

Evaluation of In-Pavement Lighted Crosswalks

**Per Gårder
Keenan Goslin
Mike Jenkins**

**Department of Civil & Environmental Engineering
University of Maine**

**Report to Bangor Area Comprehensive Transportation System (BACTS)
March 4, 2005**

ABSTRACT

The aim of this study is to evaluate the effectiveness of the in-pavement lighting systems installed across Center Street in Old Town and South Main Street in Brewer.

It was concluded that the lights were effective in improving mobility by increasing the rate of drivers yielding to pedestrians who are attempting to cross in the marked crosswalks. However, pedestrian safety is not necessarily improved as a result of this.

Factors such as nighttime and daytime visibilities, pedestrian behavior, geometry of the locations, and traffic conflicts are discussed. Recommendations to further increase the effectiveness on mobility—and possibly safety—include: Increased education through the media or school systems, better signage at the locations, and expanding the lighting system to other locations to further help with the exposure and education of these systems and the state laws regarding yielding to pedestrians.

Installing refuge islands at the locations is a requirement if a high safety level is desired. Reducing actual speeds to no more than 25 mph would probably by itself benefit pedestrian mobility and safety more than these systems do. Combining the in-pavement lighting system with designs that ensure speeds to be no more than 25 mph would possibly give a safety compatible to that of streets in the downtown areas of Bangor/Brewer/Old Town—which is a high level of safety.

Table of Content

Abstract	1
OBJECTIVE	3
BACKGROUND	4
BEHAVIOR AND SAFETY	4
METHODS OF OBSERVATION	6
RESULTS	7
Push-Button Use	7
Yield Behavior	7
Light Duration	12
Traffic Conflict Studies and Safety Estimates	12
Problems Observed	13
SAFETY EVIDENCE FROM SIMILAR INSTALLATIONS	14
CONCLUSIONS AND RECOMMENDATIONS	16
Acknowledgement	17
Attachment 1	18

Evaluation of In-Pavement Lighted Crosswalks

OBJECTIVE

The fall 2004 Transportation Safety class was asked to evaluate the lighted crosswalks in Old Town and Brewer. The crosswalks, shown in Figures 1-3, are located across Center Street at Elm Street in Old Town and across South Main Street, adjacent to Eastern Park, in Brewer. A third installation is planned for College Avenue in Orono. That installation will be using SmartStud by Econolite. The in-pavement lighting systems for the studied crosswalks were placed there in the early fall of 2004 to improve driver yield behavior. One reason drivers do not yield to pedestrians in crosswalks may be that the drivers have not seen the pedestrians. Flashing in-pavement lights should dramatically increase the likelihood that drivers will look for pedestrians, which in turn should improve their chances of seeing a pedestrian. The systems are said to increase driver yield behavior significantly—or by about 45% according to Sandi Duchesne with the Bangor Area Comprehensive Transportation Study (BACTS) in the press release *Innovative Technology Reminds Motorists to Yield*. To study whether that is the case or not is one aspect of this study. The installations were highlighted in the November 12, 2004 *Bangor Daily News* article “Old Town installs high-tech crosswalk” By Abigail Curtis, of the News Staff.

Driver yield behavior is often assumed to impact the safety of pedestrians crossing major streets. But the relationship between the two variables is not always obvious. Possible relationships between yield behavior and safety are discussed in this report.



Figure 1 South Main Street, Brewer



Figure 2 Brewer (by Flightlight, see <http://www.flightlight.com/index.shtml>) and Old Town lights (by LaneLight, see <http://www.itemltd.com/products/lanelight/index.html>)



Figure 3 Center Street, Old Town—which also has a time-actuated, overhead school-crossing light

BACKGROUND

There are clear benefits from having people walk more, not least for their own health. Walking is probably the form of exercise that has the fewest negative side effects in the form of injuries—as long as injuries caused by collisions with motor vehicles are avoided. However, the pedestrian safety situation in the United States is worse than in most other industrialized countries. And, the situation in Maine is far from perfect with 1.30 pedestrian fatalities per 100,000 people per year according to a study published by the first author of this report: Per Gårder, *Pedestrian Safety in Maine*, Report ME00-2, Maine Department of Transportation, May 2002—from here on referred to as *Pedestrian Safety in Maine*. Pedestrian crash data provided by Maine Department of Transportation and analyzed in that report show that a majority of crashes happen in the daytime and that the vast majority (71%) of pedestrian crashes happen on level, straight roads where sight distances should be adequate. About 75% of the 80 fatal crashes reported in Maine in the 5-year period 1994 – 1998 took place on arterials or major collectors. The median Average Annual Daily Traffic (AADT) was around 6,000 vehicles a day, or roughly ten vehicles per minute during the busier times of day. More than half of the fatal crashes, where a pedestrian was hit while crossing the street, occurred on streets wider than 37 feet. The data also shows that there is a very strong relationship between speed and risk of fatal injuries. In other words, safety measures—such as in-pavement lights—seem to be especially warranted on high-speed, wide arterials.

BEHAVIOR AND SAFETY

The traffic safety of a pedestrian who is crossing a street is influenced by many factors. If the pedestrian crosses when there are no vehicles close by, he/she will obviously be safe. If the pedestrian wishes to cross a street when there are vehicles going by, he/she can either

- wait for a ‘safe’ gap to occur,
- wait for a vehicle to slow down or stop for him/her, or
- just walk out into traffic hoping for the best.

The third option is primarily chosen by intoxicated people and possibly by people in great stress or with mental handicaps—or by mistake by, e.g., a visually impaired person. And

children may do it because they do not realize the dangers. Measures to provide safety for people walking straight out into traffic are different from measures aiming at providing safety for people choosing either of the other two strategies. Also, it should be taken into account that introducing measures providing safety for the group “walking straight out into traffic,” such as reducing speed, legislating pedestrian priority, or increasing pedestrian sense of safety in some other way may increase the frequency of that behavior.

Mobility may obviously be just as important a goal as safety. And, many pedestrians will not engage in safe behavior unless it gives high mobility as well. The fastest way for a pedestrian to cross a street would typically be to walk straight out without looking. But we—as transportation engineers—may not want to encourage such behavior if we feel it is unsafe. We may therefore instead try to find ways of having pedestrians wait on or near the curb (when vehicles are nearby) until the drivers yield to them. And the better the yield behavior is among drivers, the shorter the wait times will be for pedestrians. An extreme alternative to this would be to legislate that vehicles always have the right-of-way and that pedestrians do not have the right to step out into the street (including in a marked crosswalk) when there are any automobiles nearby. In other words, it would be illegal for a pedestrian to cross even if a car had stopped with the intent to let him/her cross. This would give a much lower pedestrian mobility but possibly a higher pedestrian safety.

A high safety could also be ensured if more or less all drivers would yield once one had stopped for a pedestrian. In January 2005, an elderly pedestrian was killed in a marked crosswalk in Maine. The pedestrian crossed after that a car had come to a full stop to let him cross. He was killed by a driver going in the opposite direction not yielding to (and reportedly not seeing) the pedestrian. What would make similar accidents less likely? Well, if we increase the yield percentage to, say, 99%, then it would be unlikely that a driver in the opposite direction would hit him. That could possibly be accomplished by making crosswalks more visible. But if that measure increases the yield behavior to, say, only 50%, then there would still be a high risk of a collision with a pedestrian walking out in front of a stopped vehicle and then continuing in front of an oncoming vehicle. So, unless we can get the yield behavior up around 99%, pedestrians probably should not be encouraged to walk out in front of a moving vehicle. Rather, pedestrians should be encouraged to wait at the curb until the vehicle has come to a complete stop. Unfortunately, few pedestrians do that once *one* car has stopped. The elderly man mentioned above may have felt awkward if he had stayed at the curb once the (first) car had stopped to let him cross. And then, if there is no center refuge island, he may have felt unsafe to stop in the middle of the street. Obviously, that is what he should have done if he knew that the second driver had not seen him. A question to answer is, do we improve or reduce pedestrian safety if we increase the yield percentage from say 10% to 20%? The reason we may harm safety is that we would encourage more pedestrians to step out into the street without ensuring that they are safe all the way to the other curb. And, maybe, we therefore should not allow any uncontrolled marked crosswalks to be striped if they do not have a safe refuge area in the middle (or even in between every lane of traffic) unless the yield percentage (towards pedestrians who have stepped out into the street) is, say, 99%.

