An Evaluation of the LightGuard™ Pedestrian Crosswalk Warning System

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EXECUTIVE SUMMARY

In the spring of 1997, a flashing crosswalk was installed on Livingston Street in Orlando, Florida. It connects a Marriott hotel to the south with a theater and walkways leading to the Orlando Arena to the north. Two conventional crosswalks are west of the flashing crosswalk.

This evaluation was conducted to determine the effects of the flashing crosswalk on pedestrian and motorist behavior. Both before-and-after and treatment-and-control data were collected. The before-and-after data focused on vehicle speeds and vehicle yielding. The treatment-and-control data pertained to: (1) pedestrian crossing locations relative to the flashing crosswalk, with and without police officers; (2) pedestrian-motor vehicle conflicts; (3) pedestrian activation of the flashing crosswalk; and (4) pedestrian interviews.

The flashing crosswalk had small positive effects on reducing vehicle speeds, increasing vehicle yielding to pedestrians, and reducing pedestrian - motor vehicle conflicts. It was not very effective in channelizing pedestrians. These findings are described in the following paragraphs.

Curb-lane vehicle speeds in the “before” period averaged 27.6 miles per hour (44.4 km/h) when a pedestrian was present and 29.1 miles per hour (46.9 km/h) when no pedestrians were present. After the flashing crosswalk was installed, the average speeds declined by 1.9 and 0.8 miles per hour (3.1 and 1.3 km/h), respectively, but the declines were not significant.

More motorists stopped or slowed down for a pedestrian after the flashing crosswalk was installed (13 percent “before” vs. 34 percent “after” when the flashers were activated and 47 percent “after” when the flashers were not activated) (significant at the 0.001 level). It is not clear why fewer motorists stopped or slowed down when the flashers were flashing than when they were not flashing, but this difference was not significant.

About 28 percent of the pedestrians observed when police officers were not present crossed in the flashing crosswalk. The remainder crossed elsewhere, depending on what was the most convenient path between their origins and destinations.

Prior to opera performances, one or more police officers directed pedestrians as they crossed from the Marriott hotel to the theater. The officers directed pedestrians to cross in the flashing crosswalk, and more than half (57 percent) did so. The remaining 43 percent walked along more direct routes, outside the flashing crosswalk.

Of the pedestrians who crossed in the flashing crosswalk, 40 percent did not experience any conflicts. This compared to 22 percent of those who crossed within 30 feet (9.2 m) and only 13 percent of those who crossed elsewhere. Motorists were more likely to stop or slow for pedestrians who crossed in or near the flashing crosswalk than those who crossed elsewhere.

Nearly three-fourths (73 percent) of pedestrians entered the roadway in-between the sensors, thereby activating the flashing crosswalk. The flashers never failed to activate when someone walked between the sensors.

The pedestrian interviews suggested that most people did not understand how the flashing crosswalk works. Several people said that they did not know the flashers work during the day.

Guidelines were developed for installing flashing crosswalks based partly on the results of this study and on previous testing in California and Washington State. Conditions most appropriate for their use include uncontrolled locations, average vehicular approach speeds of 45 miles per hour (72 km/h) or less, average daily traffic volumes of 5,000 to 35,000, adequate sight distance for motorists to see the flashers, no other crosswalks or traffic control devices within 250 feet (76 m), and a minimum of 100 pedestrians per day. It is not known how flashing crosswalks will ultimately affect pedestrian crashes under various site conditions. Further testing of these and other pedestrian warning devices is recommended.

INTRODUCTION

Crossing streets at uncontrolled midblock locations can pose a serious risk to pedestrians, accounting for as many as 26 percent of all crashes according to a review of crash data from six states (Hunter *et al.*, 1996). An older study performed for the National Highway Traffic Safety Administration found that 39 percent of pedestrian-motor vehicle crashes in urban areas were midblock (Knoblauch, 1975).

When vehicle volumes and speeds are high, few adequate gaps may exist for pedestrians to cross the street safely. Driver expectancy for pedestrians crossing at mid block sites may be low. In addition, the driver may physically not see the pedestrian because the pedestrian is obscured by parked vehicles along the curb or by a vehicle in the curb lane that has stopped to allow the pedestrian to cross.

Local agencies may paint crosswalks at midblock locations based on average daily traffic, pedestrian volumes, and other warrants. However, even if a crosswalk has been painted across the roadway, the driver may not notice the crosswalk, particularly if the markings are faded or if no pedestrian warning signs are in place. Furthermore, crosswalks and pedestrians can be extremely difficult to see at night.

To enhance visibility at midblock crosswalks, cities may use high-visibility (continental) crosswalk markings, or they may install supplementary signs and devices. For example, Clearwater, Florida uses an internally-illuminated overhead sign (Figure 1). Portland, Oregon, and several cities in New York State are experimenting with a “YIELD TO PEDESTRIANS” sign that is mounted on a traffic cone placed at the crosswalk, on the centerline of the roadway (Figure 2).

Figure 1. Internally illuminated overhead sign in Clearwater, Florida.

Figure 2. Sign used in New York State.

Tucson, Arizona, has several pedestrian-activated overhead LED signs (STOP FOR PEDESTRIANS IN CROSSWALK) (Figure 3). Toronto, Ontario, Canada has hundreds of internally-illuminated overhead signs and beacons that flash when activated, as illustrated in Figure 4.

Figure 3. Pedestrian-activated overhead sign in Tucson, Arizona

Orlando, Florida and Santa Rosa, California are among the cities that are currently testing in-pavement types of flashing crosswalk displays. These consist of lights embedded in the roadway on both sides of the crosswalk. Upon activation by a pedestrian, the lights flash at oncoming motorists, thereby alerting them to one or more pedestrians in the crosswalk. Two companies that manufacture flashing crosswalks are Flight Light, Inc. (based in Sacramento, California) and LightGuard™ Systems, Inc. (based in Santa Rosa, California).

This report describes an evaluation of a prototype installation of the LightGuard™ Pedestrian Crosswalk Warning System in Orlando, FL. The evaluation was conducted by the University of North Carolina Highway Safety Research Center (HSRC) with the assistance of the Center for Applied Research (CAR) during 1997 and 1998. The LightGuard™ evaluation was part of a larger Florida Department of Transportation Safety Office research effort focusing on improving pedestrian and bicyclist safety.

Figure 4. Toronto, Ontario, Canada has hundreds of internally-illuminated overhead signs and beacons that flash when activated.

EXPERIENCES WITH THE LIGHTGUARD™ FLASHING CROSSWALK SYSTEM

From 1994 through 1998, the LightGuard™ flashing crosswalk system was installed in six California cities and two sites in Kirkland, Washington. Based on before-and-after evaluations, drivers were more aware of the flashing crosswalks than they were of conventional crosswalks (Whitlock & Weinberger, 1995 and 1998). Drivers were observed to apply their brakes earlier with the flashing crosswalks than with the conventional painted crosswalks. The flashing crosswalk resulted in higher percentages of drivers yielding to pedestrians than in the conventional crosswalk situation in the tests in California and Washington. The effects of the flashing crosswalks were more pronounced at night and during inclement weather than during the day and under clear weather conditions. In terms of implementation, pedestrians reported being less confused by the use of an automated detection system than the use of push buttons to activate the flashers. The effectiveness of the flashing crosswalk was also found to depend upon the amount of parking activity in the area, the amount of pedestrian activity on the sidewalks near the crosswalk, traffic volume, and the length of time that the lights flash (Whitlock & Weinberger, 1995 and 1998).

SITE DESCRIPTION

During the Spring of 1997, the City of Orlando installed a prototype LightGuard™ Pedestrian Crosswalk Warning System on Livingston Street, just west of downtown Orlando (Figure 5). The “flashing crosswalk,” as it is referred to throughout this report, connects a Marriott hotel to the south with the Bob Carr Performing Arts Centre (referred to as the Theater) and walkways leading to the Orlando Arena to the north. The flashing crosswalk is 30.5 ft (9.3 m) wide. Sporting events, concerts, and conventions all take place in the Arena. Prior to the installation of the flashing crosswalk, a crosswalk with continental-style markings, but no flashers, existed at this location. A photograph of the installation looking south from the Theater toward the Marriott is shown in Figure 6.

