cross during the WALK interval.
- The percentage of pedestrians that begin to cross during the clearance phase.
- The percentage of pedestrians that begin to cross during the DON'T WALK interval.
- The percentage of pedestrians who start to cross during the pedestrian clearance interval who are still in the crosswalk during the DON'T WALK interval.
- The percentage of pedestrians who start to cross during the pedestrian clearance interval who are still in the crosswalk when the cross-street traffic receives the Green indication.
- The percentage of pedestrians that turn around and return to the curb when the Flashing DON'T WALK display appears.
- The number of vehicle-pedestrian conflicts with turning vehicles.
- The number of vehicle-pedestrian conflicts with through vehicles after the traffic has been released on the cross-street.

Human Factors Testing

There are several reasons for proceeding cautiously before implementing the Flashing WALK display. First, a Flashing Green Ball has been used in Toronto to inform drivers that a protected left turn phase is in effect. Since most pedestrians also drive vehicles, it is possible that some pedestrians might conclude that they have a protected crossing phase and therefore would not cross in a prudent manner.

Second, many pedestrians do currently realize that the Flashing DON'T WALK indication is a common display to indicate the end of the imminent end of the pedestrian right-of-way (even if they are not aware of how it is timed). These pedestrians might think that a Flashing DON'T WALK phase will follow the Flashing WALK phase and therefore, might step off the curb near the end of the clearance interval.

To ensure that this treatment is safe, some basic human factors testing is recommended in advance of any installations. Ideally, reaction to the display would measured using a sample of pedestrians in an closed-road setting. The use of a 'Safety Village' environment was considered as a potential surrogate for a live road environment. However, further investigation determined that the Safety Village experience would not approximate a real-life scenario. Consequently, the effort and cost to organize such testing could not be justified by the questionable benefits.

As an alternative, a survey process is proposed, wherein a sample of 200 pedestrians should be presented with 6 seconds of video showing the Flashing WALK, the solid WALK and the flashing "DON'T WALK" on videotape on separate trials in a random order. The sample should be stratified for age, and gender.

Before viewing the videos the participants should be given the following instruction: "Imagine you are walking and come to an intersection and see the following display on the pedestrian signal." The brief video segment should then shown to the participants. Participants should be informed that they will be asked a series of questions and that it is important that they do not change the answers to previous questions when asked additional questions.

Question #1: "What is the meaning of this signal?"

Question #2: "What should you do if you see this signal?"

Question #3: "Should you begin to cross the street or wait on the curb?"

Question #4: "What signal will follow this signal on the pedestrian signal head?"

It was recommended that only if it is clear that the Flashing WALK will not lead to dangerous reactions should this PSI proceed to a field study.

Far Side Pedestrian Countdown Timer

Evaluation Sites - Site Location Criteria

The *Basic Requirements* are:

- the intersection has traffic control signals;
- the site will not require modifications to accommodate the evaluation study (e.g. has a full complement of pedestrian heads);
- the traffic signal currently employs a Flashing DON'T WALK display;
- the traffic signal is not currently equipped with an audible pedestrian signal (APS), as this would provide additional cues to the pedestrian and would make comparisons with non-APS sites inappropriate;

- there is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study;
- the site has a sufficiently high pedestrian volume to observe pedestrians beginning their crossing through the WALK indication and into the clearance period.; and
- the site has a sufficiently high vehicle through and turning volume to provide vehicles turning across the subject crosswalk each cycle, and conflicting through vehicles waiting to proceed across the crosswalk at the end of the pedestrian right-of-way (i.e. at the next cross-street Green display).

Far Side Pedestrian Countdown Timers should be installed at three sites.

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of pedestrians who begin to cross during the: WALK interval.
- The pedestrian of pedestrians that begin to cross during the clearance phase.
- The percentage of pedestrians that begin to cross during the DON'T WALK interval.
- The percentage of pedestrians remaining within the crosswalk during the DON'T WALK interval.
- The percentage of pedestrians remaining within the crosswalk when the cross-traffic receives the Green indication.
- The percentage of pedestrians that turn around and return to the curb when the Flashing DON'T WALK display appears.
- The number of vehicle-pedestrian conflicts with turning vehicles (focus on the countdown timer could reduce visual scanning for turning vehicles).
- The number of vehicle-pedestrian conflicts with through vehicles after the traffic has been released on the cross-street.

Passive Pedestrian Detection

Evaluation Sites - Site Location Criteria

The *Basic Requirements* are:

- the intersection has traffic control signals;
- the site currently operates with a Flashing Don't WALK display;
- the traffic signal controller must be capable of handling the proposed operation;
- the site will not require modifications to accommodate the evaluation study (e.g. has a full complement of pedestrian heads);
- there is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study;
- the site has a sufficiently high pedestrian volume to observe pedestrians beginning their crossing through the WALK indication and into the clearance period.; and
- the site has a sufficiently high vehicle through and turning volume to provide vehicles turning across the subject crosswalk each cycle, and conflicting through vehicles waiting to proceed across the crosswalk at the end of the pedestrian right-of-way (i.e. at the next cross-street Green display).

The Passive Pedestrian Detection should be installed at three sites.