Studies from around the state (summarized in the earlier referenced *Pedestrian Safety in Maine*) indicate that the higher the driving speed, the lower is the percentage of drivers who stop and yield to pedestrians in crosswalks. This relationship can be illustrated with observations from the campus of Orono, Maine, showing that at crosswalks

where the average speed is 10 mph or less, almost 100% of drivers yield to pedestrians who have taken one step out into the crosswalk. Where the average speed is 11-15 mph, 28% do; if 16-20 mph, 23% do; and 21-30 mph, 17% yield. Observations from downtown Bangor shows that 93% of drivers yielded at a marked crosswalk (at the post office) with a pedestrian sign in the middle of the street and a median speed of 14 mph whereas the percentage of drivers yielding was only 11% at a ‘similar’ location with the same sign (at Eastern Maine Medical Center) where the median speed was a bit over 25 mph. On Main Street in Norway, between the public library and the western end of the business district, cars typically travel at low speeds. The median speed in a fall 2000 afternoon was measured to be 16.5 mph. There are several zebra-marked crosswalks across this street. The number of cars passing before one stopped when a pedestrian had stepped out into the crosswalk was, on average, 0.4. That observation confirms that drivers traveling at speeds below 20 mph are fairly likely to stop for a pedestrian even if it is just a simply marked crosswalk. On the other hand, there is a crosswalk across Route 26, at the southern entry to Norway, with a push-button activated flashing light system, as shown in Figure 4, with a median speed of 34 mph. When a pedestrian steps out into this crosswalk, with the lights activated, typically a couple of cars—and frequently four or five—go through the ‘light’ before someone stops. At the high school, close to the Paris/Norway town line, there is a marked crosswalk across Route 26 which has the same flashing lights as the crosswalk at the location in Norway but also the spring-loaded sign “State law, Stop for Pedestrians.” Speeds are here lower, with a median speed around 25 mph, and here, typically the first car stops for a pedestrian in the crosswalk when the lights are flashing. But sometimes, one or two drivers will not yield.



Figure 4 Crosswalk in Norway, Maine

METHODS OF OBSERVATION

Whether or not a driver will stop for a pedestrian does not vary only with the speed of the vehicle and with the characteristics of the location. It also varies with the pedestrian’s behavior. This should be taken into account when conducting field observations of actual pedestrian behavior. It is difficult to conduct controlled experiments to see if drivers stop when a pedestrian steps out into the roadway since it is dangerous to step out in front of cars, and one may cause crashes. On the other hand, to passively observe pedestrians

who do this is difficult since they do not always step out in front of cars with the same distance remaining, etc. Experiments here have therefore focused at looking at driver behavior when a pedestrian walks up to the curb and takes one short step out into the street, in such a way that it is obvious that he/she wants to cross.

Five students were involved in collecting data and surveying pedestrian opinions. All subjects interviewed were above the age of 18. The survey asked questions regarding the person's knowledge of the crosswalk and the in-pavement lighting system. When it came to yield observations, the class split into groups of two and visited the crosswalks at varying times of day. One person recorded traffic behavior while the other member became the test subject who actively crossed the street using the lighted crosswalks as well as the crosswalk without activating the light system. Normal pedestrians were also observed during these times, noting whether or not they pushed the button to activate the in-pavement lights. Environmental conditions such as weather and light conditions and how this seemed to affect traffic behavior were also noted.

RESULTS

Push-Button Use

It was found that a large percentage of the pedestrians did not activate the in-pavement lighting of the crosswalk. In fact, around two out of three pedestrians attempting to cross did not push the button. Rather, many pedestrian seemed to try not to affect the traffic flow at the sites by waiting for an acceptable gap to cross. However, few pedestrians were observed, and the system had not been in use for a long time when these observations were made.

No visually intoxicated pedestrians were observed but it is likely that intoxicated pedestrians and pedestrians in a great hurry will not take the time to activate the system. Since these pedestrians need the lights more than most pedestrians, a fully automatic activation system may be preferable if safety is to be optimized. However, there may be technical problems with false activations as well as missed activations with such systems as delivered by current vendors.

A behavior noted once during the Brewer observations was that two pedestrians walking by the site pushed the button and activated the lighting system with no intention of using the crosswalk or crossing the roadway. They were continuing down the sidewalk.

Yield Behavior

Around 100 pedestrian crossing passages were observed in each of the towns. They were divided among crossings with the lights activated, without the lights (which roughly represents the before situation when the system had not been installed), and outside of the crosswalk. These trials were done in both the daylight and in the evening when it was dark. Rush-hour results from Old Town, around 5 PM when it was dark, show:

- When the in-ground lighting was activated, 29 drivers (21%) out of 135 (approaching in such a way that they could have stopped) yielded, see Figure 5.
- When the in-pavement lighting system was not activated, 22 out of 194 (11%) yielded to the pedestrian in the crosswalk, see Figure 6.

- When pedestrians attempted to cross approximately 200 yards outside the crosswalk (at a straight and level section of the road) only four out of 201 drivers (2%) yielded. A part of these observations are illustrated in Figure 7.

It should be noted that these numbers were obtained when it was dark which may contribute to the visibility of a pedestrian and explain some of the yield behavior observed. A smaller study was done in the daytime, on a sunny Sunday afternoon with light traffic, when a pedestrian ought to be more visible. A higher percentage of drivers yielded but there were still many drivers who did not yield, including one driver who continued while a car had stopped in the opposing direction and a pedestrian was well out in the crosswalk.

Drivers were rarely observed to stop for a pedestrian in the crosswalk regardless of light activation or not during peak traffic hours. A possible explanation for this is that half of the traffic is coming down a fairly steep hill, and often travel at speed around 35 to 40 mph towards the bottom of the hill—where the crosswalk is located.

Yield behavior at the Brewer site was obtained during the daytime of a weekday. The results were a bit more ‘encouraging’:

- When the in-ground lighting was activated, 37 drivers (36%) out of 104 (approaching in such a way that they could have stopped) yielded, see Figure 8.
- When the in-pavement lighting system was not activated, 28 out of 122 (23%) yielded to the pedestrian in the crosswalk, see Figure 9.
- When pedestrians attempted to cross approximately 200 yards outside the crosswalk (at a straight and level section of the road) three out of 161 drivers (2%) yielded, see Figure 10.

Another observations session was conducted at the Brewer site in the evening when it was dark with the in-ground lighting activated, 13 drivers out of 73 (18%) yielded. Thirty-nine of the 60 drivers not yielding were in the far lane from the pedestrian and nine of the 13 yielding were in the near lane.