Two other crosswalks with continental-style markings, but no flashers, are located on Livingston Street, west of the flashing crosswalk. These crosswalks, termed Crosswalks A and B, were used as comparison sites for the flashing crosswalk (see “Data Collection Procedures,” below). Crosswalk A connects the east lobby entrance of the Expo Centre with Arena parking and is 123 to 138 ft (37.5 to 42.1 m) west of the flashing crosswalk. Crosswalk B is further west and connects the west lobby entrance of the Expo Centre with Arena parking. The entire study site, including the flashing crosswalk and Crosswalks A and B, is depicted in Figure 7.

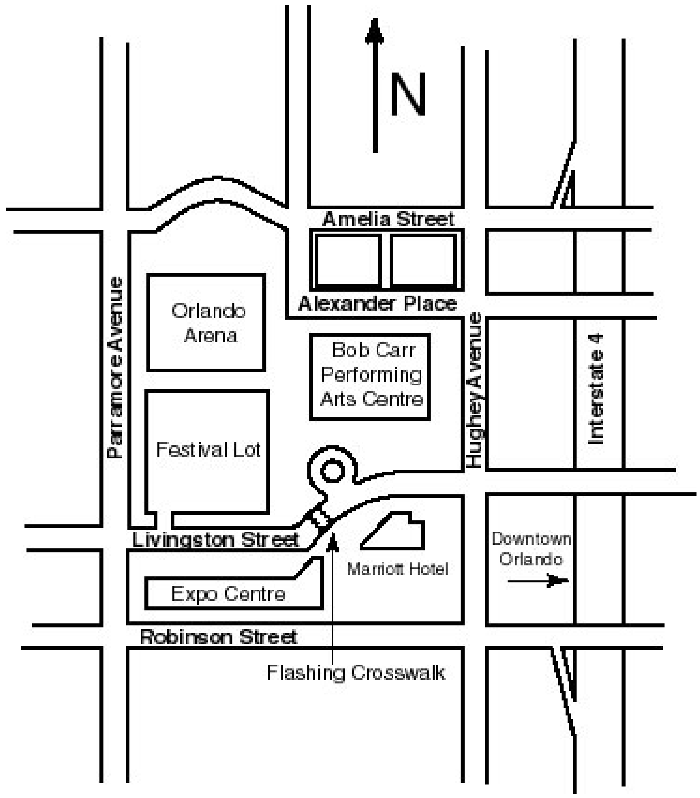


Figure 5. The flashing crosswalk in just west of Downtown Orlando.
Note: Map is not to scale.

Figure 6. Photograph of flashing crosswalk, looking south toward the Mariott Hotel and the Expo Centre.

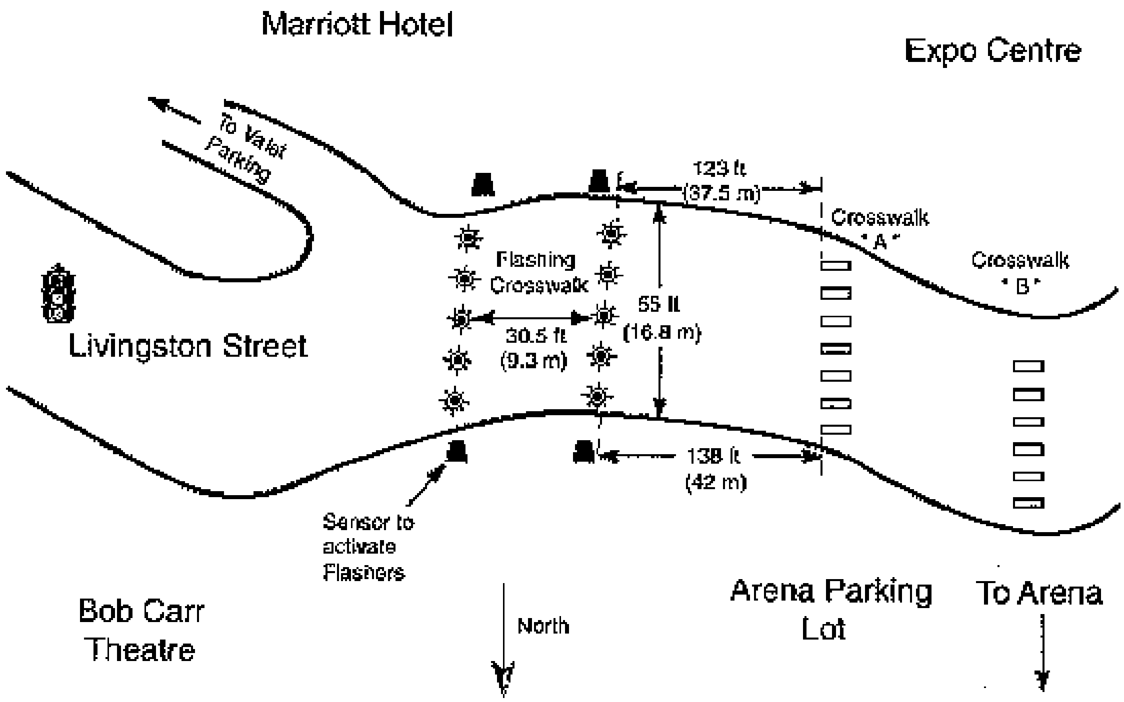


Figure 7. The entire study area, including the flashing crosswalk and Crosswalks A and B. Note: Map is not to scale.

It was desired that the flashing crosswalk be activated automatically and not require pedestrians to push a button. This is because pedestrian push buttons, as traditionally used in the U.S., when pushed, will activate a WALK display and a corresponding red traffic signal, thus requiring opposing traffic to stop. Therefore, it was thought that providing a pedestrian push button in conjunction with the flashing crosswalk might give pedestrians the false impression that motorists would be required to stop once the flashers were activated. However, the flashing crosswalk is only an advanced warning device for motorists, so pedestrians must be alert and wait for a safe gap in traffic before crossing.

The LightGuard™ representatives wanted to ensure that pedestrians did not see the crosswalk flashing and then take unnecessary risks by stepping out in front of oncoming traffic. Thus, the flashers were designed to be directed at oncoming motorists, not pedestrians waiting to cross the street.

At the Orlando site, an ultrasonic detector that was installed on an overhead mast arm was initially used to detect pedestrians waiting to cross the street and activate the flashers. However, the ultrasonic detector did not operate properly, so it was removed. As currently implemented, the LightGuard™ flashing crosswalk system consists of in-pavement flashing lights ("flashers") and sensors. The flashers are imbedded in the pavement and delineate the edges of the crosswalk

(Figure 8). When the flashers have been activated, approaching motorists from either direction will see a row of flashers, all flashing in unison.

The sensors are built into two bollards on both sides of the street. The distance between the bollards is less than the width of the crosswalk. One sensor emits a beam of light which is received by the other sensor. Pedestrians activate the flashers by stepping between the bollards and breaking the beam of light. If a pedestrian starts crossing the street outside of the bollards, the flashers do not activate. The sensors are direction-sensitive: if a pedestrian walks into the street outside of the bollards and then walks to either curb in between the bollards, the flashers do not activate. In other words, a pedestrian must pass between the bollards while walking into the street from the curb in order to activate the flashers. If activated, the flashers flash instantly and flash for approximately 20 seconds. The total cost of the system, including equipment and labor, was approximately $20,000. Detailed system specifications are given in Table A-1 in the Appendix.