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of pedestrians who start to cross during the WALK signal.
- The percentage of pedestrians who start to cross during the Clearance interval.
- The percentage of pedestrians who are still in the crosswalk when cross-street traffic has the Green signal.
- The percentage of vehicle-pedestrian conflicts.

Leading Pedestrian Intervals

Evaluation Sites - Site Location Criteria

The *Basic Requirements* are:

- The intersection has traffic control signals;
- The site will not require modifications to accommodate the evaluation study (e.g. has a full complement of pedestrian heads, crosswalk markings are in place, etc.);
- There is a reasonable degree of assurance that the site will be free of construction activity through the period of the evaluation study (assessed by checking the Five Year Capital Works program);
- There is no existing signal phasing that would preclude the proposed application (i.e. advanced left turn features);
- The site has a sufficiently high pedestrian volume to provide one observation per cycle (i.e. more than one pedestrian crossing the desired crosswalk each cycle);
- The site has a sufficiently high vehicle turning volume to provide one observation per cycle (i.e. one or more vehicles waiting to turn right when a pedestrian in present on a GREEN display); and
- There is a visually ‘busy’ environment.

The Leading Pedestrian Interval PSI should be installed at three locations.

Measures of Effectiveness

The measures of effectiveness to be used in this evaluation study are:

- The percentage of left and right turning vehicles that yield (or fail to yield) to pedestrians that begin to cross during the leading WALK interval.
- The percentage of pedestrian/motor vehicle conflicts for pedestrians that begin to cross during the leading WALK interval.
- The percentage of left and right turning vehicles that yield (or fail to yield) to pedestrians that begin to cross during the remainder of the WALK interval.
- The percentage pedestrian motor/vehicle conflicts for pedestrians that begin to cross during the remainder of the WALK interval.
- The percentage of pedestrians that begin to cross during the first 4 seconds of the WALK interval that stop and signal a vehicle to proceed by waving them on. This is a measure of pedestrians discomfort with turning vehicles and represents their giving up right of way.
- The percentage of pedestrians that begin to cross during the remainder of the WALK interval that stop and signal a vehicle to proceed before them.

PILOT TEST ANTICIPATED COSTS

Detailed pilot project cost estimates are provided in the table below and reflect the following items:

- Equipment procurement and/or installation;
- Maintenance of during pilot test;
- Human factors testing, as required;
- Data collection;
- Reliability, testing and training associated with equipment, as required;
- Education program which will include information pamphlet preparation, web-page preparation, local Councillor meeting and meetings with three local organizations per site. Up to nine groups (organizations) would be approached for each initiative; and
- Consultant fees associated with project management, data analysis and report writing.

Pilot Projects Detailed Breakdown of Cost Estimates	
Broad Pavement Markings	
Item	**Estimated Cost**
Equipment and Installation	$56,000
Maintenance	N/A[1]
Data Collection	$6,000
Project Management, Analysis and Education Program [2]	$35,000
Reliability, Testing and Training	$2,000
Total	**$99,000**
Pavement Level Delineation Lighting	
Item	**Estimated Cost**
Equipment and Installation	$75,000
Procurement of Pavement Level Delineation Lighting	$15,000
Maintenance	$6,000
Data Collection	$18,000
Project Management, Analysis and Education Program [2]	$30,000
Reliability, Testing and Training	$4,000
Total	**$148,000**
Flashing WALK Display	
Item	**Estimated Cost**
Equipment and Installation	$6,000
Maintenance	$0 [4]
Data Collection	$18,000
Project Management, Analysis, Education Program and Human Factors Testing [2, 3]	$44,500
Reliability, Testing and Training	$12,000
Total	$80,500
Far Side Pedestrian Countdown Timer	
Item	**Estimated Cost**
Equipment and Installation	$18,000
Procurement of Countdown Timers	$15,000
Maintenance	$6,000

Pilot Projects Detailed Breakdown of Cost Estimates	
Data Collection	$18,000
Project Management, Analysis and Education Program [2]	$36,500
Reliability, Testing and Training	$7,000
Total	**$100,500**
Passive Pedestrian Detection	
Item	**Estimated Cost**
Equipment and Installation	$18,000
Procurement of Passive Pedestrian Detection	$15,000
Maintenance	$6,000
Data Collection	$18,000
Project Management, Analysis and Education Program [2]	$36,500
Reliability, Testing and Training	$8,000
Total	**$101,500**
Leading Pedestrian Interval	
Item	**Estimated Cost**
Equipment and Installation	$3,000
Maintenance	N/A[4]
Procurement	N/A[5]
Data Collection	$18,000
Project Management, Analysis and Education Program [2]	$36,500
Reliability, Testing and Training	$4,000
Total	**$61,500**

Notes:

(1) It is not anticipated that the broad pavement markings will require reapplication during the study duration
(2) Printing associated with the education program activities will be borne by the City of Toronto
(3) Includes $8,000 dollars for human factors testing activity (for Flashing WALK)
(4) Maintenance of pedestrian head and operations will be carried out through the City's existing maintenance agreements.
(5) No material purchases are required.
(6) N/A – not applicable

NEXT STEPS

This project, which produced a background report, consultation with pedestrian safety advocates, and the preparation of six standalone study designs, put the City of Toronto staff in the position to secure funding from City of Toronto Council to proceed. At the time of writing, City staff had secured funding to proceed with studying three of the six PSIs.

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