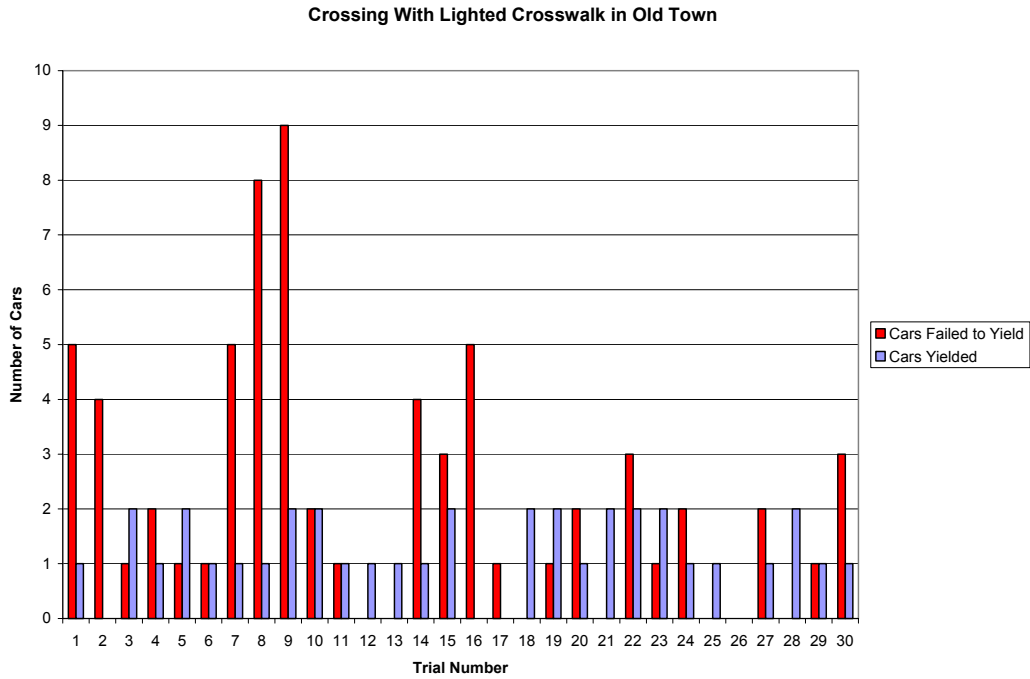


Figure 5 Example of yield observations at light-activated crosswalk in Old Town

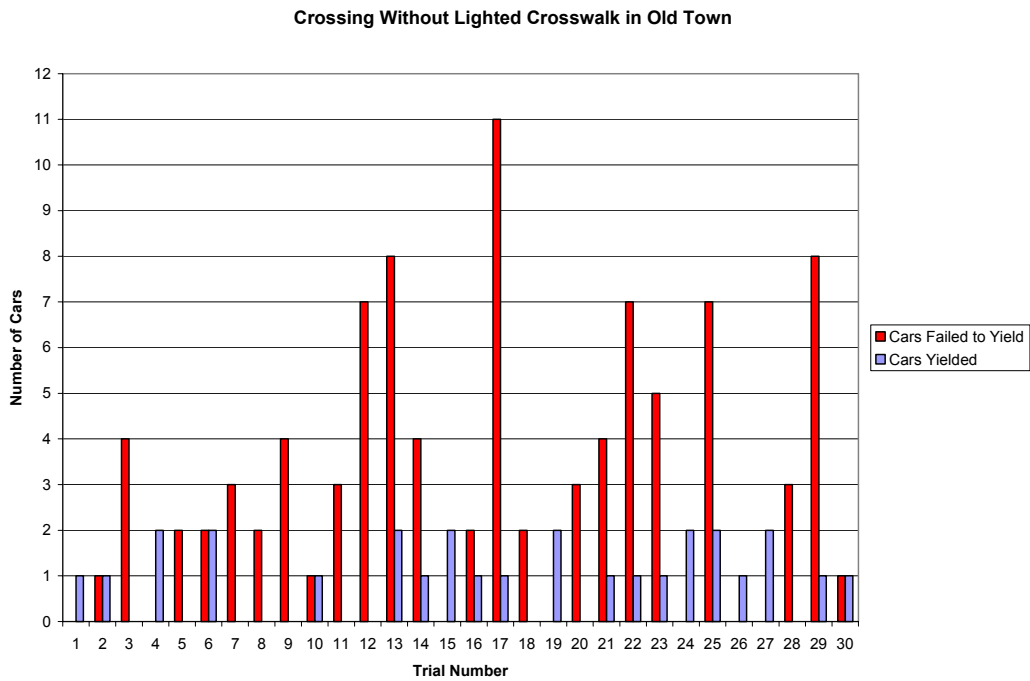


Figure 6 Example of yield observations at not activated crosswalk in Old Town

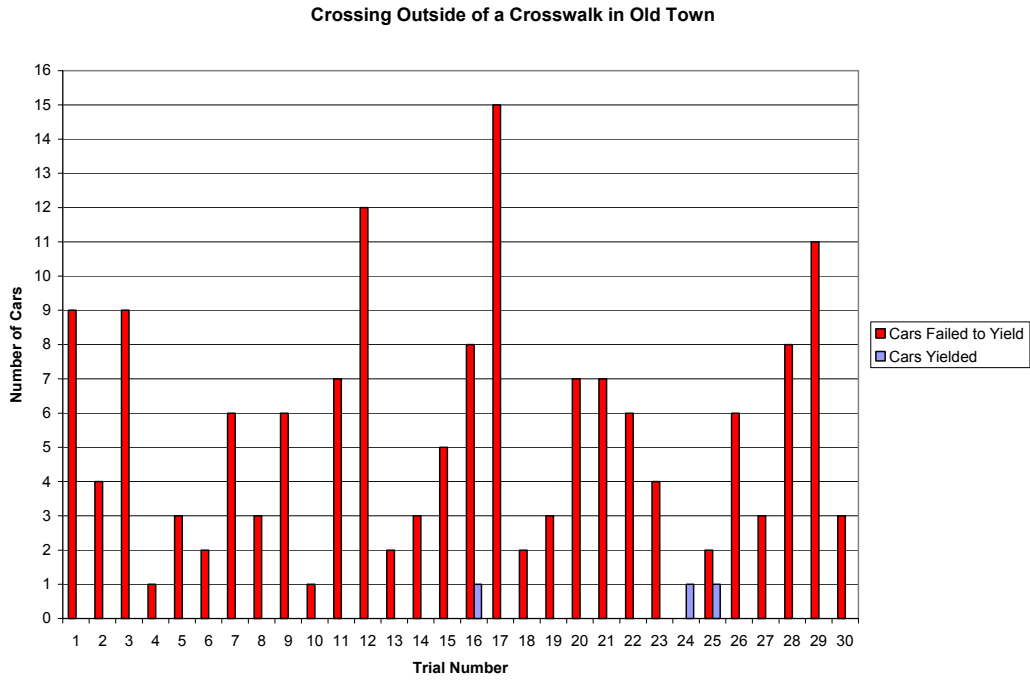


Figure 7 Example of yield observations away from the crosswalk in Old Town

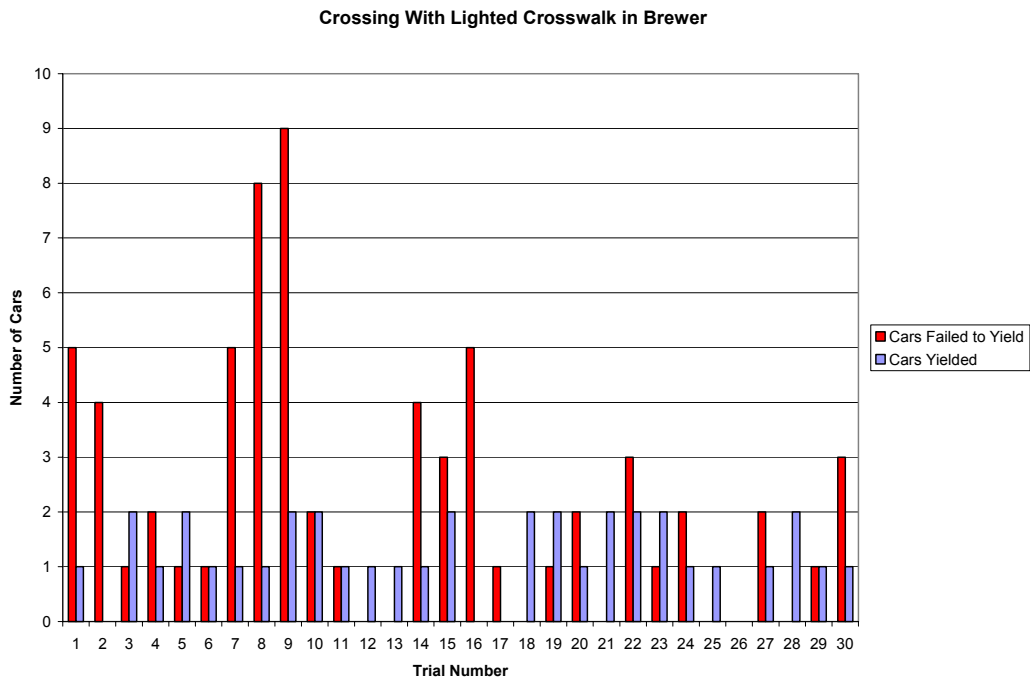


Figure 8 Example of yield observations at light-activated crosswalk in Brewer

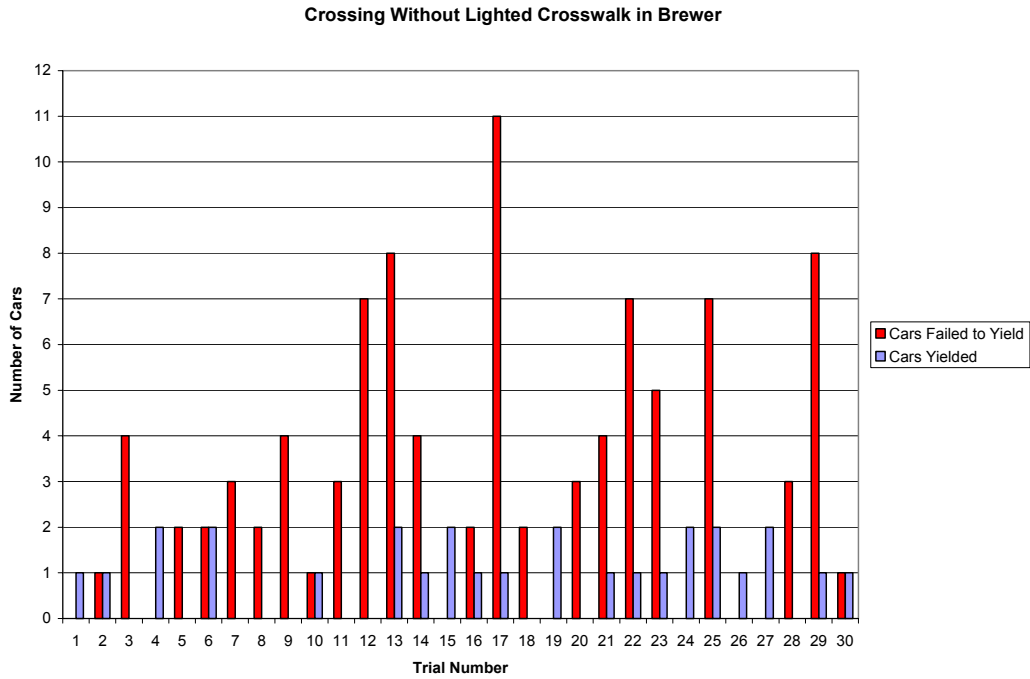


Figure 9 Example of yield observations at not activated crosswalk in Brewer

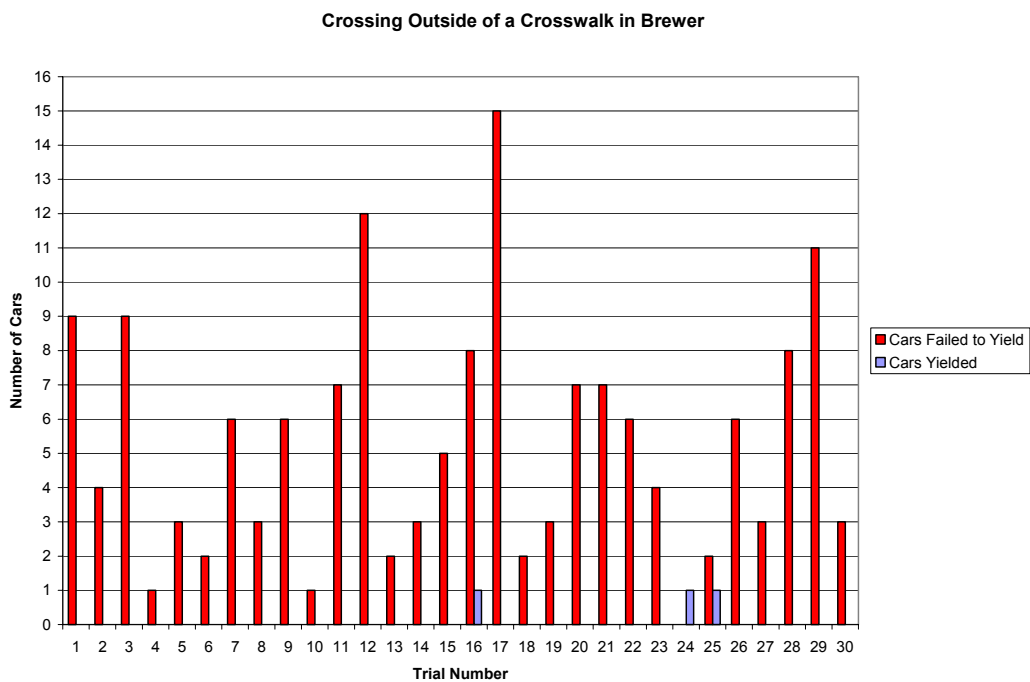


Figure 10 Example of yield observations away from crosswalk in Brewer

Light Duration

It was observed that occasionally, after a pedestrian activated the lighting system and was waiting for traffic to yield, the lights would deactivate before the pedestrian was able to cross. Out of 78 times the button was pushed to activate the in-pavement lights, the lights deactivated 14 times, giving an 18% rate of failure. It can be concluded from this that the duration of the activation should be lengthened even if the lights frequently kept flashing for a few seconds after that a pedestrian had crossed.

Traffic Conflict Studies and Safety Estimates

The travel speeds of some vehicles are clearly reduced when the lights are activated. However, a majority of drivers do not slow down at all so even if the average speeds are reduced some, the variation of speeds increases. The net effect of the change in speed is therefore probably negligible. However, drivers may be more attentive or alert as a result of seeing the flashing lights.

Two traffic conflicts were observed at the Brewer location. In one, the driver in the far lane did not slow down at all and the pedestrian had to run across the far lane to escape injury. In the other conflict, the driver yielded to the pedestrian at the last second and slammed on their brakes. Two conflicts were observed with 471 vehicles passing, giving a rate of 0.00425 per vehicle interaction. Overall, for the two sites, there were approximately 0.010 serious conflicts per crossing pedestrian. To base a safety analysis on such small numbers is dangerous, but with a conversion rate of 12.5×10^{-5} accidents/conflict (and a site-to-site variance of this ratio of 32.4×10^{-10} accidents/conflict²) we would get roughly 1.25 pedestrian crashes per million pedestrian crossings. This can be compared to findings based on actual crash data from 67 locations around Maine, classified by town/area as presented in Table 1.