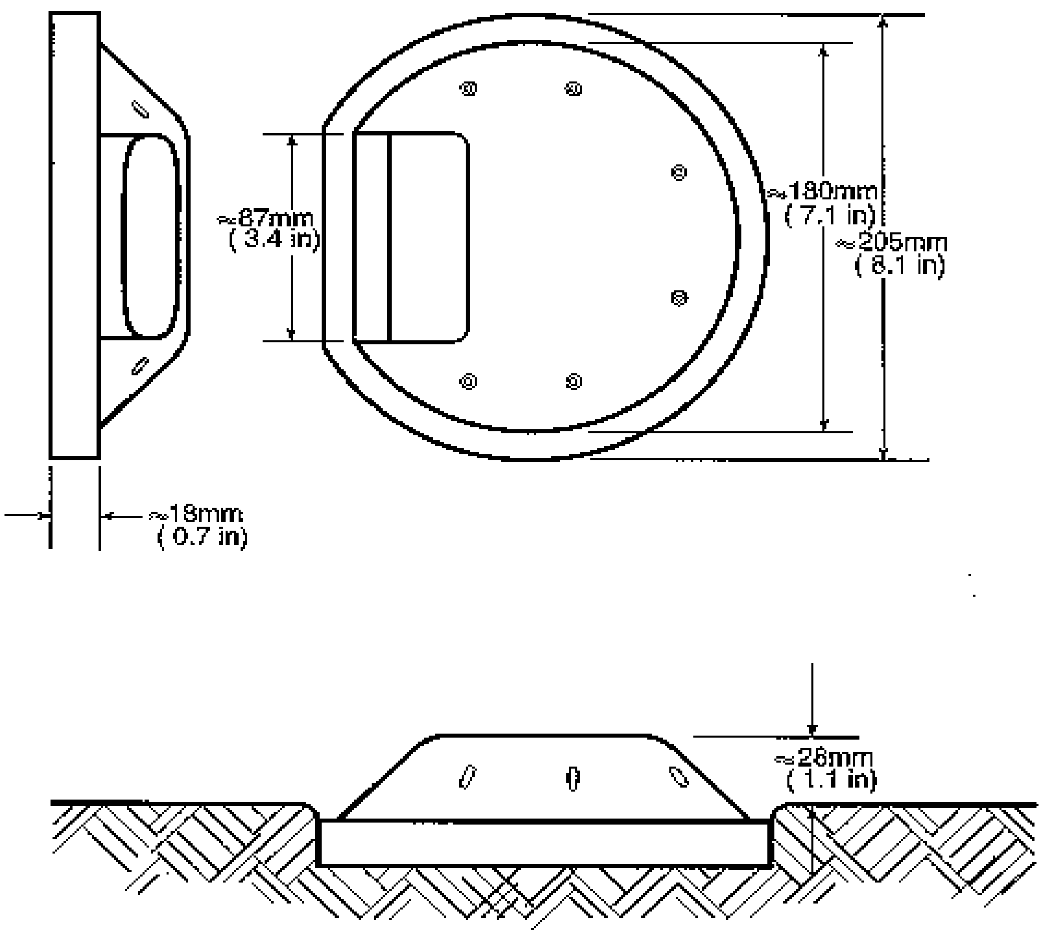


Figure 8. Specifications for the in-pavement signal head (flasher).

DATA COLLECTION PROCEDURES

Both before-and-after and treatment-and-control data were collected. The before-and-after data consisted of vehicle speeds and vehicle yielding. The "before" data were collected in March 1997, and the "after" data were collected in April 1998. All before-and-after data were collected during daylight hours, when police officers were not present.

Treatment-and-control data collection focused on observations of pedestrian and motorist behavior in the area of the flashing crosswalk connecting the Marriott Hotel and the theater, Crosswalks A and B located to the west of the flashing crosswalk (both connecting the Expo Centre and the Arena), and the roadway in between the crosswalks. The treatment-and-control data consisted of pedestrian crossing locations relative to the flashing crosswalk (with and without police officers), pedestrian-motor vehicle conflicts, pedestrian activation of the flashing crosswalk, and pedestrian interviews. The treatment-and-control data were collected in April 1998, mostly during daylight hours.

The peak periods for pedestrian activity were observed to be immediately before and after performances at the theater and events in the Arena. When the research team collected data in early April 1998, *The Phantom of the Opera* was playing in the Theater, and the Arena was being used for a convention. Pedestrian presence is clearly event-driven in this area. Little or no pedestrian and/or motorist activity was observed at other times.

RESULTS – BEFORE-AND-AFTER

Vehicle Speeds

In this study, a trained female data collector stood on the curb and acted as if she were getting ready to cross within the flashing crosswalk. In other words, she was a "staged pedestrian." The objective was to determine if motorists would slow down for her. "Before" data (speeds for 42 vehicles) were collected one afternoon in March 1997. "After" data were collected (speeds for 47 vehicles) one afternoon in April 1998. No police officers were present during either data collection period.

When the staged pedestrian was attempting to cross, vehicle speeds in the curb lane decreased by 1.9 miles per hour (3.1 km/h) (from 27.6 to 25.7 miles per hour, or 44.4 to 41.4 km/h) after the flashing crosswalk had been installed. Vehicle speeds in the inner lane decreased by only 0.5 miles per hour (0.8 km/h) (from 28.5 to 28.0 miles per hour, or 45.9 to 45.1 km/h). Speeds also declined when no pedestrians were present: from 29.1 to 28.3 miles per hour (46.9 to 45.6 km/h) in the curb lane, and from 32.2 to 29.2 miles per hour (51.8 to 47.0 km/h) in the inner lane. None of the before–and-after changes in vehicle speeds were statistically significant, not even at the 0.10 level.

It may be that the flashing crosswalk, by virtue of its flashing, captures the attention of motorists (who might not otherwise notice a pedestrian starting to cross or already in the roadway), and consequently, they slow down (Figure 9). It is not clear, however, why motorists also slowed down when *no* pedestrians were present. Perhaps they were reacting to the flashers sticking up from the pavement. This finding could be an artifact of the small sample sizes; the observed speeds and changes in speeds might not be representative of long-term conditions.

Figure 9. A view of the flashing crosswalk as it might appear to an oncoming motorist.