Table 1 Observed pedestrian crashes per million pedestrians, Maine summary

Town	Pedestrian volume*	Crashes**	Crashes per million crossings
Bangor, CBD	6174	3	0.27
Bangor, outside CBD	1670	7	2.30
University of Maine	8333	2	0.13
Rest of Penobscot	1680	1	0.33
Hallowell	1863	1	0.29
Camden	3990	1	0.14
Brunswick	2000	8	2.20
Oxford Hills	1467	16	5.98
SUM Maine	27177	39	0.79

* Number of crossing pedestrians per day. Expanded from a few counts of 20 minutes or more

** The observed number of pedestrian crashes in the 5-year period 1994-1998

If the estimate of 1.25 crashes per million crossings holds true for these in-pavement lighted crosswalks, then these locations would be considerably safer than the 2.3 crashes per million crossings which was observed on the arterials in the outskirts of Bangor but they would still not be at all as safe as crossing in downtown Bangor at a location lacking this lighting system. If we have a total of 100 pedestrians crossing at these two locations per day (and disregard that many of them cross when there is a crossing guard at the Old

Town location) we would have around 36,500 pedestrian crossings per year¹. It would then take ‘only’ around 20 years before a pedestrian crash would occur at one of these locations.

The Brewer site has an AADT of around 15,000 vehicles per day. If it, on average, has 25 pedestrians per day crossing here, the Swedish model discussed in *Pedestrian Safety* predicts that a typical (Swedish) crosswalk with such traffic volumes would have around 0.009 pedestrian crashes per year, whereas the British TRL model predicts that there would be around 0.017 pedestrian crashes per year. In other words, we should have to wait around 60 to 110 years before we get a crash reported here if it has a ‘typical’ European safety level. A typical 2-lane road with a marked crosswalk and speeds a bit above the posted 25 mph limit (as observed here) would *without* the in-pavement lighting system have a safety standard close to that seen in Europe according to the studies presented in *Pedestrian Safety*. In other words, even without the lighting system we should not expect a crash for at least 60 years or so.