Vehicle Yielding

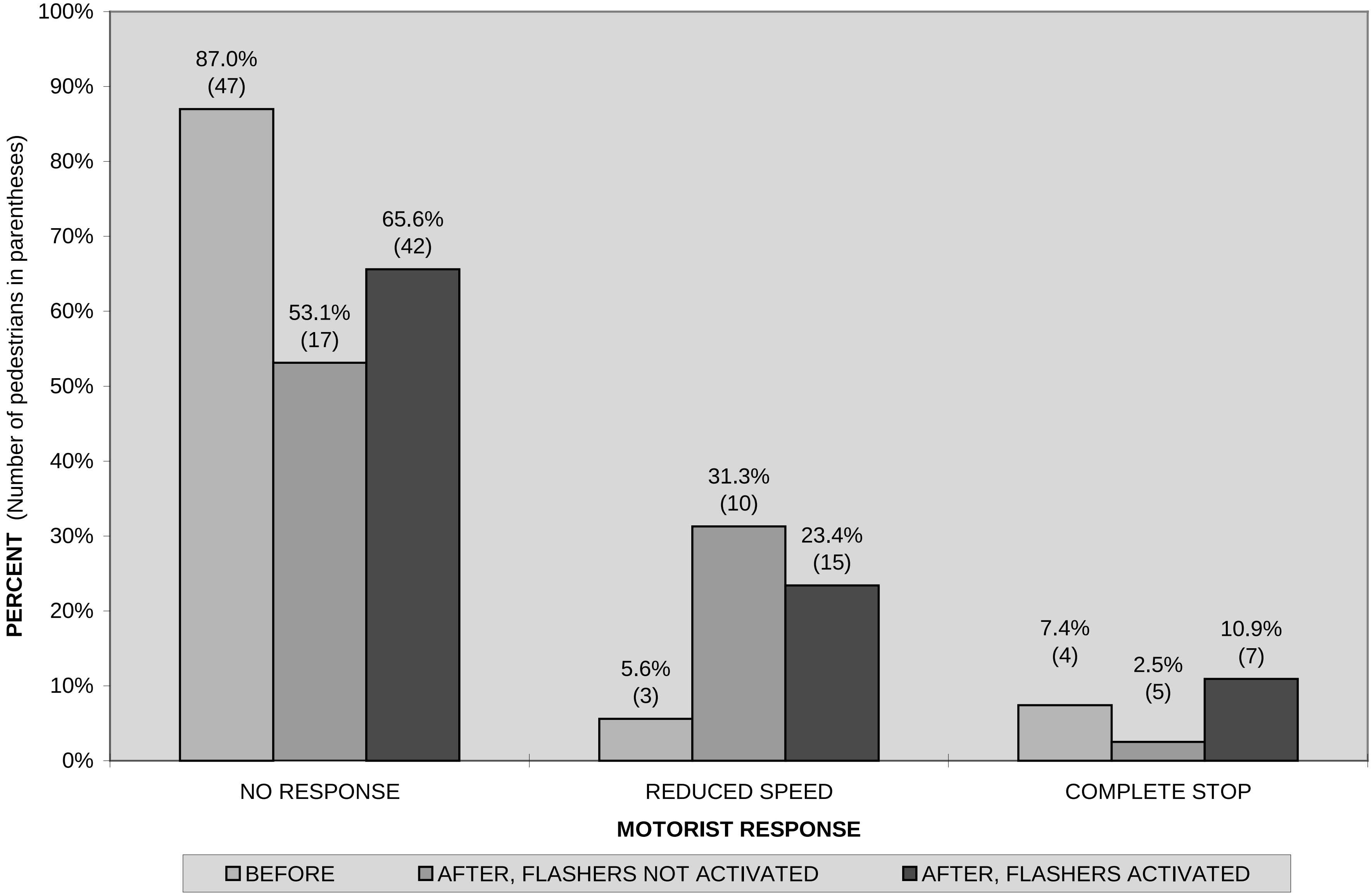
This study also used a staged pedestrian. The objective was to determine whether motorists yielded more frequently to a staged pedestrian attempting to cross within the flashing crosswalk when the flashers were activated compared to non-flashing periods. “Before” data were collected one afternoon in March 1997, and “after” data were collected one afternoon in April 1998. No police officers were present during either data collection period.

Figure 10 shows that 7.4 percent of motorists came to a complete stop for the staged pedestrian in the “before” period. Another 5.6 percent reduced their speed but did not yield. The remaining motorists (87.0 percent) did not respond (*i.e.*, did not reduce speed or yield).

In the “after” period, when the flashers were activated, 10.9 percent of motorists came to a complete stop and 23.4 percent reduced their speed but did not yield. By comparison, when the flashers were *not* activated, 15.6 percent of motorists came to a complete stop and 31.2 percent reduced their speed.

In short, more motorists stopped or slowed down for a staged pedestrian after the flashing crosswalk was installed. According to the chi-square test, these differences were significant at the 0.001 level. It is likely that the flashers capture the attention of motorists who might not otherwise notice a pedestrian starting to cross or already in the roadway. Although fewer motorists stopped or slowed down for the staged pedestrian while the flashers were flashing than when the flashers were not flashing (in the “after” period), this difference was not significant, not even at the 0.10 level, based on the chi-square test.

Figure 10. Motorists' responses to a staged pedestrian.



RESULTS – TREATMENT-AND-CONTROL

Where Do Pedestrians Cross When Police Officers Are Not Present?

Pedestrians were observed in April, 1998, to see where they cross relative to the flashing crosswalk. Most of the data were collected during daylight hours. No police officers were present during any of the data collection periods.

A total of 1,327 pedestrians were observed. Of these, 373 (28.1 percent) entered the roadway within the flashing crosswalk (Figure 11). The remaining pedestrians crossed elsewhere, such as Crosswalks A and B, or between crosswalks.

The specific place where pedestrians crossed (*i.e.*, in the flashing crosswalk or elsewhere), depended on their origins and destinations. Pedestrians walking between the Marriott and the Arena often crossed in the flashing crosswalk. By comparison, pedestrians walking between the Expo Centre and the Arena usually crossed in Crosswalk A, B, or somewhere in-between. This is not surprising, because people can be expected to walk the shortest route between their origins and destinations. Due to the dispersed nature of where pedestrians start and finish (Marriott, Expo Centre east entrance, Expo Centre west entrance, Theater, and Arena), it is to be expected that many people will cross the street somewhere other than in the flashing crosswalk.

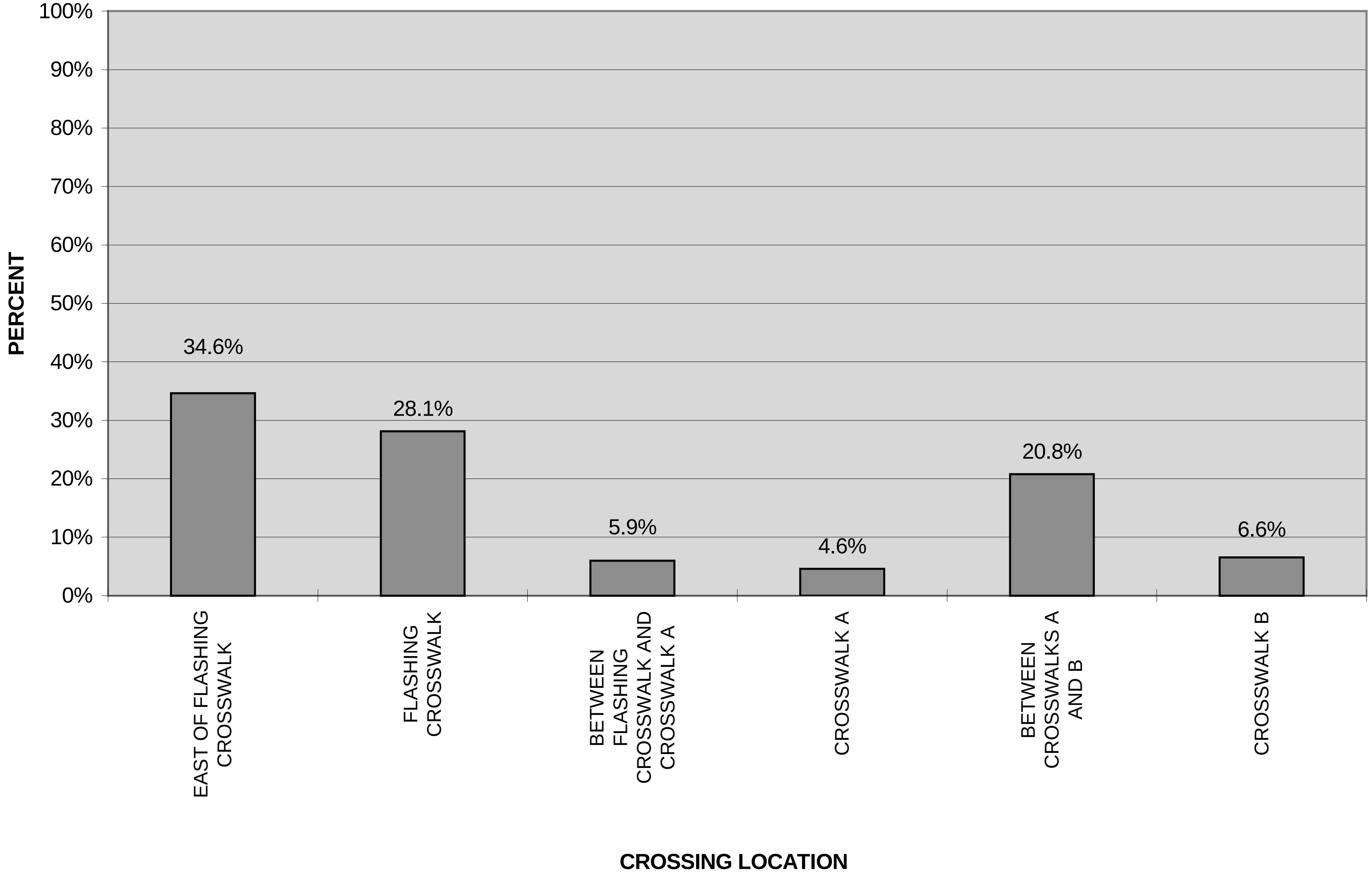
Where Do Pedestrians Cross When Police Officers Are Present?