The interviews with pedestrians also revealed that there at the Old Town site had been a rear-end collision—prior to the light-system being installed. A vehicle had stopped to let a pedestrian cross in the marked crosswalk. A second vehicle failed to stop and it seems as if the second vehicle driver did not see the crossing pedestrian and was not paying attention to the vehicle ahead of him when that driver stopped for the crossing pedestrian. This is an instance where the in-pavement lighting could be beneficial. The flashing lights would have given additional notice to vehicles. Maybe this crash could have been avoided. On the other hand, with more drivers stopping to let pedestrians cross, more rear-end crashes could also be expected—until we get to the situation where more or less all drivers stop for pedestrians who intend to cross. Today, we are far from that situation at the two studied crosswalks.

Problems Observed

The students observing traffic at the two sites noted that the main problems with the Brewer crosswalk were: Lights not to grade, new pavement only near crosswalk, and poor choice of striping. Other design flaws with the crosswalks included poor lighting near the activation device. In the following paragraphs, these factors will be discussed.

When pedestrian movements were observed at the Brewer crosswalk, it was compared to the studied crosswalk in Old Town. The Brewer crosswalk did not compare well, as several problems with its construction were evident. The first problem, possibly the most severe, is that several lights embedded in the pavement were not at grade with the surface of the asphalt. This caused motorists to have less visibility of the lights. This could explain why fewer cars stopped for pedestrians at nighttime hours in this lighted crosswalk. Considering the expense of installing each individual light in the crosswalk system, it should be a high priority for the lights to be at grade with the pavement. This should optimize the cost, function, and safety of the pedestrian in the crosswalk system.

The lighted crosswalk in Brewer was constructed on a roadway with deteriorating asphalt. When people drive South Main Street towards the crosswalk, many may notice the strip of new asphalt first, not the crosswalk—and concentrate on the asphalt patch.

¹ This is a rough estimate. It is possible that the pedestrian volume is considerably greater in the summer than during the observed periods.

The new asphalt only continues to a length of one foot from each end of the striping of the crosswalk. Motorists may focus on this new pavement and not notice the crosswalk or possibly a pedestrian, as they fear the new asphalt is a spot for a bump in the road. In future lighted crosswalk installations, there should be a minimum distance from the crosswalk that contractors must install new asphalt so motorists are already on the new pavement when approaching the crosswalk. Else this diversion of driver attention from the pedestrian crosswalk to the roadway surface may increase the risk of a vehicle-pedestrian conflict.

Also, the striping at the Brewer crosswalk is unacceptable in that it does not provide enough visibility. Consideration should be made in future designs to specify a retro-reflective striping since proper striping can aid a pedestrian in crossing safely at night as well as during daytime hours. The in-pavement lighting will also work more effectively at night with retro-reflective paint, as the striping will glow from the flashing lights. In summary, it is the observer's view that good retro-reflective striping is critical to the effectiveness of a lighted crosswalk system and should be considered as a mandatory feature in future lighted crosswalk systems.

Furthermore, a concern that was shared by several team members was the question as to how effective the lighted crosswalks will be during the winter months when there is snow and salt and dirt possibly covering the in-pavement lights. Is there an increased need of maintenance for these facilities?

Finally, both the Old Town and Brewer lighted crosswalks have a notable error in their designs which hampers their use, particularly at nighttime hours. Activation devices located on both sides of the roadway are almost completely unnoticeable to crossing pedestrians during nighttime hours. This could cause pedestrians to cross without activating the lights, thus not utilizing the additional safety measures available. These activation devices should have some low source light that would alert pedestrians to the device, while not distracting motorists and consequently putting the crossing pedestrian at higher risk. It may be possible to power these location-lights with solar cells. Also, automatic detection systems should be considered since some users—probably the ones that need the system the most—are unlikely to activate the system themselves.

SAFETY EVIDENCE FROM SIMILAR INSTALLATIONS

A March 2005 TRIS search reveals that there are only two 'scientific' publications on this topic. Adding Compendex literature search gave a third source. A full Engineering Village 2 search did not yield any further references.

Internet searches outside 'scientific' databases gave some additional material. Maybe the most interesting one is provided by Light Guard Systems Inc. The full text of "An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights" performed by Whitlock & Weinberger Transportation, Inc (and funded by the State of California Office of Traffic Safety and the Federal Highway Administration through the University of North Carolina Highway Safety Research Center) is here provided as an attachment starting on page 18. There is no crash data presented in that summary but general advice and beliefs expressed by a manufacturer that seems to have researched 'potential' benefits of such systems. The University of Maine in no way endorses a specific make by here referring to conclusions expressed by this manufacturer.

Another manufacturer, LaneLight, gives a link to the full text of a report “The Effects on Safety of In-Roadway Warning Lights at Crosswalks: Novelty or Longevity?” written by two research psychologists (Gabriel K. Rousseau, Ph.D., and Sheryl Miller Tucker, Ph.D.) and one research engineer (Ann Do) at the Federal Highway Administration. The full report is available on internet.² There is no crash data presented in this report.

The first publication encountered in the ‘scientific’ databases is “Evaluation of Lighted Crosswalks--Are They Really Effective?” by A M Kothari, presented at the Institute of Transportation Engineers Annual Meeting and Exhibit in 2002. The abstract of that paper reads:

“The City of Oakland, California, recently installed Lighted Crosswalks, also known as "Santa Rosa Lights," at 6 critical locations citywide. This paper describes a thorough study conducted to evaluate the usefulness of these installations. The data collected before and after the installation of these systems has been analyzed, and the paper summarizes valuable study results for these locations. Before/after data, costs, construction, and maintenance issues are discussed. Valuable experience of other cities where similar devices have been used is also shared. The paper provides an interesting insight for all transportation professionals who must make sound decisions on implementing new devices with appropriate emphasis on real benefits, community concerns, and city council priorities.”

The second publication, *In-Roadway Flashing Lights at Crosswalks*, from 2001 is also published by the Institute of Transportation Engineers. The abstract of this reads:

This informational report contains information and data on the In-Roadway Flashing Light Crosswalk Warning System. This system is a traffic warning device used at pedestrian crosswalks. It consists of a series of amber lighting units encased in durable housings and embedded in the pavement parallel to a marked crosswalk. When activated by a pedestrian, the light emitting diodes flash toward oncoming traffic to alert approaching motorists of the potential presence of pedestrians in or about to enter the crosswalk. Essentially, the in-roadway flashing lights serve a purpose similar to traditional overhead flashing beacons, with the major difference being the location of the lights and the pedestrian activation feature. This report is based on the experiences of transportation professionals and on research conducted on the system. The report includes the following: Introduction; History; Testing Sites; Signal Head and Installation Alignment; Illumination and Flash Rate; Activation Methods; Other Uses of the Device; and List of Installed Sites.

The third publication, “Development and analysis of a pedestrian crossing warning system,” by Ian Lewin (with Lighting Sciences Inc) and John O'Farrell, published in the *Journal of the Illuminating Engineering Society*, v 29, n 2, Summer, 2000, p 100-105, has an abstract stating:

“A lighting system which is believed to increase pedestrian safety at crosswalks was developed. The system consists of embedded roadway markers which are internally lighted. The flashing amber lights embedded in the roadway at uncontrolled crosswalks is helpful in increasing driver awareness. This system proves to be more useful during darkness, fog and rain. Overall, the implementation of this system will provide increased safety and a significant reduction in vehicle/pedestrian injuries and fatalities.”

² http://www.itemltd.com/products/lanelight/resources/ll_xw_ITE2004-InRoadwayLightingPaper.pdf

Based on the above literature searches—and other attempts to retrieve relevant literature—it was concluded by the principal author of this report that no conclusive safety evaluation exists at this time, if we exclude speculations based on indirect measures of safety, such as behavioral studies. Most likely, there are at the very most only limited direct safety evaluations from a few sites. At least the abstracts that can be obtained via the databases—show no empirical crash data evaluation supporting any claims of higher safety. Full-text versions were not obtained in this limited literature review but it would be surprising if actual effectiveness numbers exist in the full texts when they are not summarized in the abstracts.