The objective of this study was to see where pedestrians actually cross when police officers direct them to cross in the flashing crosswalk. Observations were made during the one-hour period prior to three showings of *Phantom of the Opera* in April, 1998. One data collection period was entirely daylight. The other two data collection periods were during evening twilight. Throughout each data collection period, as many as three police officers stood on the curb or in the roadway, within the flashing crosswalk, and directed motorists and pedestrians. At the same time, a parking valet directed motorists to the Marriott's valet parking lot. The police and the valet left immediately after the show started.

Most of the observed pedestrians were walking from the valet parking lot at the Marriott to the theater across the street. The police directed many people to cross in the flashing crosswalk, even though it is not the shortest route between the parking lot and the theater. In fact, people who tried to cross the street on a shorter route were redirected by the police to the flashing crosswalk. Overall, 57.0 percent crossed in the flashing crosswalk. The other 43.0 percent crossed along shorter routes, to the east of the flashing crosswalk (Figure 12).

Figure 11. Pedestrian crossing locations relative to the flashing crosswalk when police officers are not present.

(Total number of pedestrians = 1,327)



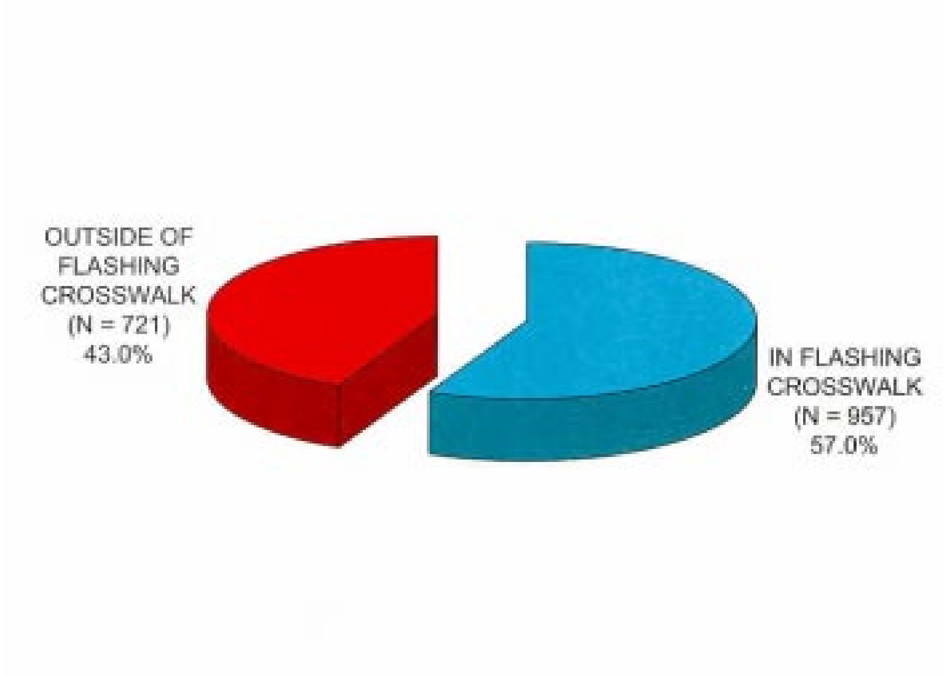


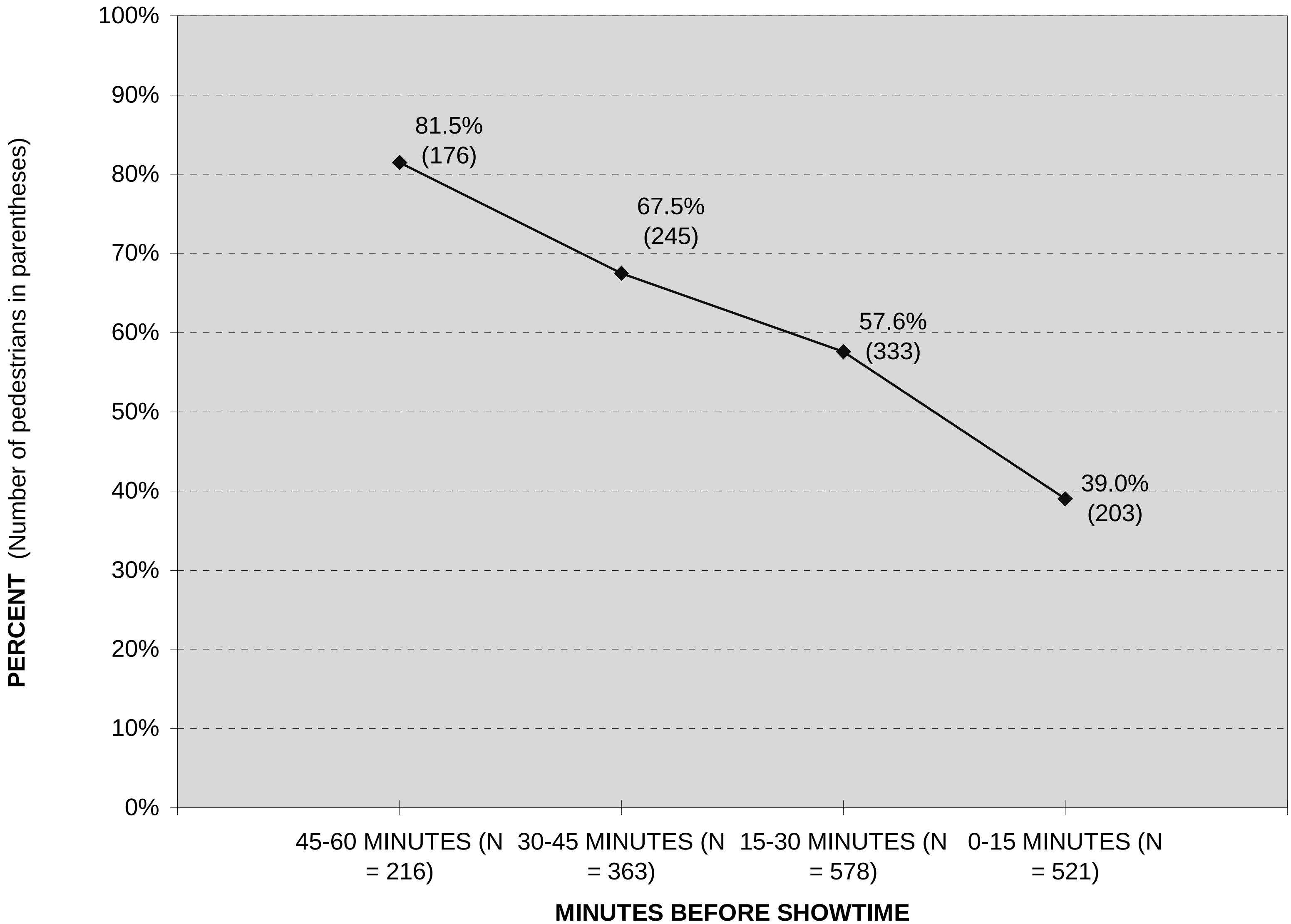
Figure 12. Where do pedestrians cross when police officers are present?

As show time approached, pedestrians were less likely to cross in the flashing crosswalk and more likely to cross along a shorter path. For example, when there were 45 to 60 minutes before show time, 81.5 percent crossed in the flashing crosswalk (Figure 13). When fewer than 15 minutes remained before show time, only 39.0 percent crossed in the flashing crosswalk. Perhaps pedestrians were in more of a hurry to get to the theater on time, so they were more apt to take shorter paths. Also, the police appeared to become less consistent in directing pedestrians to cross in the flashing crosswalk as time progressed.