CONCLUSIONS AND RECOMMENDATIONS

The observations are limited in their scope but it is obvious that, at both locations, the in-pavement lighting system while activated increased driver yield percentages. The system is thereby ‘proven’ to be an effective measure with respect to decreasing the waiting time of a pedestrian at a crosswalk. With activated lights, the share of vehicles stopping for a pedestrian in the marked crosswalk increased by 60% to 90% compared to when the lights were not activated. However, still only about one in four drivers yield at these locations when the lights are activated. This is better than the typical yield percentage for the speed environment where they are located but much lower than the yield percentage on streets with 25-mph traffic. In other words, reducing the actual speed to 25 mph at these locations would benefit pedestrian mobility more than these systems do.

It was found that the activation of the lighting system was rather low; leading to the recommendation that further education through the media, the addition of signs notifying pedestrians of the lighted crosswalk, and night-time illumination of the buttons activating the system should be added. Automatic detection systems should also be considered since the pedestrians that need the system the most may be the most unlikely to push the activation buttons. If the problem with automatic systems is that they sometimes do not detect pedestrians, a push button should be provided as an additional way to get activation. Another advantage with automatic detection would be that the duration of the activation phase could be varied and the system activated for a set number of seconds after that a pedestrian left the curb rather than as today, a set number of seconds after the button is pushed. Also, more sophisticated automatic detection technique could be used to detect pedestrians in the crosswalk and activate the system only as long as there are pedestrians in the crosswalk.

Adding the in-pavement lighting system to other locations should also be considered. If this is done, it should eventually be possible to evaluate if drivers having their yield behavior improved at these locations bring that behavior to other (non-lighted) crosswalks or if the opposite effect will happen, that drivers start relying on these lights rather than look for pedestrians the way they do today. In the FHWA study “The Effects on Safety of In-Roadway Warning Lights at Crosswalks: Novelty or Longevity?” referred to on page 14, it seems as if there is a small positive change in driver behavior at the equipped crosswalks even when they are not activated. However, the authors state that the yield behavior during the not-activated passages resembles the before situation much more than the after situation with the lights activated.

Improving yield behavior does not automatically lead to better safety as ‘proven’ by a legislative change in Sweden in May 2000 which gave pedestrians absolute priority

in marked crosswalks rather than priority only when drivers reasonably could yield to them. This change significantly increased the percentage of drivers stopping and yielding to pedestrians. However, crash analysis based on a macro study of all of Sweden suggests that the injury risk in marked crosswalks increased by 27%.³ It was found that reconstructions are needed for the change of code to have a positive safety impact. It was also concluded that the 90-percentile speed should not exceed 30 km/h (20 mph) to make it safe for pedestrians to walk out before ‘all’ traffic has stopped.

As stated, it is clear that the in-pavement lighting system increases pedestrian mobility. It is much less clear if the lights improve the safety of a crosswalk. The conflict studies indicate that the safety of these locations is still far from ‘perfect.’ Not until crash data is available will it be possible to say anything definite about how safety is impacted. With only two or three sites with these lights, we will have to wait about 200 years before the safety level can be assessed—unless the safety is so bad that the crash rate here is much higher than at locations lacking the in-pavement lights. However, enough out-of-state crash data—free from regression-to-mean effects and other biases—may soon be available for analyzing the safety of such systems.

The observations here make it clear that adding center refuge islands is a requirement if we desire ‘high’ pedestrian safety at locations with in-pavement lights. The yield percentage is far below that where we get a net benefit in safety of having one vehicle stop and thereby ‘encouraging’ pedestrians to cross in front of other vehicles still moving. Rather, each car that stops will most likely cause higher risk to pedestrians. Only in the situation where a high percentage of pedestrians are intoxicated, mentally handicapped or in a great hurry would there be a clear safety benefit from increasing the percentage of drivers who yield from, say, 20% to 30%. However, the flashing lights may mean that more drivers are prepared to brake even if they do not yield voluntarily until the pedestrian is right in front of them. There is therefore a chance that the system already today does have a net benefit on pedestrian safety. But that net benefit could easily disappear if pedestrians feel less vulnerable when crossing at locations with in-pavement lights.

If we want clearly higher pedestrian safety at these locations, we should take out the shoulders and put in refuge islands to narrow the crossing distances. If this gives true speed reductions, we would expect a clear additional benefit of the in-pavement light installations.

ACKNOWLEDGEMENT

The field studies were made by Keenan Goslin, Ntiense Awakessien, Joshua Clapp, Kenneth Fortier and Michael Jenkins as part of coursework in CIE 425—Transportation Safety. Keenan Goslin and Michael Jenkins also helped in reporting these findings by writing a project report for the course. I would also like to thank Sandi Duchesne of the Bangor Area Comprehensive Transportation System for bringing the in-pavement lighting systems to Maine and assisting in this project. Finally, comments by John Foster, Town of Brunswick, were considered when writing this report and the photographs in Figures 1 to 3 where provided by him.

³ <http://w1.sydsvenskan.se/Article.jsp?article=10111641>

ATTACHMENT 1

An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights

Primary Funding Provided By
State of California Office of Traffic Safety

Additional Funding Provided By
Federal Highway Administration through the University of North Carolina
Highway Safety Research Center

April 10, 1998

WHITLOCK & WEINBERGER TRANSPORTATION, INC
2200 Range Avenue, Suite 102, Santa Rosa, California, 95403
(707) 542-9500, Fax (707) 542-9590

EXECUTIVE SUMMARY

Introduction

In response to an unusually high incidence of pedestrian/vehicle collisions, the City of Santa Rosa, California initiated a new concept in proactive pedestrian warning systems for uncontrolled crosswalks in 1993 after experiencing a significant number of pedestrian fatalities and injuries. A private citizen came forth to the City with an idea for a flashing device to be installed on the pavement surface along the crosswalk lines facing traffic. The In-Pavement Flashing Lights Crosswalk Warning System's purpose was to warn the driving public of the presence of pedestrians in the crosswalk at uncontrolled intersections. The citizen is a pilot and the idea came to him when he thought that airport runway strobe lights used in landing his plane might be useful at crosswalks. The experimental system consists of a series of flashing light units which are embedded in the pavement adjacent to a marked crosswalk. The lights reflect toward the oncoming traffic to warn drivers of a pedestrian's presence.

The California Traffic Control Devices Committee allowed the City of Santa Rosa to test the experimental device at selected locations. The California Office of Traffic Safety also granted funds to the City to study the effectiveness of the device. The private citizen developed the In-Pavement Flashing Lights Crosswalk Warning System, while the City was responsible for the construction and installation requirements of the devices and the analysis of the device through a consultant. The system was eventually installed at three locations in the City of Santa Rosa, two in 1994 and one in 1995. Those sites were evaluated and the findings presented in a report, *Analysis of an Experimental Pedestrian Crosswalk Device, W-Trans/TJKM, July 17, 1995*.

In 1996, the California Traffic Control Devices Committee (CTCDC) endorsed the testing of the system in additional California cities in order to determine if the device should be sent on to the California State Department of Transportation for standardization. *Evaluation of an Experimental Crosswalk Warning System, July 1, 1997*, presented an evaluation on the In-Pavement Flashing Lights Crosswalk Warning System based on the operation and experience in the Cities of Fort Bragg, Lafayette, Petaluma, and Willits. Additional evaluation was conducted at one of the original Santa Rosa test sites two years following the initial installation of the device.

Primary funding for that study was provided primarily by the California Office of Traffic Safety (OTS) through the Cities of Fort Bragg, Lafayette, West Hollywood and Willits.

This report presents an update to the *Evaluation of an Experimental Crosswalk Warning System* based on additional experience in the Cities of Orinda, California and Kirkland, Washington. Funding for this update was provided through the Federal Highway Administration's Pedestrian Facilities Program, which is being conducted by the University of North Carolina Highway Research Center.