Because the officer stopped and released motor vehicles, and directed pedestrians to cross in the flashing crosswalk, the officer functioned as a midblock pedestrian signal. The influence of the police officers directing traffic clearly overshadowed any effect of the flashing crosswalk.

The actions of the police officer and the Marriott parking valet appeared to confuse many pedestrians and motorists. The parking valet waved a flashlight to direct motorists, but many pedestrians interpreted this action as a signal for them to cross the street, even when the police officer was telling pedestrians to wait while allowing through traffic to proceed. This lack of coordination between the police officer and the parking valet created several pedestrian - motor vehicle conflicts.

Figure 13. Pedestrians who crossed in the flashing crosswalk as show time approached.



Pedestrian-Motor Vehicle Conflicts

Pedestrian-motor vehicle conflicts were observed for 246 pedestrians who crossed the street when vehicles were approaching. A conflict was defined as having occurred either (1) when a motorist slowed, braked, or stopped to avoid hitting a pedestrian, or (2) when a pedestrian slowed or increased his/her walking speed (or stopped in the roadway) in order to avoid being struck by a vehicle. Most of these data were collected during daylight hours, and no police officers were present at any time. The available data do not allow for separate daytime and nighttime analyses.

Sixty-three of the 246 pedestrians used the flashing crosswalk as vehicles were approaching. Table 1 and Figure 14 show that motorists slowed down, braked, or stopped for 23 pedestrians (36.5 percent). Almost one-fourth (23.8 percent) of the pedestrians took action (slowing down, increasing walking speed, or stopping in the roadway) to avoid being hit by a vehicle accounted for 23.8 percent. Approximately 40 percent of pedestrians using the flashing crosswalk as vehicles approached experienced no conflicts.

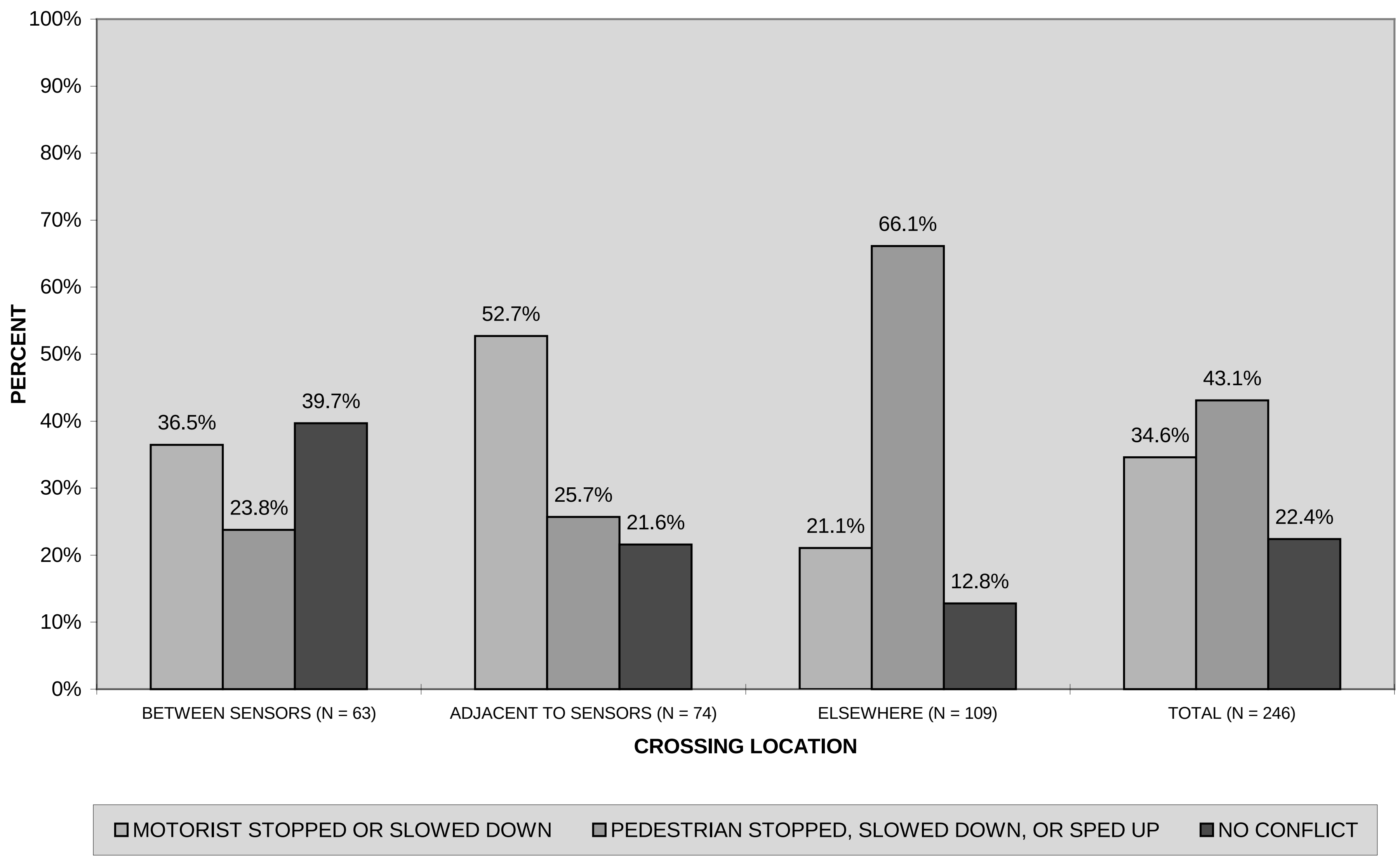
Table 1. Conflicts According to Crossing Location

PEDESTRIAN CROSSING POINT	MOTORIST ACTION	PED. ACTION	NO CONFLICT	TOTAL
In Flashing Crosswalk	23 (36.5%)	15 (23.8%)	25 (39.7%)	63
Adjacent to Flashing Crosswalk	39 (52.7%)	19 (25.7%)	16 (21.6%)	74
Crossed Elsewhere	23 (21.1%)	72 (66.1%)	14 (12.8%)	109
TOTAL	85	106	55	246

Note: Based on the chi-square test, these differences were statistically significant at the 0.001 level.

Seventy-four pedestrians were observed to cross within 30 feet (9.2 m) of the flashing crosswalk while motorists were approaching. Motorists were observed to slow down, brake, or stop for 39 (52.7 percent). One-fourth (25.7 percent) of the pedestrians took action to avoid being hit. Another 21.6 percent experienced no conflicts while crossing. Of the 109 pedestrians who were observed to cross at other points while vehicles approached, motorists slowed, braked, or stopped for 21.1 percent; 66.l percent of pedestrians were required to take action to avoid being struck while 12.8 percent of pedestrians experienced no conflict.

Figure 14. Pedestrian - motor vehicle conflicts by crossing location.



It is clear from these data that the fewest conflicts occurred when pedestrians crossed within the flashing crosswalk, even though 60 percent of the pedestrians using the flashing crosswalk experienced some form of conflict. The reduced number of conflicts may result in part from motorists driving a little slower at the flashing crosswalk (see "Vehicle Speeds," above) and being more likely to yield to pedestrians.

At points other than "in" or "adjacent to" the flashing crosswalk, it was primarily the pedestrian, not the motorist, who was responsible for avoiding a conflict. Perhaps pedestrians were less aggressive, and less likely to force the right-of-way, when they were not in or near the flashing crosswalk. It may be that pedestrians who cross away from the flashing crosswalk did not expect motorists to slow down for them, so they yielded to motorists instead.

Motorist actions (such as slowing and yielding to pedestrians) were more likely to be prompted when pedestrians crossed either in the flashing crosswalk or in the area immediately adjacent to the flashing crosswalk, than when they crossed somewhere else. It is likely that many pedestrians crossed in the area immediately adjacent to the flashing crosswalk while other pedestrians crossed in the crosswalk, thereby activating the flashers. The large percentage of drivers responding to pedestrians in the area *adjacent to* the flashing crosswalk (52.7 percent) suggests that the flashing in-road display may have served as an effective "pedestrian area" warning to motorists in addition to delineating the area of the actual crosswalk.