Findings

The concept of flashing amber lights embedded in the pavement at uncontrolled crosswalks clearly has a positive effect in enhancing a driver's awareness of crosswalks and modifying driver habits to be more favorable to pedestrians.

The In-Pavement Flashing Lights Crosswalk Warning System has a much more significant effect in enhancing a driver's awareness of crosswalks during adverse weather conditions such as darkness, fog and rain.

Over the long term, the affect of the crosswalk warning system will degrade slightly during day-time condition from initial implementation of the system. However, the resulting conditions will represent improved vehicle reaction characteristics compared with conditions before installations.

The In-Pavement Flashing Lights Crosswalk Warning 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.

An automatic detection system is more appropriate than a push button system and can result in less confusion for the pedestrian.

A recently demonstrated "bollard gateway system" which utilizes two parallel modulated visible red beams seems to be the most promising automatic activation technology.

The warning system seems to be partially effective at locations where there is at least a moderate flow of pedestrians (100 pedestrian crossing per day).

At speeds less than 35 mph, drivers seem to be able to respond properly if at least 400 feet of sight distance is provided to the warning system.

The presence of a lighting device at the outer edge of the travel lane may be a hazard to some bicyclists.

Each successive prototype of the lighting devices which has been tested has been superior in terms of their physical durability. Further improvements to its durability are still warranted. However, the desires of the market will dictate further physical evolution of the device.

Recommendations

Since the concept of flashing amber light embedded in the pavement at uncontrolled crosswalks clearly has merit in modifying driving habits to be more favorable to pedestrians, further use of this concept should be perused at appropriate locations.

The current installation pattern should be maintained as a standard. However, the outermost device should be placed to avoid the path of bicyclists the extent possible.

The device should be no higher than $\frac{3}{4}$ -inch, which is the maximum height of a standard lane delineator button.

Amber flashing lights seem to be the most appropriate color based on vehicle laws and considering a person's visual capabilities.

In the long run, an automatic pedestrian activation system seems to be more appropriate than a pedestrian push button. This allows the pedestrian to cross with caution and at their own discretion. The most promising technology to date has been the bollard gateway system.

Appropriate street lighting should be considered at crosswalks where the system is applied. Street lighting will allow the pedestrian to be more visible at night and wash out the glow of the lighting devices so they do not distract the pedestrian.

Federal standardization through the Manual on Uniform Traffic Control Devices (MUTCD) and consistency with crosswalk laws in states other than California should be investigated. An organization such as the Institute of Transportation Engineers would be an appropriate organization to peruse this course of action.

Based on the experience of the initial test sites, it is recommended that the following guidelines be met for installation of the In-Pavement Flashing Lights Crosswalk Warning System. The development of guidelines will be important in focusing use of the device where it will be most effective and maintaining its effectiveness through limiting the number of locations where it is present.

The Crosswalk Warning System should be used at uncontrolled crosswalks.

Main street average vehicular approach speeds should be 45 mph or less.

Main street traffic volumes should be between 5,000 and 30,000 vehicles per day. (It should be noted that the City of West Hollywood will be testing the device on Sunset Boulevard which has 55,000 vehicles per day.)

At speeds less than 35 mph, the approaching motorist should have visibility of the lighting devices at least 400 feet in advance of the crosswalk (measured from 3.5-foot eye height of the driver to 1 inch at the edge of the crosswalk line). At speeds greater than 35 mph, appropriate additional sight distance to the warning lights should be provided.

There should be no other crosswalks or traffic control devices at least 250 feet in advance or following the crosswalk location.

A minimum pedestrian volume of 100 pedestrian per day is suggested for application of the system.

Agencies, which install the system, should ensure that the public is educated on the proper use of the device by both driver and the pedestrian.

Effectiveness

Based on these survey results, the In-pavement Flashing Lights Crosswalk Warning System has clearly had a positive effect in enhancing a driver's awareness of the crosswalks and modifying driving habits to be more favorable to pedestrians. The extent of the effectiveness of the device depends on the specific site and seems to be impacted by the following geometric and operational characteristics:

- weather and lighting conditions
- width of the street and associated number of light installations
- grade change and curvature of the street

- level of traffic enforcement
- community's attitude toward the pedestrian
- speed of the traffic
- amount of pedestrian activity

Based on observations of the device's operation during adverse lighting conditions, it should be noted that the In-Pavement Flashing Lights Crosswalk Warning System has a much more dramatic effect in increasing a driver's awareness of crosswalks during adverse weather conditions such as darkness, fog and rain.

To be effective, as defined by the *Manual on Uniform Traffic Control Devices*, a traffic control device should meet five basic requirements, as follows:

1. Fulfill a need
2. Command Attention
3. Convey a clear, simple meaning
4. Command respect of road users
5. Give adequate time for proper response

The In-Pavement Flashing Lights Crosswalk Warning System has met these requirements in the following ways:

Fulfill a Need

This warning system was developed due to a specific need in the City of Santa Rosa. The interest by other jurisdictions to be a part of this second phase of testing, indicates that the concern and associate need were not isolated. The exposure of this concept through the media and professional journals has helped it gain national attention and interest because communities do have need for a cost effective means of addressing pedestrian safety issues at unprotected crosswalks.

Command Attention

The results of the data analysis has clearly shown that the use of lights in the pavement activated only when pedestrians are present gains the attention of the driver. The percentage of drivers which yield to the pedestrians has increased significantly at all of the study locations with the addition of the warning system.

Convey a Clear Simple Meaning

A flashing amber/yellow light used under various applications is intended to warn drivers to act with caution. With the experimental system, the intention is the same. The flashing amber lights placed on the roadway conveys the clear message of caution.

Command Respect of Road Users

Previous studies have shown that continuously flashing beacons at urban crosswalks do not increase driver awareness since these passive applications eventually become part of the background scenery. The experimental warning system commands respect of the road users since it is only activated when a pedestrian is crossing the street.

Give Adequate Time for Proper Response

Depending on the roadway alignment, the lights can be viewed from 1,000 to 1,500 feet away from the crosswalk. As long as the devices are being placed so that at least 300 to 400 feet of sight distance is available to the lead vehicle in a platoon, adequate time for driver response is available.

Driver Understanding of the Device

Based upon some of the comments received from drivers, most drivers seem to understand that they should react with some caution by either reducing their speed, or applying their brakes. Observations of drivers' reaction two years later at the original Santa Rosa installation revealed a consistent "sweeping" of the drivers head back and forth looking for pedestrians when lights were activated. There is some confusion by a small percentage of drivers who are unaware of whether they are required to stop when lights flash. Some other confusion has been caused by malfunctions on the automatic detection system.

Pedestrians Understanding of the Device

The automatic detection system has seemed to result in less confusion for the pedestrian than the push button activation because it does not require them to act in any way other than crossing the street as they would at any other uncontrolled crossing. Based on field observations at the Petaluma test site, which has the automatic activation, the pedestrians seem to be continuing to cross the street with the same level of caution as before.

Give Adequate Time for Proper Response

Depending on the roadway alignment, the lights can be viewed from 1,000 to 1,500 feet away from the crosswalk. As long as the devices are being placed so that at least 300 to 400 feet of sight distance is available to the lead vehicle in a platoon, adequate time for driver response is available.

Activation System

The activation system for this type of warning system is one of the most important features contributing to its effectiveness. Considering the experience at all of the test sites which have included both manual activation (push button) and automatic activation (overhead ultrasonic and overhead video imaging), an automatic detection system seems to be more appropriate than a manual push button activation. This recommendation is based on the following considerations:

- Historically, the pedestrian push button has been used almost exclusively as part of a standard traffic signal installation, which includes pedestrian signal heads. Pedestrians who encounter a pedestrian push button with out the associated traffic signal equipment are unlikely to expect it and may not understand what it is for. Worse, they may interpret a push button as giving them the right of way.
- Since this application is considered a warning system to the driver, no visual indication should be given to the pedestrian.
- The public may perceive the act of pushing a button as a way to cause approaching vehicles to stop.
- Based on field observations of several push button operated crosswalks warning systems in Santa Rosa, California, the frequency with which pedestrians used the push buttons varied with the volume of traffic. During off-peak periods when traffic volumes were lower, approximately one-third of the pedestrians activated the system. During peak periods when traffic volumes required the crossing pedestrian to wait for a gap, the use of the push button increased up to approximately two-thirds of the time.
- An automatic detection system should be less confusing to pedestrians because it does not require them to act in any way other than crossing the street with caution and at their own discretion. It also makes the pedestrian more responsible for their actions and causes less confusion.

It should be noted that the ultrasonic detection system which has been used to date has not performed satisfactorily. In general, the lights have activated 60 to 70 percent of the time when a pedestrian uses the crosswalk. Periodically, a turning vehicle or swaying trees have activated the lights with no pedestrians present. The video imaging detection system which was installed by the City of Petaluma seems to be a superior system but still has occurrences of false and non-

activations. A recent demonstrated "bolland gateway system" which utilizes two parallel modulated visible red beams seems to be the most promising technology. When pedestrians break the two beams in succession while walking into the street, the system activates 100 percent of the time. The system does not activate when a pedestrian breaks the beam in the reverse order leaving the street.

Physical Durability

The devices used in the In-Pavement Flashing Lights Crosswalk Warning Systems for the current test site, which are a third generation prototype, have been superior to the original prototype in terms of durability. There have been several instances of devices being damaged due to a street sweeper in Petaluma and logging trucks in Willits. They were replaced. The newest button type design, which has been tested in the field for less than a year. Has performed better in terms of durability than the previous design and is more resistant to damage by snowplows and street sweepers, however, there have been instances of damage which required replacement.

Comparisons with Standard Devices

An overhead flashing beacon is a standard device which can be used in the application of warning the driver of a pedestrian crosswalk. As indicated above previous studies have shown that continuously flashing beacons at urban crosswalks do not increase driver awareness since these passive applications eventually become part of the background scenery. Currently, there are other studies underway in the East Coast, which are evaluating the effectiveness of pedestrian activated, overhead flashing pedestrian signs.

The only way to directly compare the effectiveness of the In-pavement Flashing Lights Crosswalk Warning System versus an overhead flashing beacon would be to install each at the same location in succession to determine how each impacts driver attention. None of the participating agencies was willing to go to the expense of this endeavor. Therefore, this report focussed directly on the potential effectiveness of the experimental system and its merit.

Based on the experience of the test sites in Fort Bragg, Lafayette, Petaluma, Santa Rosa, Willits, Orinda and Kirkland, the following findings and recommendations are presented. These findings and recommendations may be modified based on future experiences of the system.

Findings

1. The concept of flashing amber light embedded in the pavement at uncontrolled crosswalks clearly has a positive effect in enhancing a driver's awareness of crosswalks and modifying driving habits to be more favorable to pedestrians.
2. The In-Pavement Flashing Lights Crosswalk Warning Systems has a much more significant effect in enhancing a driver's awareness of crosswalks during adverse weather conditions such as darkness, fog, and rain.
3. Over the long term, the affects of the crosswalk warning system will degrade slightly during daytime conditions from initial implementation of the system. However, the resulting long-term conditions still represent improved vehicle reaction characteristics compared with conditions before installations.
4. The warning system is expected to be extremely effective over the long term in enhancing driver awareness of the presence of a pedestrian during the hours of darkness.
5. The In-Pavement Flashing Lights Crosswalk Warning System has the potential to be 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.
6. An automatic detection systems is more appropriate than push a button system and can result in less confusion for the pedestrian because it does not require them to act in any way other than crossing the street as they would at any other uncontrolled crossing.

7. The ultrasonic automatic pedestrian detection technology tested in this evaluation was not found to be completely reliable in activating the system. The video imaging technology was superior to the ultrasonic detection, but still had many instances of false and non-activities. A recently demonstrated "bollard gateway system" which will utilize two parallel modulated visible red beams seems to be the most promising technology.
8. It is estimated that pedestrians use a push button in the 30 to 60 percentage range for this type of application depending on the volume of traffic. The absence of a pedestrian crossing indication does not generally prompt pedestrians to seek out the push buttons.
9. The warning system seems to be particularly effective at locations where there is at least moderate flow of pedestrians (100 pedestrians crossing per day). These locations tend to have sites characteristics, which lead the driver to expecting pedestrian crossings.
10. At speeds less than 35 mph, drivers seem to be able to respond properly if at least 400 feet of sight distance is provided to the warning system.
11. At speeds greater than 40 mph, drivers seem to have difficulty stopping safely if less than 600 feet of sight distances is available prior to the warning lights.
12. The presence of a lighting device at the outer edge of the travel lane may be a hazard to some bicyclists.
13. Each successive prototype of the lighting devices that have been tested has been superior in terms of their physical durability. Further improvements to its durability are still warranted. However, the desires of the market will dictate further physical evolution of the device.

Recommendations

1. Since the concept of flashing amber lights embedded in the pavement at uncontrolled crosswalks clearly has merit in modifying driving habits to be more favorable to pedestrians, further use of this concept should be pursued at appropriate locations.
2. There have been suggestions to have the devices only on the lane lines. This may not be desirable since the device in the center of the lane is the light most visible to drivers in that lane. The current installation pattern should be maintained as a standard. However, the outermost device should be placed to avoid the path of bicyclists to the extent possible.
3. The device should be no higher than $\frac{3}{4}$ -inch which is the maximum height of a standard lane delineator button.
4. Amber flashing lights seem to be the most appropriate color based on vehicle laws and considering a person's visual capabilities. Therefore the amber lights and size of the lens should be maintained as a standard.
5. In the long run, an automatic pedestrian activation system seems to be more appropriate than a pedestrian push button. This allows the pedestrian to cross with caution and at their own discretion. It also makes the pedestrian more responsible for their actions and causes less confusion. The most promising technology to date has been a "bollard gateway system" which utilizes two parallel-modulated visible red beams.
6. If a pedestrian push button is used, the sign which accompanies the button should be yellow and read, "Push Button for Warning Flasher/Cross with Caution" or similar wording. The use of a standard walking man symbol such as is used in the pedestrian head at a traffic signal and which indicates a protected pedestrian crossing should be avoided.
7. If a pedestrian push button is used with appropriate signage, in order to address ADA (American with Disabilities Act) issues, the installation could be supplemental with a voice box which says, "The warning flashers have been activated – cross with caution," or similar wording.
8. Appropriate street lighting should be considered at crosswalks where the system is applied. Street lighting will allow the pedestrian to be more visible at night and wash out the glow of lighting devices so they do not distract the pedestrian.

9. Federal standardization through the Manual on Uniform Traffic Control Devices (MUTCD) and consistency with crosswalk laws in states other than California should be investigated. An organization such as the Institute of Transportation Engineers would be an appropriate organizations to persue this course of action.
10. Based on the experience of the initial test sites, it is recommended that the following guidelines be met for installation of the In-Pavement Flashing Lights Crosswalk Warning System. These guidelines may be modified based on future experiences of the system. The development of guidelines will be important in focusing use of the device where it will be most effective and maintaining its effectiveness through limiting the number of location where it is present.
11. Main street average vehicular approach speeds should be 45 mph or less.
12. Main street traffic volumes should be between 5,000 and 30,000 vehicles per day. (It should be noted that the City of West Hollywood will be testing the device on Sunset Blvd. Which has 55,000 vehicles per day
13. The Crosswalk Warning System should be used at uncontrolled crosswalks.
14. At speeds less than 35 mph, the approaching motorists should have visibility of the lighting devices at least 400 feet in advance of the crosswalk (measured from 3.5-foot eye height of the driver to 1-inch height at the edge of the crosswalk line). At speeds greater than 35 mph, appropriate additional sight distance to the warning lights should be provided.
15. There should be no other crosswalks or traffic control devices at least 250 feet in advance or following the crosswalk locations.
16. A minimum pedestrian volume of 100 pedestrians per day is suggested for application of the system.
17. Agencies that install the system should ensure that the public is educated on the proper use of the device by both drivers and the pedestrian.