Pedestrian Activation of the Flashing Crosswalk

The flashing crosswalk is activated when a pedestrian starts to cross by stepping between the sensors. Once activated, it stays activated even if the pedestrian strays outside the crosswalk while crossing. If the pedestrian starts to cross outside the sensors, then the flashing crosswalk is not activated, even if he or she later strays into the crosswalk. Data were collected in April 1998, during daylight hours, to determine how often pedestrians activated the flashing crosswalk. No police officers were present.

Nearly three-fourths (73.4 percent) of pedestrians entered between the sensors, and therefore activated the flashing crosswalk (Figure 15). The flashing crosswalk never failed to activate when pedestrians stepped between the sensors.

People who entered outside the sensors (and did not activate the flashing crosswalk) typically did so because they were walking along the most direct travel paths from their origins to their destinations. These people may not know how to activate the flashers, may not care, and may not have been willing to go out of their way to activate the flashers, even if they knew to do so. Also, the crosswalk, as delineated by the rows of flashers, is wider than the distance between the sensors. Thus, pedestrians who start crossing in the crosswalk and enter outside the sensors will not activate the flashers.

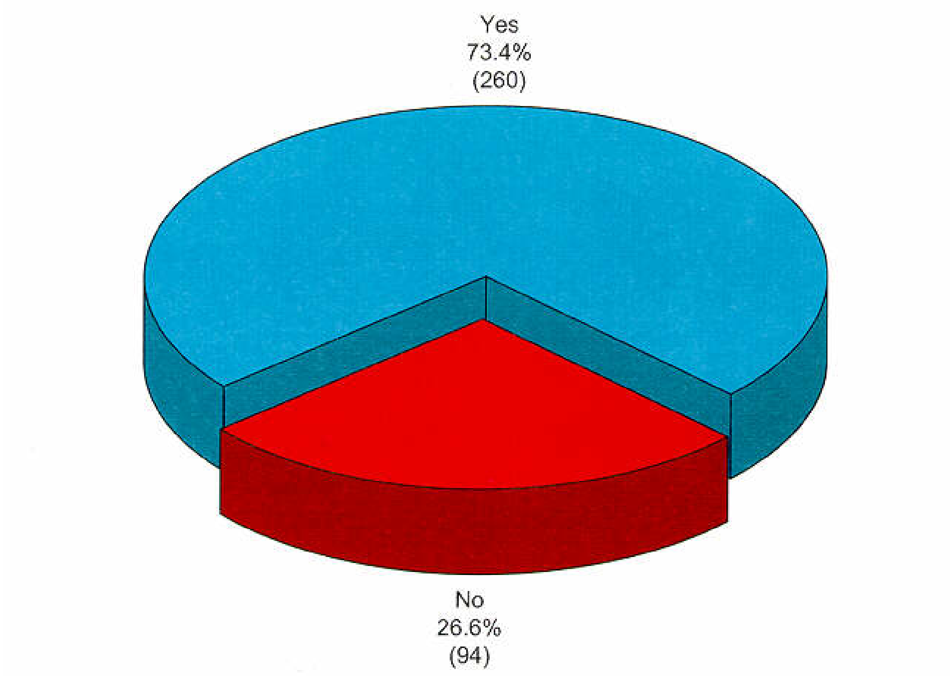


Figure 15. Pedestrian activation of flashing crosswalk.

Pedestrian Interviews Concerning the Flashing Crosswalk

Thirty-three pedestrians were interviewed during daylight hours, just after they had finished crossing in or next the flashing crosswalk. They were asked whether or not they were aware of the flashing crosswalk, if they knew how to activate it, and what their opinions were of the flashing crosswalk. Eighteen (18) of the 33 (54.5 percent) indicated that they had noticed the flashing crosswalk. Only three (9.1 percent) indicated they understood (or thought they understood) how it worked. Many pedestrians offered their opinions of the flashing crosswalk:

- “Oh, I saw them light up last night, but I didn’t realize they were related to our walking across. It’s kinda neat, it’s the first time I’ve seen one like that... “
- “It’s a good idea.”
- “It’s nice that they do light up, yes, I think it’s a good idea.”
- “ [I] did not know they go on during the day. . . there should be a sign to show how the sensors work and where they are.”
- “. . . they’re really cool. . . saw them last night flashing all over the place.” (see Figure 16)
- “[I] didn’t know they work during the day, don’t think drivers can see them in daylight.... it totally brings attention to the crosswalk, no doubt about it.”

- “I don’t think the sensors are obvious to pedestrians. Who would know that’s what they were for?”

- “I didn’t know they flash during the day. I don’t think they show up during the day.”

- “. . . a sign would help, yea, right on that post. It should say, “‘Walk between crosswalk posts.’”

Figure 16. A view of the flashing crosswalk at night.

- “I know how it works, but it’s too far to walk to use it . . .it should be more understandable.”

The interviews suggest that most people did not understand how the flashing crosswalk works. Indeed, there are no signs instructing pedestrians to enter between the sensors. People may not recognize the sensors for what they are. The lack of pedestrian awareness of the flashing display is probably due in large part to the fact that the flashers face outward (toward oncoming motorists) and are not easily visible to pedestrians in the crosswalk. As mentioned earlier in this report, the flashers were in fact designed to face oncoming motorists, so that pedestrians would not see the crosswalk flashing and then take unnecessary risks by stepping out before ascertaining that it was safe to do so.

SUMMARY AND CONCLUSIONS

This report evaluated a prototype installation of the LightGuard ™ Pedestrian Crosswalk Warning System (referred to as the “flashing crosswalk”) in Orlando, Florida. The flashing crosswalk was installed in the spring of 1997 on Livingston Street in downtown Orlando, connecting a Marriott Hotel to the south and the Bob Carr Theater and walkways leading to the Orlando Arena to the north. This evaluation was conducted for the Florida DOT to determine the effects of the flashing crosswalk on pedestrian and motorist behavior. The key findings are given below.

1. The flashers are visible to motorists during the day. This was evidenced by motorists’ greater likelihood of slowing down or stopping for staged pedestrians after the flashing crosswalk had been installed than before (Figure 10). The flashers are more visible at night (Figure 16), and can draw a motorist’s attention to a pedestrian that he or she might not otherwise be able to see in time to avoid a collision.

2. About 28 percent of the observed pedestrians crossed in the flashing crosswalk instead of Crosswalks A, B, or in-between crosswalks. The pedestrian-motor vehicle conflict findings suggest that if more people could be induced to cross in or near the flashing crosswalk rather than elsewhere (such as Crosswalks A and B), the number of conflicts would decrease. Table 1 shows that 40 percent of those crossing in the flashing crosswalk did not experience any conflicts, compared to 22 percent of those who crossed within 30 feet (9.2 m) of the flashing crosswalk, and only 13 percent of those who crossed elsewhere.

   It will not be easy to encourage more people to cross in the flashing crosswalk instead of somewhere else. The specific place where pedestrians choose to cross reflects their origins and destinations (Figure 17). Most people crossed in or near the flashing crosswalk when they were walking to and from the Marriott. On the other hand, most people crossed in or near Crosswalk B when they were walking between the Expo Centre and the Arena. It would not be reasonable to expect them to go out of their way so as to cross in the flashing crosswalk, when Crosswalk B is a more direct route. Thus, there is no single best alignment for the flashing crosswalk.

3. Although the police were fairly effective in encouraging people to cross in the flashing crosswalk, the actions of the police clearly had more influence on motorist and pedestrian behavior than the flashing crosswalk had. By holding and releasing motor vehicles and telling pedestrians when to cross, the police functioned as a midblock signal. Motorists stopped in response to the police as they would in response to a red traffic signal, and not in response to the flashers themselves.

Figure 17. The specific place where pedestrians choose to cross reflects their origins and destinations.

4. There was concern that a push button would cause pedestrians to step into the street without waiting for vehicles to stop, because push buttons are normally used to activate pedestrian signals and stop vehicles with a red traffic signal. Thus, some type of an automatic pedestrian detection system was desired. The flashers were activated 100 percent of the time when pedestrians walked between the sensors mounted on bollards. Earlier use of an ultrasonic detector (mounted on a mast arm above the crosswalk waiting area) was not successful in detecting pedestrians.

5. Most people who crossed in the general vicinity of the flashing crosswalk did so by entering the roadway between the sensors and thus benefitted from having the flashers activated. Some people's walking direct when they entered just outside the sensors than if they were to enter between the sensors. Also, the interviews suggested that people did not always know that they had to step between the sensors to activate the flashers.

6. It should be pointed out that the flashing crosswalk conceptually has a clear advantage over the conventional warning flashers in that the information conveyed by the flashing crosswalk to motorists is in "real time." That is, the flashing lights are correlated with the presence of pedestrians waiting to cross, as opposed to simply flashing all the time. A continuously flashing device can become part of the background visual clutter that confronts motorists and may lose its effectiveness as motorists tune it out.

7. In short, the flashing crosswalk had positive effects on reducing vehicle speeds, increasing vehicle yielding to pedestrians, and reducing pedestrian - motor vehicle conflicts. It was not very effective in channelizing pedestrians because they were walking to and from several scattered places along the street.

RECOMMENDATIONS

Though expensive, flashing crosswalks are cheaper than full signalization. Thus, flashing crosswalks can be an attractive alternative when conditions at the crossing location are appropriate. Whitlock & Weinberger (1998) concluded that a flashing crosswalk system "has the potential to be an effective traffic control device since it fulfills a need, commands attention, conveys a clear meaning, commands respect of road users, and gives adequate time for proper response."

Whitlock & Weinberger (1998) recommended that the following guidelines be met for installing flashing crosswalks:

- Flashing crosswalks should be used at uncontrolled crosswalks.
- Main street average vehicular approach speeds should be 45 miles per hour (72 km/h) or less.

- Main street traffic volumes should be between 5,000 and 30,000 vehicles per day.

- At speeds less than 35 miles per hour (56 km/h), approaching motorists should be able to see the flashers at least 400 feet (122 m) in advance of the flashing crosswalk. At speeds greater than 40 miles per hour (64 km/h), at least 600 feet (183 m) of sight distance should be available.

- There should be no other crosswalks or traffic control devices within 250 feet (76 m) of the flashing crosswalk.

- A minimum of 100 pedestrians per day is suggested.

Caltrans (the California Department of Transportation) is developing standards and guidelines towards making flashing crosswalks standard traffic warning devices in California. At the national level, the U.S. Federal Highway Administration is authorizing flashing crosswalk test sites. The data from these test sites will be used to recommend national standards and warrants for inclusion in the Manual on Uniform Traffic Control Devices (Whitlock & Weinberger, 1998).

The authors of the present report offer the following additional recommendations:

1. If a bollard detection system is used, the bollards should be placed along the same line as each row of flashers. In Orlando, the bollards were placed closer together than the rows of flashers. Thus, it was possible for someone to enter in the crosswalk (*i.e.*, between the rows of flashers), but outside the bollards and therefore not activate the flashers.

2. In terms of automated pedestrian detection systems, Whitlock & Weinberger (1998) found that ultrasonic detection was not completely reliable. They also found that video imaging was superior to ultrasonic detection but still had false activations and missed activations. Other technologies, such as infrared and microwave detection, should also be further tested in conjunction with flashing crosswalks. With additional experimentation, ultrasonic detection and video imaging could be refined to improve their reliability.

3. A sign such as “YIELD TO PEDESTRIANS” (preferably over the roadway) would remind drivers of their responsibilities. With the passage of time, more motorists will hopefully become familiar with flashing crosswalks at this and other such sites and will associate the flashing lights with the presence of pedestrians. This sign could be retrofitted with lights that flash only in conjunction with the in-pavement lights. Alternatively, a beacon that flashes only with the in-pavement lights could be mounted below a standard pedestrian crosswalk sign.

4. To improve pedestrian understanding of how the flashing crosswalk works, custom-made signs directed at pedestrians could be placed on or near the bollards. The suggested wording might be: FLASHING CROSSWALK – WALK BETWEEN POSTS TO ACTIVATE – WATCH FOR CARS – CROSS ONLY WHEN IT IS SAFE TO DO SO. In time, more pedestrians will become familiar with how to use the flashing crosswalk.

5. The flashers should be examined periodically for signs of wear and tear. They can be situated on the roadway so that they are not in the direct path of vehicle tires. (They can also be placed so that they do not impede bicyclists.)

The University of North Carolina Highway Safety Research Center is under contract to the Florida Department of Transportation to evaluate additional flashing crosswalks. Flashing crosswalks are planned at three locations in Lakeland, Florida, and several locations in St. Petersburg, Florida. The flashing crosswalks in Lakeland will use microwave detection. A bollard detection system is planned for the flashing crosswalks in St. Petersburg. All three Lakeland locations are along Lime Street, adjacent to the Lakeland Center. The St. Petersburg locations are scattered throughout the city. “Before” data have already been collected at one location in Lakeland and two in St. Petersburg. “After” data will be collected once the flashing crosswalks have been installed.

These evaluations are being performed in a variety of settings. The Lakeland site is similar to the Orlando site in that both are arena / theater complexes. One of the flashing crosswalks in St. Petersburg will connect the police headquarters with a parking lot. The other flashing crosswalk will connect apartments for senior citizens with a strip shopping center. As such, these evaluations will provide additional data regarding the effectiveness of flashing crosswalks under different conditions, as well as any possible adverse effects.

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REFERENCES

Hunter, William W., Jane C. Stutts, Wayne E. Pein, and Chante L. Cox. *Pedestrian and Bicycle Crash Types of the Early 1990's*. Report No. FHWA-RD-95-163. Federal Highway Administration, McLean, Virginia, June 1996.

Knoblauch, R.L. *Urban Pedestrian Accident Countermeasures Experimental Evaluation. Volume II: Accident Studies*. National Highway Traffic Safety Administration and Federal Highway Administration, February 1975.

Whitlock & Weinberger Transportation, Inc. *An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights*. Whitlock & Weinberger Transportation, Inc., Santa Rosa, California, April 1998.

Whitlock & Weinberger Transportation, Inc., in conjunction with TJKM Transportation Consultants. *Analysis of an Experimental Pedestrian Crosswalk Device – Phase II*. Whitlock & Weinberger Transportation, Inc., Santa Rosa, California, October 1995.

APPENDIX

Table A-1. Technical specifications of the LightGuard™ flashing crosswalk.

<u>Signal Head</u>	
Model No.	LSG-IRSH Type V-A
Name	LightGuard™ In-Roadway Signal Head
Housing	Aluminum
Coating	Powder Coat/White
<u>Base Plate</u>	
Model No.	LSG-IRB V-A
Name	LightGuard™ In-Roadway Base Plate
Material	Aluminum
Attachment to LGS-IRSH V-A:	(6) 1/4-20 x ½" Tamper Proof Bolts
Attachment to Roadway:	Industrial Standard Epoxy
<u>Bollard Detection System</u>	
Model No.	LGS-B1A (Active Side)
Name	LightGuard™ Bollard Activation Unit
Detection Method	Break beam modulated 650 nm LED
Distance	25ft maximum betweeen sensor and reflector
Power	0.04 A. 12 VDC Sensors
	0.04 A. 12 VDC Lighting
Rating	250 ma maximum
Response Time	4 milliseconds
Adjustments	Light/dark operate and sensitivity
Model No.	LGS-B1R (Reflective Side)
Name	LightGuard™ Bollard Reflector Unit
Material	Steel (Body) Top (Aluminum)
Finish	Powder Coat/White
Dimensions	8.5" d x 42" h x .12"
Mounting	(3) ½" bolts
Access	Two part center detachment
Sensors	LGS-SBM1